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BIOLOGICAL FILTRATION AND BIOFILM SYSTEMS FOR DRINKING WATER TREATMENT

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Abstract - Biological treatment destroys contaminants entirety and is able to remove multiple contaminants at the same time. This cuts down on sludge production and bacterial regrowth. Biological treatment can be used to remove natural organic matter, color, chloroform, perchlorate, nitrate, nitrite, bromate, iron, manganese, selenate, chromate, arsenate, and a variety of other contaminants. It eliminates the need for chemical oxidation prior to filtration or settling, eliminates the need for chemical reduction methods, and produces innocuous end-products, thus reducing the risk of a contaminated concentrate stream.

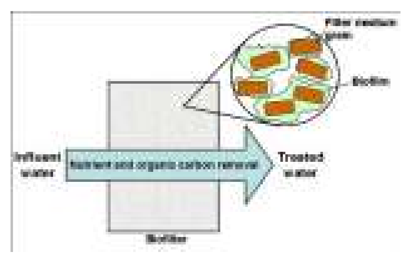
Biofilms are playing a major role in drinking and waste water treatment processes due to their enhanced properties of mineralization, bioaccumulation and bioadsorbtion. Despite the beneficial effects of the biological filter known as schmutzdecke in slow sand filtration or of the bio-sand filters, biofilms occurrence in other treatment stages, in drinking water networks and reservoirs represents a continuous challenge to water professionals. Drinking water associated biofilms induce residual disinfectants depletion and may cause aesthetic problems consisting in colour, odour and taste degradation due to chemical compounds released and more important, they pose a threat to human and animal health by hosting pathogenic or toxins producing bacteria, viruses, protozoa, algae, fungi and invertebrates. The great majority of water related health problems are the result of microbial contamination (Riley et al, 2011). Considering these aspects, naturally occurring biofilms in contact with drinking water were identified and described as microbial reservoirs for further contamination (Szewzyk et al, 2000; Wingender and Flemming, 2011).

I. Introduction:

For drinking water, biological water treatment involves the use of naturally occurring microorganisms in the surface water to improve water quality. Under optimum conditions, including relatively low turbidity and high oxygen content, the organisms break down material in the water and thus improve water quality. Slow sand filters or carbon filters are used to provide a support on which these microorganisms grow. These biological treatment systems effectively reduce water-borne diseases, dissolved organic carbon, turbidity and color in surface water, thus improving overall water quality.

II. Biofiltration Process:

Biofiltration as a treatment technology in water purification. The arrow indicates the direction of water flow. Biofilters contain filter medium grains (e.g., sand, granular activated carbon) that are covered with biofilms. The biofilm activities break down nutrients (e.g., nitrogen and phosphorous-containing compounds) and organic carbon as well as capture other unwanted contaminants in the influent water. Water coming out of a biofilter typically undergoes disinfection prior to entering drinking water distribution pipes or being released to the environment as wastewater effluent.



III. Biofilm:

A **biofilm** is any group of microorganisms in which cells stick to each other and often also to a surface. These adherent cells become embedded within a slimy extracellular matrix that is composed of extracellular polymeric substances (EPS).The EPS components are produced by the cells within the biofilm and are typically a polymeric conglomeration of extracellular DNA, proteins, and polysaccharides.Because they have three-dimensional structure and represent a community lifestyle for microorganisms, biofilms are frequently described metaphorically as "cities for microbes."

IV. Biofilms Uses:

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We know that microorganisms are the main agents that cause decay in dead plants and animals. Microorganisms feed on the decay of life. Placing these decay eating organisms in water could work as a natural way to clean water and rid it of mold and decay. Engineers and scientists adapted a way to form a beneficial biofilm that eats all of the "bad stuff" in water, effectively filtering it without adding harmful pesticides and chemicals. There is more likely to be less microorganism contamination in water that has passed through a biofilm-based filter than there is in water that has passed through some alternative treatment system. This implies that biofilm treated water typically has lower disinfectant demand and disinfection by products than water treated in other ways if the water prior to treatment is high in the kind of nutrients the biofilm craves (organic carbon).

V. Elimination of Organic Trace Contaminants During Drinking Water Treatment:

Some trace organic contaminants biodegrade during biological wastewater processes (Clara et al., 2009; Nghiem et al., 2009; Radjenovic et al., 2009; Kimura et al., 2007; Joss et al., 2005) reducing the risk to contaminate sources of drinking water (Lindqvist et al., 2005). Common biologically active treatment processes for drinking water treatment including slow sand filtration, biologically active carbon filtration, and riverbank filtration may provide some removal of easily biodegradable contaminants. Biodegradation of ibuprofen and clofibric acid was observed in river biofilm systems (Winkler et al., 2001). The EDC amitrol was effectively biodegraded using biologically activated carbon but poorly adsorbed on GAC, while nonylphenol and bisphenolA show a reduced adsorption capacity over time suggesting a limited biodegradability of these compounds (Choi et al., 2005). During conventional wastewater treatment, Radjenovic et al. (2009) show high removal ($\geq$ 70 %) of ibuprofen, acetaminophen, naproxen, sulfamethoxazole, ofloxacin, and benzafibrate. Some compounds such as carbamazepine and gemfibroxil are persistent in biological treatment of wastewater and drinking water (Radjenovic et al., 2009; Joss et al., 2005). However, as mentioned for oxidation processes, biological degradation of trace organic contaminants can transform the parent compound into by-products causing environmental concern but further research is needed on this area.

VI. Summary and Research Gaps:

As presented in the review, trace organic contaminants can be detected in drinking water sources at ng/L to low µg/L concentrations. Although studies have shown that treated drinking water usually contains lower numbers of compounds at lower concentrations than in the source water, the presence of these contaminants remains a public concern. A study published by Pomati et al. (2006) showed that human embryonic cells may experience physiological and morphological transformations when exposed to a mixture of pharmaceuticals at concentrations typically present in the environment. Therefore, further research on the removal of PhACs, EDCs and PCPs occurring during the water treatment process is needed.

VII. Physio-Chemical Analyses:

Weekly parameters measured on Grand River water were TOC, DOC, UV254, SUVA, turbidity, conductivity, pH, and temperature.

The concentration of TOC and DOC were respectively measured using the OI-Analytical TOC analyser (Model 1010, College Station, TX) with the wet-oxidation method as described in Standard Methods 5310C (Standard Methods, 2005). DOC samples were filtered through a 0.45 µm cellulose acetate filter prior to analysis.

Turbidity was measured using a Hach 2100P turbidimeter following Standard Methods 2130 (Standard Methods, 2005). Samples were analyzed within 24 h after sampling

A pH meter Orion 720A and a glass electrode Orion 91-02 were used to measure pH.

Conductivity was determined using a conductivity meter (Hach 44600) following Standard Methods 2510 (Standard Methods, 2005). The replicability of the conductivity measurement is ± 1 µS/cm unit based on 10 analyses.

The water temperature was measured using a general purpose thermometer filled with mineral fluid.

VIII. Conclusion:

Biomass Attached To Filter Media:

Biomass Attached to Filter Media Phospholid analysis is useful to demonstrate the presence of biomass on the media but it was not a good indicator for biodegradation performance. Phospholipids did not vary substantially throughout the seasons and were therefore not indicative of the seasonal trends observed in the performance of the biofilters.

Removal Of Microbial Material By Biofiltration:

The investigated pretreatment (roughing filtration followed by biofiltration) was able to significantly reduce microbial product contents as the ATP, HPC, and TDCC content were all significantly lower in the biofilter effluents than in the raw water. It is anticipated that this should be 251 beneficial with respect to a reduction in biofouling of subsequent membrane filtration but further investigations are necessary to confirm this hypothesis.

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