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Biofilm-Based Reactors For Wastewater Treatment

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Abstract:

The escalating global industrial activity contributing to substantial pollutant release into aquatic environments, prompting the implementation of environmental regulations for industrial wastewater. However, the diverse raw materials and production methods employed by industries present challenges in identifying effective control technologies. Biofilm-mediated processes emerge as a promising alternative, showcasing superior pollutant degradation efficiency. Microbial cell aggregates, including flocs and biofilms, prove valuable in biotechnology due to advantages in cell-liquid separation. The distinct phases of microbial aggregates and bulk culture medium significantly impact reactor performance, affecting biomass retention and separation. Substrate transport within aggregates, particularly within biofilms, depends on factors such as porosity, mass transfer, and reaction rates, which influence penetration depth. Diffusion gradients create a layered structure in the biofilm system that protects slow-growing organisms from external forces and reduces the risk of detachment. The physical and structural properties of the aggregate determine the substrate concentration and distribution gradient of the biomass. Flakes are smaller, more porous, and less gradient, whereas biofilms and granules have better sedimentation properties and are easier to retain in bioreactors. Despite the potential of biofilm reactors in wastewater treatment, their widespread application in large-scale industrial processes, especially those with high substrate concentrations, remains limited. In industrial fermentation processes with elevated substrate concentrations, biofilm formation may be unnecessary or even disadvantageous. Although biofilm reactors have been extensively reviewed for various biotechnological processes, their full-scale industrial utilization is constrained, primarily finding practical application in the domain of wastewater treatment processes.

Introduction:

There are actually many different ways to clean dirty water and one method uses tiny living organisms called biofilms. These biofilms play an important role in the cleaning process, and special machines called reactors are used to facilitate their work (Asri et al., 2018). The reactor can use a variety of techniques to move the biofilm and water, such as floating the biofilm or using gas to create movement. Below are some types of reactors commonly used to purify dirty water. Biofilm counter flow/ up flow sludge blanket (USB) reactor uses counter flow hydraulics to create a sludge bed where the biofilm grows. The wastewater flows up through the sludge layer, allowing the biofilm to come into contact and remove contaminants. Biofilm fluidized bed (BFB) reactors use a liquefied medium, such as sand or plastic beads, to create a biofilm layer. Water circulates through this layer, allowing the biofilm to capture and biodegrade contaminants. The fluidized bed improves the contact between the biofilm and water, thereby improving cleaning efficiency (Nicolella et al., 2000).

Biofilm Expanded Granular Sludge Bed (EGSB) Reactor, Similar to the upflow sludge bed reactor, the EGSB reactor also uses a counterflow hydraulic mode. However, in this case, the biofilm forms particles with a more solid structure. The particles are designed to expand and create a larger surface area for biofilm growth, resulting in greater treatment efficiency. The Biofilm air suspension reactor (BAS) uses a combination of gas and liquid flows to create a biofilm suspension in water. Air currents promote the movement of biofilms, allowing them to come into contact with contaminants for effective removal. Suspended biofilm provides a large surface area for treatment (Nicolella et al., 2000). Internal circulation reactor (IC reactor) is a type of anaerobic digester designed primarily for wastewater treatment. These reactors are a development of the counter flow anaerobic sludge system (UASB) and the expanded granular sludge system (EGSB). IC reactors are designed to improve digestion rates and biogas yields and typically operate as part of a two-stage anaerobic digestion system. This system requires additional aerobic treatment to meet discharge tolerances for biochemical and chemical oxygen demand (Nicolella et al., 2000). Microbial fuel cells (MFCs) are specialized devices that use microorganisms as biocatalysts to convert organic materials into electrical energy. In MFC, biofilm forms on the electrode surface and as microorganisms metabolize the organic substrate; chemical energy is converted into usable electrical energy (Asri et al., 2018). These different types of reactors offer different approaches to cleaning dirty water. Each reactor design offers unique benefits and efficiencies depending on the specific requirements and the contaminant being treated. It is important to note that these reactors can be used individually or in combination to achieve the desired results.

References:

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