Using Oxidants to Enhance Filter Performance
[Project #2725]

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OBJECTIVES:
The goals of this project were to
1. determine the mechanisms of oxidant-enhanced particle removal (OEPR),
2. determine the conditions under which it will occur, and
3. develop design and operating criteria (concentration and time) for oxidant-enhanced particle removal to take place.

BACKGROUND:
It is well known that the removal of particles in conventional treatment plants and granular media filters is a function of the optimum coagulant dose. What is not nearly as well recognized or understood is the impact of pre- or intermediate oxidation on particle removal.

HIGHLIGHTS:
1. Oxidation with chlorine, ozone, or chlorine dioxide can significantly reduce filtered water particle counts by as much as an order of magnitude compared to the no oxidant case, even when filtered water turbidities are less than 0.1 ntu.
2. This oxidant-enhanced particle removal phenomenon was observed at low to moderate oxidant dosages (i.e., in the range of 0.5 to 1.0 mg/L) and typical detention times (e.g., chlorine application to clarified water as it enters the filter).
3. There seems to be a biological or photosynthetic component to the observed oxidation effects. The observed oxidant effects were more pronounced in summer than winter.

APPROACH:
The experimental plan was divided into three phases. The first two phases consisted of experiments designed to provide insight into the mechanisms of OEPR. These phases relied on the use of synthetic waters with model particles and model organic matter, and on well-characterized natural waters. Phase I experiments consisted of performing surface characterization studies with the goal of providing a mechanistic understanding of the effect of oxidation on the conformation of the adsorbed layer of NOM. Phase II research consisted of conducting laboratory-scale filtration experiments using synthetic and natural waters to determine the conditions under which oxidant-enhanced particle removal occurs. On-site pilot plant experiments (Phase III) were conducted at four treatment plants selected to cover a wide range of raw water quality and plant designs.

RESULTS/FINDINGS:
The major finding of this research relates to the benefits in filtered water quality that result when an oxidant is applied in pretreatment or prior to filtration. The benefits include a decrease in filtered water particle counts by as much as an order of magnitude compared to the case where no preoxidants are added. There was a corresponding decrease in filtered water turbidity levels, but it was much less pronounced. Results from controlled laboratory studies demonstrated that oxidants affect the conformation of natural organic matter on particle surfaces. These results partially explain the observed filtration effects. However, it is apparent that there is also a biological or photosynthetic component to the beneficial effects. Although the exact mechanisms are still unknown, it is clear that filtered water particle counts are much higher when pre-filter oxidation is not practiced, even when filtered water turbidity levels are low. From a public health perspective, the importance of adding an oxidant in the treatment process prior to filtration should not be underestimated. This is particularly
relevant to utilities considering decreased pre-oxidant usage as a strategy to minimize disinfection byproducts.

**IMPACT:**
The results of this research demonstrate the beneficial effects of pre-filter oxidant addition on particle removal. Before eliminating pre- or intermediate oxidant addition in an attempt to reduce disinfection by-products, plants should consider the effect on particle removal. As shown in this research, the application of an oxidant in the treatment process prior to filtration can have a profound effect in minimizing filtered water particle counts. It is possible that the widespread use of pre-filter chlorination is the reason more waterborne outbreaks of cryptosporidiosis or giardiasis have not occurred.

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