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Catalytically Oxidizing Manganese Improves Results

At its recently built water treatment plant, a Minnesota water utility compared catalytically oxidizing manganese with chlorine against using sodium permanganate. The chlorine came out the winner.

BY NAEEM QURESHI, EMILY STRAND, MIKE SHELTON, AND CALEB PETERSON

APPROXIMATELY 150 miles north of Minneapolis/Saint Paul is the city of Cloquet, Minn. In 2018, the city constructed a water treatment plant to remove iron and manganese; the plant went on line in 2019. Table 1 shows the water quality data of raw and treated water. The water treatment plant is served by Well 8, which has a capacity of 700 gpm.

In 2022, an operational review was conducted to optimize the treatment process. It was decided to catalytically oxidize the manganese instead of using sodium permanganate and having a manganese oxide coating on the media, consisting of 12 inches of anthracite and 18 inches of greensand.

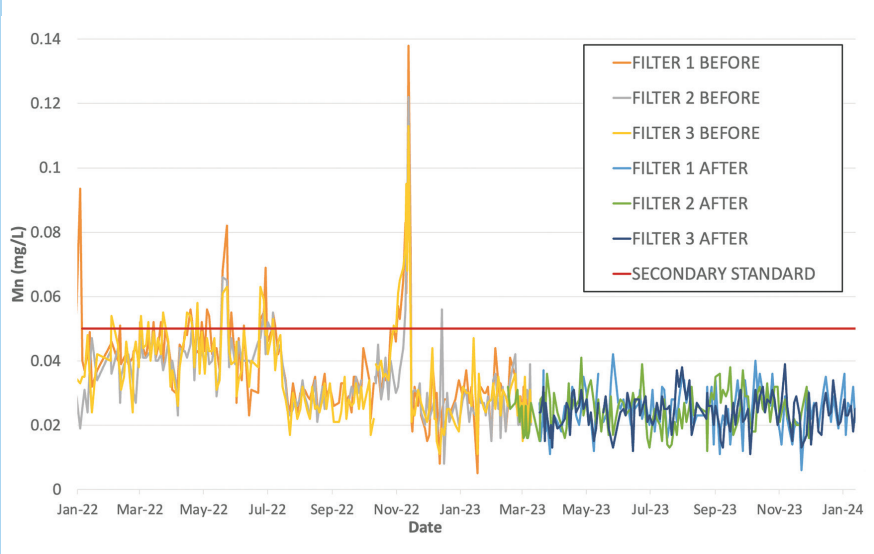
In March 2023, each filter was dosed with 50 mg/L of potassium permanganate solution to create a manganese oxide coating on the media. On the basis of the filter size (14 × 11 feet) and water depth (10.05 feet), it required 5.83 pounds of potassium permanganate, assuming 98% purity and 10% spillage. The dosage for each filter was rounded up to 6 pounds, for a total of 18 pounds for three filters. The cost of 18 pounds of potassium permanganate, used to charge all the filters, was approximately $300. Each filter was air-washed after adding the 6 pounds of potassium permanganate. After the air wash, the tap at the bottom of each filter was sampled to ensure the entire bed was soaked with the solution. The filters were soaked with the potassium permanganate solution for 48 hours. The filters were backwashed until no pink water was visible, and the filters were then placed in service. The chlorine dosage was increased.

Figure 1 shows the result of manganese levels before and after charging the filters with potassium permanganate. The media was charged in March 2023. The graph shows how the manganese levels are much more consistent and stable after charging the filters. At no point did the manganese level exceed the secondary standard of 0.05mg/L.

Sodium permanganate ($NaMnO_4$) contains 38.7% manganese. Using sodium permanganate to oxidize manganese results in additional manganese loading on the filters, which are tasked with removing manganese in the well water,

Figure 1. Effluent Manganese Levels Before and After Media Charging

The manganese levels are much more consistent and stable after charging the filters.



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Catalytically oxidizing manganese with chlorine doesn't cause additional manganese on the filters aside from what is in the well water; this results in improved filter performance.

City of Cloquet, Minn.

along with additional manganese from the sodium permanganate, resulting in shorter filter runs.

Catalytically oxidizing manganese with chlorine doesn't cause additional manganese on the filters aside from what is in the well water; this results in improved filter performance.

Table 2 shows the chemical cost per million gallons. The cost is slightly less before charging the media with potassium permanganate. The manganese levels in the filter effluent before charging the media varied, exceeding the secondary standard for manganese of 0.05 mg/L on several occasions. The results after charging the media were much more consistent with manganese levels—always below the secondary standards for manganese.

AN ALTERNATIVE WORTH CONSIDERING

Catalytically oxidizing manganese with chlorine produced more consistent and better effluent water quality. Although the cost per million gallons is slightly higher, it's balanced by the fact that staff have one less chemical to handle.

Table 1. Water Quality Data for Raw and Treated Water

In 2022, an operational review was conducted to optimize the treatment process.

Parameter	Units	Well 8 Raw	Water Treatment Plant Effluent
Alkalinity	mg/L	198	186
Arsenic	ug/L	ND	ND
Nitrogen, ammonia	mg/L	0.35	ND
Hardness, calcium	mg/L	99.9	100
Chloride	mg/L	232	222
Total hardness	mg/L	368	371
Total hardness	grains	21.4	21.6
Iron, total	ug/L	ND	ND
Manganese, total	ug/L	585	9.1
Total organic carbon	mg/L	3	2.9
Sodium, Total	mg/L	75.1	74.3
Specific conductance	umhos/cm	1140	1100
Sulfate	mg/L	22.4	21.1
Total dissolved solids	mg/L	748	793
pH	SU	7.8	7.8

Test completed by Pace Analytical, Duluth, Minn.; date of sampling: Sept. 29, 2021. ND—no data

Table 2. Chemical Cost per Million Gallons

The cost is slightly less before charging the media with potassium permanganate.

Period	Production (1,000 gallons)	Chlorine (pounds)*	Cost ($)	Sodium Permanganate (pounds)**	Cost ($)	Total Cost/mil gal ($)
Jan–Feb 2023	20,123	613.4	1,190.00	77.8	170.38	67.57
April–Aug 2023	62,686	2,264.8	4,348.42	0	–	69.37

*Chlorine cost: $1.92/pound based on vendor invoice.

**Sodium permanganate cost: $2.19/pound based on vendor invoice.

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