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# Modelling the performance of biological rapid sand filters used to remove ammonium, iron, and manganese from drinking water

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**Abstract:**

Although biological rapid sand filters are a well established technology for treating drinking water, there is still a lack of scientific understanding of the processes controlling their performance. For example, the distribution and role of microorganisms in contaminant removal in the filter has not been described. As a result, the design and operation of these filters is based on rules of thumb rather than firm scientific understanding. The goal of this research is to characterize the underlying processes that control the biological performance of biological rapid sand filters in order to link filter management to performance .

Biological rapid sand filters are used for the dual purpose of particle removal (including microorganisms) and contaminant removal through biological activity on the filter media. For drinking water treatment in the United States, biological filters use granular activated carbon and are often used following ozonation to remove additional biodegradable organics created during ozonation. In Europe, biological filters are also used to remove ammonium and reduced forms of iron and manganese. These compounds can cause biological instability in the distribution system and can lead to many problems including the growth of pathogens and aesthetic problems (taste, odor, and color). All of these compounds can be removed through chemical oxidation with oxidants such as chlorine, but biological filters can be used to remove these compounds and thereby reduce the need for chlorine addition following treatment. Under the normal conditions found in many water treatment plants, reduced iron can be oxidized through aeration and the precipitates can be captured by the filter media. Ammonium and manganese can be removed biologically.

This research uses both pilot and full scale studies to determine how operating conditions affect the performance of the filters. Substrate concentrations, particle/precipitate accumulation, and biomass kinetics are monitored throughout the depth of the filter and over the operational cycle of the filter. Tracer tests, using a conservative salt tracer, are performed during an operational cycle of a filter to examine how the filter flow changes with time. The data is used to validate a mathematical model that can both predict process performance and to gain an understanding of how dynamic conditions can influence filter performance. The mathematical model developed is intended to assist in the design of new filters, set up of pilot plant studies, and as a tool to troubleshoot existing problems in full scale filters. Unlike previous models, the model developed accounts for the effects of particle/precipitate accumulation and its effects on the biological performance of the filter.