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Hydrodynamic Properties of Aerobic Granules Cultivated on Phenol as Carbon Source

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Abstract

The cultivation and hydrodynamic properties such as morphology, fractal dimension, porosity, size distribution, and settling velocity of stable aerobic granules, developed in a column type sequencing batch reactor SBR was investigated in this study. A column type SBR was operated with organic loading rate of 1.8 kg phenol/m^3day with phenol as a sole carbon source. The granules were fractal and porous aggregates and had a fractal dimension and porosity of 2.47 and 0.7-0.9 respectively. The settling velocities of aerobic granules were in the range of $2.38x10^{-02}$m/s-$7.1x10^{-02}$m/s. This was in good agreement with the settling velocities predicted by Stoke's law for porous but impermeable spheres. This may be due to the EPS (Extracellular Polymeric Substances) produced by bacteria form a gel matrix that clogs the pores within the granules which resulted in reduced permeation and settling velocities.

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Keywords: Aerobic Granules; Phenol; Porosity; Sequencing Batch Reactor (SBR); Settling Velocity

1. Introduction

The use of aerobic biological treatment can be traced back to the late nineteenth century.. These days a new innovation in aerobic process has been developed known as aerobic granular sludge technology. It has many advantages over the conventional activated sludge process i.e. it can withstand fluctuating loads; lesser space requirement; lower biomass production due to high biomass retention [1]. Settling velocity is a critical

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factor that regulates sludge liquid separation and effluent quality in biological wastewater treatment processes. The settling velocity of aerobic granules depends upon its drag coefficient, and hence the calculation of drag coefficient has been an important parameter for microbial granules. In this study, aerobic granules were cultivated in SBR with phenol as only carbon source. Aerobic granules developed were analysed for hydrodynamic and other properties.

2. Materials and Methods

2.1. Reactor Setup and Operation

A laboratory scale SBR with an effective volume of 2 L was used to cultivate aerobic granules. The internal diameter of the reactor was 5 cm and the working H/D (Height/Diameter) was about 20. Fine air bubbles for aeration and mixing were supplied by diffusers placed at the reactor bottom. Superficial air velocity was maintained in the range of 2-3 cm/s. A reactor was operated sequentially in 8 h cycles which consist of 5 min of influent filing, 472-447 min of aeration, 5-30 min of settling and 3 min of effluent withdrawal. Effluent was discharged at 50 cm from the bottom of the reactor with a volumetric exchange ratio of 50%.

Seeding biomass was obtained from the municipal wastewater treatment plant, Okhla, New Delhi, India. The sludge was acclimatized to phenol in batch culture for a period of one month. The acclimatized sludge was used as inoculum for the reactor. The reactor was fed with phenol as a sole carbon source by using a synthetic wastewater with following nutrient composition. Phenol, NH_4Cl, $MgSO_4 \cdot 7H_2O$, K_2HPO_4, and KH_2PO_4 at a weight ratio of 1:0.4:0.26:3.3:2.7. The media was supplemented with 1 ml/ L of micronutrients, as described previously [2].

2.2. Characteristics of granules

2.2.1. Terminal Settling Velocity of granules

The settling velocity study of granules was performed in a vertical glass column filled with tap water. The glass column which was 100cm in height to insure that terminal settling velocity could be reached, and 5.0 cm in internal diameter to minimize the wall effect on granule settling. Before the settling test each granule was analysed using Cenisco binocular petrological microscope with SANYO digital camera. The photographs were analysed using image analysis system (Averz Software). More than 40 granules diameter were determined using image analysis system. After the settling test the dry mass of aerobic granule was measured. The granule was dried at 105^{o} C for 1.5 h on a pre-weighted membrane filter and its dry mass 'W_d' was measured.

2.2.2. Granule Strength and Density

Granule strength is defined as the ability of granules to resist disintegration. It is defined as an integrity coefficient (IC) (%) which is the residual volatile suspended solids (VSS) after sample was agitated for 5min at 200 rpm to a total VSS of the intact granules prior to agitation [3] .The stronger granules have higher ICs. The density of aerobic granules was determined using (Volumetric Displacement Method).

2.2.3. Stroke's law for porous but impermeable granules.

The terminal settling velocity, U_s of single impermeable particle aggregate can be predicted by the following generalization of Stoke's law for wide range of Reynold's number [4]. $Us= \sqrt{(4g(\rho_a-\rho_l)d/3\rho_l C_d)}$ where ρ_a and ρ_l are the densities of the aggregate and the liquid respectively , g is the gravitational constant