

Mitigation of Anoxic Hypolimnetic Water in a Drinking Water Reservoir by Bottom Water Withdrawal and Treatment – Bench-Scale Ozone Test and Full-Scale Water Treatment

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Abstract

Due to thermal stratification followed by the development of anoxic hypolimnion, accumulation of reduced constituents, including sulfide, manganese, ammonia, as well as phosphate, was noticed in the Walnut Canyon Reservoir (WCR), a drinking water reservoir in the city of Anaheim, in the summer of 2010. In order to minimize the risks associated with these constituents, withdrawal of the anoxic water and its treatment using an existing ozonation facility in the Lenain water treatment plant (LWTP) was considered as an effective mitigation option. First, a bench-scale ozone test was conducted to determine the ozone demand and the mass ratio between ozone and sulfide to achieve treatment targets based on the odor threshold of sulfide (0.05 mg/L) and the secondary maximum contaminant level for manganese (0.05 mg/L). An ozone to sulfide mass ratio of 2:1 was found to be sufficient to reduce the sulfide concentrations to below 0.05 mg/L, which is lower than published values (3:1 to 4:1). In order to remove manganese, more ozone was required (ozone:sulfide \approx 2.6:1), although over-oxidation of manganese occurred when a higher ozone-to-sulfide mass ratio, such as 3:1, was used. Based on these results, the anoxic bottom water was withdrawn from the lowest intake (30 m below the water level) in the WCR, blended with bypass water (5% bottom + 95% bypass) and treated by a treatment train consisting of pre-chlorination, coagulation, flocculation, clarification, intermediate ozonation, filtration, and post-chlorination in the LWTP. Majority of sulfide was removed or volatilized during coagulation, flocculation, and clarification. Sulfide was not detected (<0.005 mg/L) after ozonation. The applied ozone dose was 0.75 mg/L. Manganese was removed by about 40% by clarification, and an additional manganese removal (up to 20%) was achieved by ozonation. In finished water, manganese concentration was around 0.03 and 0.04 mg/L. Bromate was not detected (<0.005 mg/L) in ozonated water or finished water.

Key words: Ozone, Hydrogen Sulfide, Manganese, Bromate, Drinking Water Treatment, Reservoir Water Quality