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Abstract Title: Comparing Pre-Ozonation and Intermediate-Ozonation Treatment Trains for Manganese Removal

Abstract: The Stanislaus Regional Water Authority (SRWA) is planning to construct a new surface water treatment plant (WTP) on the Tuolumne River to provide a new, supplemental drinking water supply to the Cities of Ceres and Turlock, California. Initial phases of the project included source water characterization and bench-scale tests to evaluate enhanced coagulation, ozone demand, and removal of reduced manganese (Mn2+). To provide treatment for potential pesticides and tastes and odors (T&O), along with additional disinfection and lower disinfection by-product formation, ozone will be included in this WTP's treatment train. Because manganese removal can be challenging with ozone in the process train, these bench tests allowed SRWA to evaluate the optimum location for ozone.

Although dissolved manganese concentrations in this source water are typically low, experience in water treatment and with sub-surface intakes (this WTP will utilize an infiltration gallery) indicates that manganese can show up as a treatment issue because of other potential sources such as (a) a component of a ferric chloride coagulant, (b) reduction of particulate manganese through the sub-surface intake or unanticipated contribution of groundwater and (c) reduced manganese in sludge decant streams.

While ozone offers many benefits to surface water treatment, it can oxidize Mn2+ to colloidal MnO2 and even sub-colloidal MnO2 which can pass through treatment, including filtration. Deciding where to put ozone in the treatment train is water specific and should be considered during process train selection.

Bench-scale tests were conducted to evaluate and compare the effectiveness of pre-ozonation with intermediate ozonation for manganese removal (with coagulation/sedimentation)—both with and without permanganate addition for Mn2+ oxidation to MnO2. For these tests, raw water was spiked with Mn2+ to simulate worst case treatment conditions. Throughout all the testing, the total manganese was measured and partitioned into particulate manganese (above 0.45 µm), colloidal manganese (between 30K Dalton and 0.45 µm) and sub-colloidal manganese (passes through a 30K Dalton UF). Testing showed that only modest ozonation is required to form sub-colloidal manganese and, once it is formed, this sub-colloidal manganese is very difficult to remove in subsequent treatment. Pre-ozonation followed by clarification was not able to remove the sub-colloidal fraction—resulting in high manganese concentrations that could pass through filtration. Clarification followed by intermediate ozonation resulted in a substantially lower sub-colloidal fraction, along with a higher particulate fraction and moderate colloidal fraction, but still insufficient removal to produce a finished water meeting the Project's manganese treatment goal of 0.015 mg/L. Successful treatment was achieved when permanganate was added for Mn2+ pre-oxidation, followed by coagulation/sedimentation, intermediate ozonation and then filtration.