Chapter 9
Aerobic Granular Sludge: Treatment of Wastewaters Containing Toxic Compounds

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ABSTRACT

Aerobic Granular Sludge (AGS) has been successfully applied for carbon, nitrogen and phosphorous removal from wastewaters, in a single tank, reducing the space and energy requirements. This is especially beneficial for, often space restricted, industrial facilities. Moreover, AGS holds a promise for the toxic pollutants removal, due to its layered and compact structure and the bacteria embedding in a protective extracellular polymeric matrix. These outstanding features contribute to AGS tolerance to toxicity and stability. Strategies available to deal with toxic compounds, namely granulation with effluents containing toxics and bioaugmentation, are addressed here. Different applications for the toxics/micropollutants removal through biosorption and/or biodegradation are presented, illustrating the technology versatility. The anthropogenic substances effects on system performance and bacterial populations established within AGS are also addressed. Combination of contaminants removal to allow water discharge, and simultaneous valuable products recovery are presented as final remark.

INTRODUCTION

Aerobic granular sludge (AGS) has emerged as a promising biotechnology for the treatment of industrial wastewaters. AGS consists of near spherical sludge aggregates formed by self-immobilization of microorganisms commonly found in activated sludge systems, when specific operational conditions are applied

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(D. Gao, Liu, Liang, & Wu, 2011; Q. Zhang, Hu, & Lee, 2016). Compared with conventional activated sludge flocs, AGS has a compact structure with excellent settling capability, reducing the settling time applied in each treatment cycle and avoiding the need for separate settling tanks, thereby reducing the space needed for its implementation. However, in general, AGS system start-up is usually longer than that of conventional activated sludge system, which is a disadvantage of this kind of treatment systems.

Nevertheless, these microbial aggregates possess higher biomass retention and tolerance to toxic substrates than activated sludge flocs (Adav, Lee, Show, & Tay, 2008), which contribute to the great potential of the AGS technology to operate with industrial wastewater, including those effluents where toxic substrates are commonly present. Moreover, the aerobic granules contain diverse microbial communities that allow the establishment of efficient microbial communities and metabolic networks (Winkler, 2012). With a proper system operation mode, characterized by cyclic, fill-an-draw operation, the simultaneous removal of carbon, nitrogen and phosphorus from wastewater can be accomplished in a single tank. Also, as no recycle pumps and mixers are needed the energy requirements can be reduced (de Kreuk, Heijnen, & van Loosdrecht, 2005). These features could be beneficial for the implementation of the AGS technology, especially in industrial facilities.

The requirement of a minimal amount of mechanical equipment and more efficient aeration results in energy saving as an extra attractive aspect of the AGS technology. For the industrial sector, generating large quantities of wastewater, the application of this technology reduces the economic costs to treat their effluents and make it available for reuse. Nevertheless, generally for large-scale industrial operation, continuous-flow reactors are preferred over batch-reactors, such as SBR. Up to date, AGS technology at full-scale was implemented using SBR, which is usually more suitable for the treatment of smaller amounts of wastewater. Therefore its implementation on industrial facilities can become more difficult. Much effort has been made in the development of AGS continuous-flow reactors which can lower plant installation cost, maintenance and control. Recently, the possibility of operating an AGS reactor in continuous mode for the treatment of an industrial wastewater from a milk-processing factory was demonstrated with satisfactory treatment performances (Bumbac, Ionescu, Tiron, & Badescu, 2015). However, in the long-run AGS lost its structural stability faster when compared with granules from a SBR. AGS continuous-flow reactors could be more feasible in large scale application; however further knowledge on the reactor design optimisation and operation conditions is needed for its scale-up.

In spite of some limitations, the AGS system is an upcoming technology for the biological wastewater treatment and research on this technology is a hot topic in the field of wastewater treatment, opening new perspectives for its upgrading. At the present, Netherlands, Portugal, South Africa, Brasil, Poland, Ireland, Australia and China have full-scale AGS systems in operation, and it is expected that the number of installations will increase rapidly worldwide (http://www.royalhaskoningdhv.com/en-gb/nereda). Recent reports revealed that there are projects in the pipeline to apply the AGS systems for the treatment of effluents from food, beverage and chemical industries (Giesen, de Bruin, Niermans, & van der Roest, 2013). So far, AGS full-scale operation processes available describe the system performance treating domestic wastewater (Pronk, de Kreuk, et al., 2015a) or a mixture of domestic and industrial wastewater (Giesen et al., 2013; J. Li, Ding, Cai, Huang, & Horn, 2014a). Currently, data on AGS full-scale performance when treating industrial wastewater containing toxic compounds is less available.

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