



Review

# Microbial Ecology of Granular Biofilm Technologies for Wastewater Treatment: A Review

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**Abstract:** Nowadays, the discharge of wastewater is a global concern due to the damage caused to human and environmental health. Wastewater treatment has progressed to provide environmentally and economically sustainable technologies. The biological treatment of wastewater is one of the fundamental bases of this field, and the employment of new technologies based on granular biofilm systems is demonstrating success in tackling the environmental issues derived from the discharge of wastewater. The granular-conforming microorganisms must be evaluated as functional entities because their activities and functions for removing pollutants are interconnected with the surrounding microbiota. The deep knowledge of microbial communities allows for the improvement in system operation, as the proliferation of microorganisms in charge of metabolic roles could be modified by adjustments to operational conditions. This is why engineering must consider the intrinsic microbiological aspects of biological wastewater treatment systems to obtain the most effective performance. This review provides an extensive view of the microbial ecology of biological wastewater treatment technologies based on granular biofilms for mitigating water pollution.

**Keywords:** microbiota; aerobic granular sludge; anaerobic granular sludge; anammox; microbial ecology; nutrient removal; organic carbon degradation



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## 1. Introduction

Microorganisms are ubiquitous in every habitat on Earth, and they are the main drivers of the exchange of carbon, oxygen, nitrogen, phosphorous, and sulfur in the biogeochemical cycles that comprise the basis of life. The mixed microbial populations interact, connect, influence, and alter the biochemical and physiological processes occurring on the planet [1]. The microbial ecology of bioengineering systems is a key factor in the performance of bioprocesses. The design and operation of biotechnological approaches must consider their intrinsic microbiological aspects [2]. Furthermore, the understanding of the microbial communities and their roles are basic for the profitable management of biological resources [3]; thus, microbial ecosystems are considered functional entities in processes based on the metabolic pathways of mixed-culture microorganisms such as wastewater treatment (WWT) systems, which are among the most widespread uses of microbial communities currently [1]. The processes in WWT are not carried out by specific genera but by complex microbial communities that are usually characterized by parameters such as biomass concentration, the number of cells, sludge age, or kinetics, all of which are studied from the engineering point of view [4].

Furthermore, the microbiological aspects tend to be focused on the cultivation of isolated microorganisms that play a role in the destabilization of biomass, such as filamentous bacteria [5]. It is important to note that new molecular biology tools have allowed for the

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