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ADVANCES IN BIOFILTER TECHNIQUES FOR WASTEWATER TREATMENT

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Abstract

One of the most essential separation methods for removing organic contaminants from air, water, and wastewater is the use of a biofilter. Despite the fact that it has been in use for over a century, it is still impossible to describe all of the biological activities that occur in a biofilter conceptually. The basic biological processes involved in the biofilter are critically evaluated in this study. The most significant operational and design parameters are covered in depth, along with typical values for various applications. The biomass attached to the medium is the most critical parameter that affects this process. The relative benefits of several approaches used in biomass measurement are examined.

Keywords: Biofilter, Wastewater, Biomass, Organics.

Introduction

Filtration are among the most essential treatment procedures in the treatment of water and wastewater. Filtering is used in water treatment to purify surface water for potable use, but in wastewater treatment, the major objective of filtration is to create high-quality effluent that may be reused for a variety of applications. A biofilter is any form of filter having connected biomass on the filter-media. It might be a trickling filter in a wastewater treatment plant, a horizontal rock filter in a polluted stream, granular activated carbon (GAC), or a sand filter in a water treatment facility. Biofilters have been used effectively to purify air, water, and wastewater. It was originally utilised as a trickling filter in wastewater treatment in England in 1893 (Metcalf and Eddy, 1991), and it has since been effectively used for the treatment of home and industrial wastewater. Originally, rock or slag were used as filter media in biofilters; however, many kinds and forms of plastic media are now employed. There are already a variety of tiny package treatment plants with various brand names on the market, in which various shaped plastic materials are packed as filter media and are primarily used for treating small amounts of wastewater. Regardless of the many titles given to it depending on operating mode, the essential concept in a biofilter is the same: biodegradation of contaminants by microorganisms adhering to the filter medium. Only after the discovery of re-growth of microorganisms in water distribution pipe lines a few decades ago did the use of a biofilter in drinking water treatment particularly with granular activated carbon as filter medium seem required. It has been found that after a few years of operation, the inner surface of water distribution pipes conveying potable water gets coated with layers of biomass (Van der Kooij et al., 1982).

Biological Process

Pollutants are eliminated from a biofiltration system by biological decomposition rather than physical straining as in a conventional filter. Microorganisms (aerobic, anaerobic, and facultative bacteria; fungus; algae; and protozoa) eventually proliferate on the surface of the filter medium and produce a biological film or slime layer known as biofilm as the filtering process progresses. Depending on the organic content in the influent, biofilm growth might take a few days or months. The ability to regulate and maintain a healthy biomass on the filter's surface is critical for the proper functioning of a biofilter. Because the biofilter's effectiveness is heavily reliant on microbial activity, a regular supply of substrates (organic substances and nutrients) is essential for its consistent and successful functioning. There are three major biological processes that may occur in a biofilter: (i) microbe attachment, (ii) microorganism development, and (iii) microorganism decay and detachment. Because the effectiveness of a biofilter is dependent on the development and maintenance of microorganisms (biomass) on the surface of filter media, understanding the processes of attachment, growth, and detachment on the surface of the filter media is essential.

Attachment of Microorganisms

Microorganisms may attach and colonise on the surface of a biofilter's filter medium via the following mechanisms: (I) transit, (ii) initial adhesion, (iii) firm attachment, and (iv) colonisation (Van Loosdrecht et al., 1990). The movement of microorganisms to the surface of the filter medium is further governed by four major processes: (a) diffusion (Brownian motion), (b) convection, (c) sedimentation owing to gravity, and (d) active mobility of the microorganisms. When microorganisms reach the surface, they form an initial adhesion that may be reversible or irreversible depending on the overall interaction energy, which is the sum of Van der Waals and electrostatic forces.

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Detachment of Biomass

The proper management of biomass attached to the filter medium is critical to the performance of a biofilter. One of the most critical factors that might impact biomass maintenance in a biofilter is biomass detachment. The most often seen and discussed detachment processes include erosion, abrasion, sloughing, grazing or predation, and filter backwashing. Erosion of biomass happens as a result of fluid shear, while abrasion of biomass occurs as a result of an external particle colliding with the biocell. Similarly, huge patches of biomass are separated via sloughing, and a portion of biomass, particularly on the biofilm's outer surface, may be lost owing to protozoa nibbling. The assessment of biomass loss due to filter backwashing is critical from an operational standpoint. Backwash bed expansion and backwash mode, such as air scour, filter effluent, or chlorinated water backwash, may all have an impact on biomass during backwashing. Previous research has demonstrated, however, that the effective biomass that is primarily responsible for organic removal is not lost during typical filter backwash (Chaudhary et al., 2001).

Application of Biofilter

In a wastewater treatment system, a biofilter may be used as either a primary or secondary treatment unit. When the volume of wastewater is modest, a full treatment may be completed in a single tank -package treatment plant that has been partitioned for pretreatment, biofiltration, and sedimentation processes. As biofilter medium, several kinds and forms of plastic materials are employed. Package treatment plants of this sort are often used to treat on-site home and industrial waste water.

Biofilter has been utilised effectively as a trickling filter for home wastewater treatment. Depending on the properties of the influent and the effluent quality need, it may be utilised with or without other biological treatment procedures. The trickling biofilter medium is made of rock, slag, or plastic.

The trickling biofilter application choices vary depending on the treatment goals, media type, and the characteristics of the other treatment units in the process train. It may be used for roughing, carbon oxidation, combined carbon oxidation, and nitrification in a variety of configurations including two or more biofilter units. The benefits of adopting a bio-trickling filter over a typical activated sludge process are (i) lower operating costs, (ii) less space required, and (iii) well-stabilized sludge (no sludge bulking or floating problem).

Biofilters may be employed in advanced wastewater treatment with traditional physicochemical processes such as coagulation, flocculation, filtration, and sedimentation. Depending on the concentration of suspended solids, the conventional filter and biofilter units may be combined. Because the primary function of the biofilter is to remove dissolved organics, the suspended particles are removed in a conventional filter before the wastewater is sent to the biofiltration system. Many studies have also deemed the biofilter to be a vital component of potable surface water treatment in order to minimise microbial growth in distribution pipe lines, corrosion potential, and disinfection by-products (Bouwer and Crowe, 1988)

Surface Water Treatment

A study of a GAC biofiltration system conducted at the Neuilly-sur-Marne treatment plant in France by Servais et al. (19940) using selected three filters with differing bed depth and filtration velocity, but equivalent empty bed contact time (EBCT) revealed that the organic percentage removal of the GAC filter for a given EBCT is independent of filtration velocity in the 6-18 m/h range. According to this research, the removal of biodegradable organic carbon on the GAC surface improves with biomass development, whereas the filter's non-biodegradable organic removal effectiveness declines.

Low Strength Wastewater

The daily backwash used to prevent physical clogging of the biofilter had no effect on the filter's organic removal effectiveness. Hozalski and Bouwer (1998) discovered that water backwash had no effect on biomass buildup in their laboratory-scale filter investigation. The organic removal effectiveness of the biofilter was found to be unaltered after the backwash in their testing. Some biomass may naturally be lost during filter backwashing, but the loss of biomass might provide additional sites for organic adsorption, so the impairment is balanced. This may happen if GAC's adsorption capability is not completely used.

The effects of influent organic concentration and filtration rate on the biofilter's organic removal efficiency were explored experimentally (Chaudhary et al., 2001). It was discovered that when the filtration rate rose, the effluent quality deteriorated compared to the lower filtration rate at which the filter was acclimatised, but the organic removal pattern remained constant over time. It's possible that when the hydraulic loading rate of the biofilter was raised, the EBCT fell, and the increased organic mass loading surpassed the biomass's capacity to absorb the available biodegradable organic compounds, resulting in unsatisfactory effluent quality.

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It must be mentioned that the filter column was acclimatised with a low organic content (TOC of 3.5 mg/L) and a low filtration rate of 1 m/h to allow for the slow accumulation of biomass in the filter medium.

Conclusions

Because of its constant TOC removal effectiveness, extended operational life, and ease of operation, biofilters may be utilised successfully and economically to create high quality effluent. The biological activity results in a steady organic content in the effluent over a lengthy period of time. The daily backwash that is often used to relax the filter bed seems to have little influence mostly on biomass growth rate, and thus the effluent quality. However, its performance is determined by the filtration rate as well as the influent organic content, implying that the biofilter should be used under the same circumstances under which it was acclimatised for optimal and constant organic removal effectiveness. A proper flow rate and GAC medium depth, together with an adequate backwash, may result in a long-term functioning with constant and excellent effluent quality.

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