Development of Domestic Aerobic Granular Sludge (AGS) with Activated Carbon and Its Potential in Removing Water Pollutants: A Mini Review

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ABSTRACT

Aerobic granular sludge (AGS) technology is a biological treatment that widely use in treating the industrials and other types of wastewaters. Currently, AGS are considered as the most effective and cost alternative wastewater treatment. However, the granulation process usually requires a long time period in completing the whole process. Recent studies have investigated that, by adding the activated carbon which act as a carrier will enhance the granulation process by shorten the time and improving the granule stability. Besides, the development of granules with the carrier also increasing the removal efficiencies of the emerging water pollutants. So, this review will discuss on the role of activated carbon as a carrier for bacterial attachment, the characteristic of the granule developed from this process and the potential in removing the pollutants in waster environment.

Keywords: Biological wastewater treatment, bacteria aggregation, biofilm, domestic activated sludge, aerobic granules.

1. INTRODUCTION

Aerobic granular sludge (AGS) is a technology for a wastewater treatment in treating various types of pollutants by biological process. Aerobic granulation is mainly developed in sequencing batch reactor (SBR) with the supply of oxygen [1]. The granulation is the process of self-immobilization of bacterial by developing a dense and microbial community through the high shear force of aerobic velocity [2].

Besides than the excellent settling properties, this technology is also cost effective as it being used in many industrial and other water treatment applications. However, the development of AGS requires a long period of time as it fully depends on the biological process [3]. So, in order to shorten the granulation time, recent study have suggested by adding the activated carbon as the carrier or nucleus to accelerate the granules formation.

Commonly, activated carbon (AC) is well known as the effective adsorbent in removing contaminants through adsorption process. In spite of that, the adsorption process will reach the adsorption capacity limit in adsorbing any adsorbate in a certain concentration or time period [4]. So, with the combination of both technology, there is the advantage in enhancing the water treatment by the adsorption and bacterial degradation process. Therefore, this review will be focusing on the characteristic of activated carbon that influence the bacterial attachment, the characteristics of the AGS developed with AC and the potential in removing contaminants with the combination of the both technologies.

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2. THE ROLE OF ACTIVATED CARBON AS A CARRIER FOR BACTERIAL AGGREGATION

The natural characteristics of activated carbon is the material have many pores and a correspondingly high surface area. These condition attribute to the initial successful adhesion of abundance microorganism [5]. During early stage of granule development, the porous structure on the AC surface provides a further spaces or shelter for microaggregates from the adverse environmental conditions [6]. The bacterial aggregation process is illustrated as shown in Figure 1.

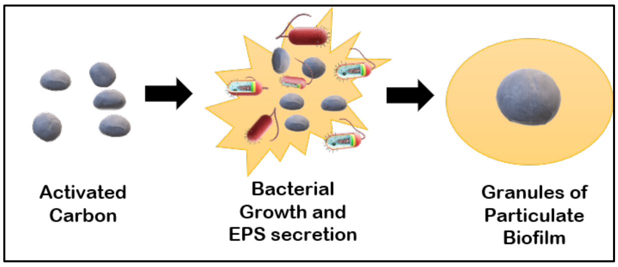

Figure 1. The formation of bacterial aggregation with AC.

In addition, those cationic ions which are located on the AC surface accelerated the bacterial adhesion by the interaction with the negatively charge cellular component within the environment. This condition promotes to extracellular polymeric substances (EPS) secretion. EPS is a type of biofilm which are mainly composed of polysaccharides, protein and DNA [7]. This excretion may shorten the granule formation time by use it as a bridge between the bacteria and other particles.

3. GRANULES CHARACTERISTICS THAT ENHANCE THE AGS PROCESS

The characteristics of the granule developed is significant in improving the AGS process. Initially, the addition of AC to the sludge promotes to formation of particulate biofilm which contributes to biomass retention in the bioreactor. The increase in biomass influenced the sludge settleability. This is also stated by [8] which mentioned that the sedimentation characteristics (SVI30) of the sludge increasing as the MLSS recorded in high concentration which represent the growth of sludge biomass.

Besides, the compact and dense granule structure formed when the AGS process is accelerated with the carrier. According to [9] the matured granules was formed on day 62 with the addition of AC particle more compact and in regular shape compared to the AGS develop without any carrier.

In addition, prior to the morphology, according to [10] the granules developed with the carrier resulted the larger in size compared to the none carrier. The largest mature granule was formed on day 50 with the diameter of 6.51mm with the addition of biochar as the carrier to the AGS process [11].

All the characteristics mentioned, promotes to the sludge settling performance. Some researchers have proven that AGS with Fe-modified granular activated carbon was reported to have a better settling properties during the whole granulation process[12]. Besides, according to study done by [13] reported that the settling velocity was improved from 92.7 m/h to 7.1 m/h with the addition of granular activated carbon to the granulation process.

4. POTENTIAL IN REMOVING WATER POLLUTANTS

The granules developed with the carrier have the high potential in removing pollutants from water and wastewater. The combination of these formation have the ability of adsorption and bacterial degradation process [14][15]. Table 1 shows the previous research done by some researches in investigating the removal efficiency by using the process.

Table 1 The previous study of the water pollutant removal by the addition of carrier to AGS Technology

Carrier Description	Pollutants	Ref.
Amino functionalized AGS with biochar	88.14% of Heavy metal Pb (II)	[16]
AGS developed from $ZnCl_2$ modified biochar	Maximum adsorption 93.44 mg. g^{-1} Tetracycline	[17]
Biochar and municipal activated sludge	65% of Ammonium	[18]
Activated carbon and municipal activated sludge	95% of Nitrogen and 90% of Phosphorus	[9]
Biochar and petroleum activated sludge	Petroleum refinery (enhanced removal efficiency by 3-10%)	[19]
Activated sludge and granular activated carbon (GAC)	97% of COD, 83.3% of TKN and 58%.9 of TN	[20]

Besides, [11] also proved that, 75% of COD was successfully removed in the bioreactor operated with the addition of biochar. Meanwhile only 45% of COD removal was recorded in the bioreactor which operated without biochar. Other than that, [21] also stated that the highest in removal efficiencies of colors, COD and total nitrogen was obtained in the sequencing batch reactor (SBR) operating with the granular activated carbon (GAC). So, the studies have proven that, with the addition of carrier in the AGS process will improve the removal efficiency of the pollutant in water environment.

5. CONCLUSION

Overall, this modification is significant in improving the aerobic granulation technology (AGS) in terms of the granule formation and stability. Besides, this method can also enhance the wastewater treatment by shorten the settling process especially in flocculation phase. Other than that, this technology also has the ability in removing various types of water contaminant and have the great potential in further research in water and wastewater treatment.

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