APPLICATION NOTE

Hach LDO®
For Manganese Monitoring and Control in Drinking Water Treatment Operations

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Introduction

Many drinking water facilities in the US and all over the world suffer from annual changes in manganese concentration in their source water due to inversion—a process that occurs when water in reservoirs stratifies and then turns over. This phenomenon is usually explained by seasonal change of water temperature in reservoirs such as lakes and ponds, poor mixing, and other factors. Temperature of the surface water decreases and becomes lower than water temperature at the bottom layers of the reservoir, which causes the inversion. The problem is most pronounced in shallow reservoirs, both natural (lakes, ponds, etc.) and open basins specially built for water storage in the ground.

When a reservoir becomes thermally stratified, the bottom layer will be low in dissolved oxygen. This leads to the development of anaerobic conditions in the deeper layers of the lake and bottom sediment. Manganese in those layers is converted through bacterial action from insoluble oxide forms to manganese ions (Mn^{2+}), which are soluble and can easily leach out of the sediment into the water. The inversion is, therefore, accompanied by a rising concentration of dissolved metals, such as iron and manganese in drinking water plant intake. The effects of elevated manganese levels have been discussed in drinking water treatment-related and regulatory literature and may be summarized as causing aesthetic problems in the distribution system, such as staining, as well as bad taste and odor. However, manganese will also foul equipment within the water treatment process and may affect filter performance, thus presenting unwanted challenges for the plant personnel.

All these issues dictate a necessity to constantly monitor concentration of manganese, as well as other indicators in the source water, to be able to initiate additional treatment measures at the right moment, preventing the unwelcome consequences of high levels of this metal in the water. Drinking water treatment plants have been implementing various monitoring and treatment techniques, and we believe that continuous monitoring of dissolved oxygen (DO) concentration in source water prior to intake is of special value for optimization of the treatment processes. It has been shown that dissolved oxygen is a good indicator of manganese concentration and may help to predict the beginning of this seasonal issue with high accuracy.

Data Review and Interpretation

HISTORICAL LABORATORY DATA

Hach Company and Soldier Canyon DWTP (Fort Collins, CO) have collaborated for many years in testing analytical instrumentation. This facility has always striven to optimize water treatment by implementing

new methods of monitoring and control. The plant has suffered from seasonal surges in manganese concentration for years and long ago developed monitoring protocols that employ laboratory analyses (Fig. 1). However, plant management decided to use online sensors to continuously monitor the concentration of dissolved oxygen in their reservoir water intake. The water is usually coming from nearby Horsetooth Reservoir (HT, Fig. 3), their main water source, which has suffered from droughts and forest fires in the past several years. To mitigate the risks, the facility uses an alternative source of surface water, the Cache La Poudre River. Even though the river water is usually not subject to manganese fluctuations, it was a natural choice for the plant to install two Hach LDO® sensors, one sensor per sample stream (Fig. 2), to establish equal monitoring capabilities (DO, temperature, pH, turbidity) for each source water stream. Figure 1 below shows the results of annual inversion in Horsetooth Reservoir captured via daily lab analyses of DO, manganese concentration, and water temperature.

Figure 1: Historical data for several years of observation of Horsetooth Reservoir source water at Soldier Canyon DW plant

The graph clearly shows the cyclical nature of the phenomenon, however it is difficult to pinpoint the beginning of problems associated with high manganese concentration and administer countermeasures in a timely manner.

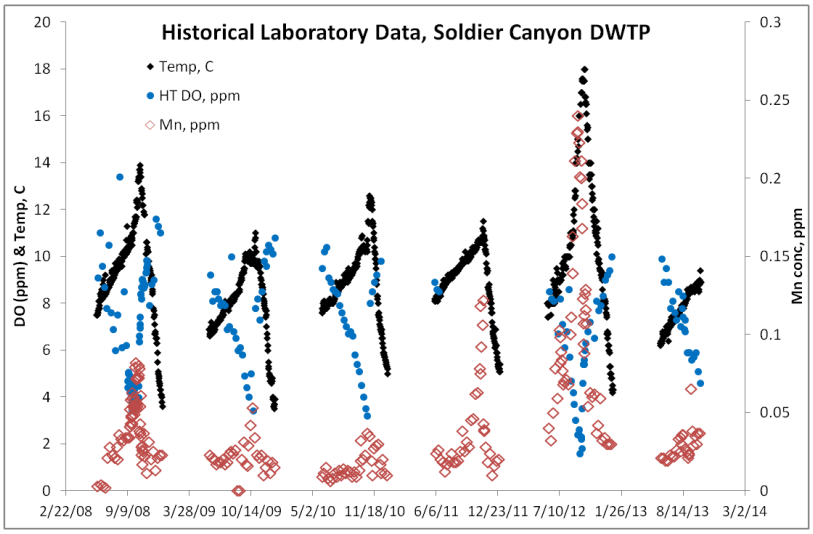
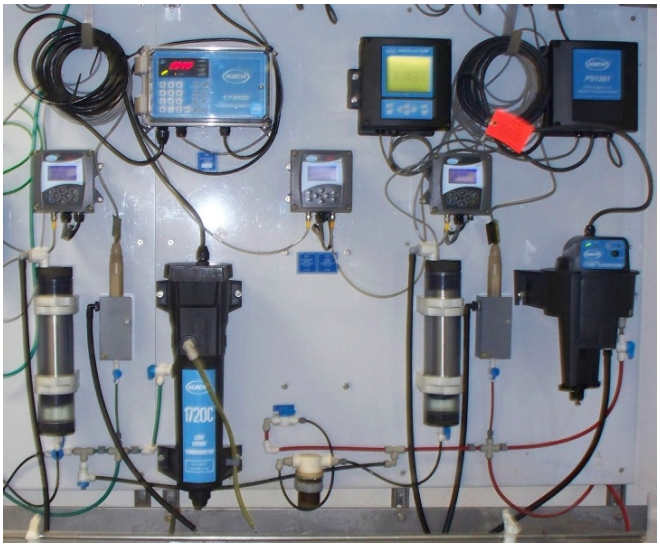


Figure 2: Raw water monitoring instrumentation at Soldier Canyon plant. Left: general view, right; LDO sensor in a flow cell, pH probe, and turbidimeter monitoring one sample stream)

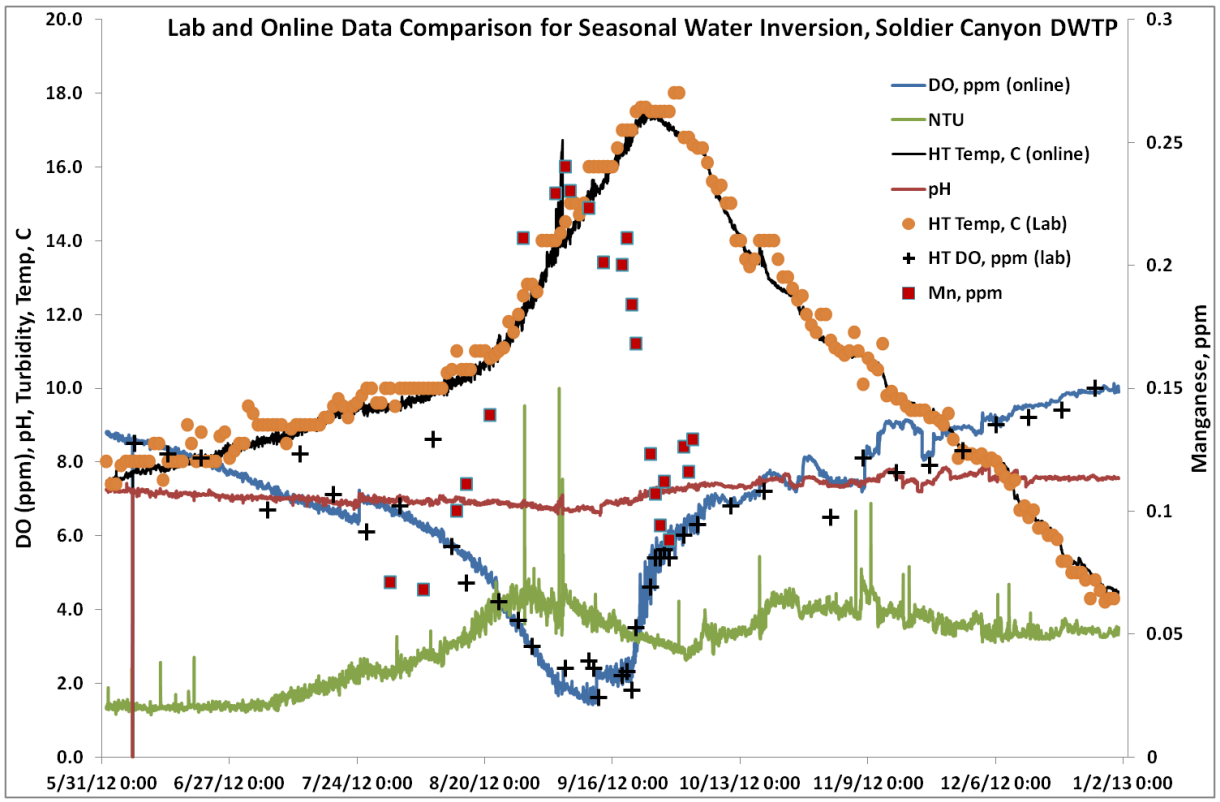


ON-LINE DATA

The data generated by on-line DO sensors every second contain both dissolved oxygen concentration and temperature readings and can be uploaded to the plant's SCADA system via analog or digital outputs. In case of an external communication error, the data are logged with the sc controller and can be downloaded to a computer within a reasonable time if needed, depending on the logging frequency.

Several years' worth of DO, temperature, pH, and turbidity data from the SCADA system were examined, and the monitoring results for the second half of 2012 were chosen as the most representative (Fig. 3). The data registered by on-line instrumentation were compared with lab results for manganese, DO, and temperature. This comparison allowed validation of the on-line results and made clear the correlation between the main analyte concentration and the indicators, DO and temperature. As seen from the graph in Figure 3, the moment that the temperature and DO concentration trends cross indicates the beginning of the inversion and may serve as a trigger point to adjust water treatment processes to address rising manganese levels in the source water.

Figure 3: Detailed results of both lab (temperature) and on-line measurements (10-min intervals) for one water inversion cycle in Horsetooth Reservoir (HT)



As the graph shows, the maximum manganese concentration clearly corresponds with the minimum DO level, which can be used as another marker to predict source water quality and optimize treatment. The DO charts in Fig. 3 also show the superiority of on-line data over daily lab analysis results. The analysis of pH and turbidity trends over several years of monitoring, and as seen in the chart above did not reveal these parameters as distinctive indicators of the inversion.

Conclusions and Suggestions

From the conducted analysis, it is quite clear that online monitoring of DO concentration and temperature of source water can signal the beginning and end of reservoir inversion. A timely response to rising manganese concentration with adequate pre-oxidation measures may save facilities and water districts money on water treatment and prevent unwanted consequences in the distribution system. The distinct indication of the end of inversion may also help facilities to further optimize their processes in terms of chemical cost and overall water quality.

Hach LDO sensor installation for source water monitoring in the drinking water industry is justified from theoretical, empirical, and economic standpoints.

Acknowledgement

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References

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2. Paul M. Kohl, Steve J. Medlar “Occurrence of Manganese in Drinking Water and Manganese Control”, 2007, Water Research Foundation, 184 p, ISBN: 9781583215043

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