https://doi.org/10.1002/opfl.1560

Shaz Chan is a water quality engineer with San Jose Water (www.sjwater.com), San Jose, Calif.

Experimentation Leads to Lower THM Removal Costs

When rehabilitating one of its water storage tanks, San Jose Water (Calif.) modified its typical boosting system with a powered ventilator and larger mixers to achieve promising trihalomethane removal. **BY SHAZ CHAN**

LIKE MANY other water utilities, San Jose Water (Calif.) experiences periodically high trihalomethane (THM) concentrations. Particularly during drought events, SJW has observed high THM concentrations in tanks with poor turnover or at the periphery of its distribution system.

In the past, SJW has mitigated high THMs by making treatment and source water changes at its water treatment plants; rebalancing its water portfolio by blending groundwater with treated water; or, in one location, installing an in-tank spray aeration system composed of an aerator, mixer, and powered ventilation. Although aeration is a proven means of THM removal, it has relatively high capital and operating costs. The aerator is the most expensive component of an aeration system, both in terms of capital and operating costs. That prompted SJW, in partnership with PSI Water Technologies (www.4psi.net), to investigate whether SJW could reduce THM concentrations without the most expensive piece of equipment. By using only a mixer and a powered ventilator, could a modified mixing system remove an adequate percentage of THMs?

INVESTIGATING THM REMOVAL

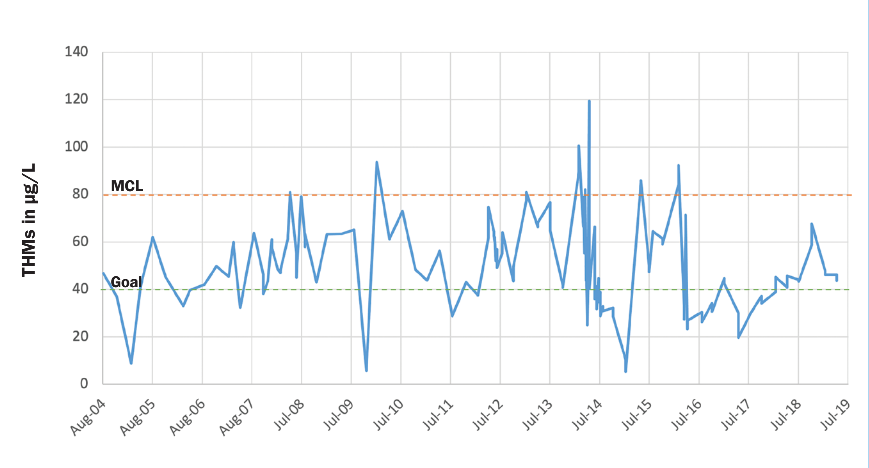
SJW and PSI had already collaborated together in the past to develop the ChemLocker dosing system, which includes a chlorine analyzer, a Venturi chemical injection port, and a recirculation pump driving a mixer. Incidentally, this includes half of the newly proposed THM removal system. With tanks designed and built with ladders and passive mixing, SJW typically didn't add chlorine in the past for safety reasons. In addition, effective chlorine dosing inside a tank requires active mixing. To meet the need to dose tanks safely and effectively, the dosing system allows chlorine and ammonia addition at ground level, delivering the chemical directly into the mixing zone within the tank. A tank equipped with the dosing system eliminates the need to bring chemicals up a ladder or stairs to be poured through the tank roof hatch.

Since then, SJW has been retrofitting its existing tanks and designing its new tanks with this dosing system. As a follow-up to this project, PSI approached SJW with the idea of upgrading the dosing system to also remove THMs by upsizing the mixers on the dosing system and adding a powered ventilator. The timing couldn't have been more fortuitous, as SJW was in the process of rehabilitating its Mercedes tank, providing an excellent opportunity to test the concept.

The Mercedes tank is a 100-foot diameter, 2-mil-gal chloraminated tank, with

Figure 1. THM Results in Mercedes Zone

Occasionally the tank's THM concentrations have measured above 100 µg/L.



Water storage tank aeration has become a common process to help utilities mitigate trihalomethane (THM) formation in distribution networks. San Jose Water recently upgraded its dosing system to remove THMs by upsizing the system's mixers and adding a powered ventilator.

PHOTOGRAPH: © 2021 SAN JOSE WATER

turnover of about four times per day (approximately 0.7 mgd). The tank is located at an endpoint of SJW's distribution system, and occasionally the tank's THM concentrations have measured above 100 µg/L, as shown in Figure 1. Although SJW has maintained compliance with the Stage 2 Disinfectants and Disinfection Byproducts Rule, these high concentrations have been a cause of concern. Moreover, the tank already had a THM analyzer installed on the common inlet/outlet, making accurate data collection an easy proposition.

With a tank the size of Mercedes, a regular version of the dosing system would have been designed with a 30-gpm mixer running at 2 hp and would have used passive venting. To upsize the system for THM removal, SJW installed a variable mixer of 3–15 hp that could run up to 200 gpm and added a powered vent capable of 3,000-ft^3/min air exchange, running at up to 1.5 hp. Despite the extra cost of the upgraded hybrid mixing/THM removal system, SJW saved around $75,000 in capital expenses over what it would have spent on a conventional aeration system.

Because all of the data for the THM analyzer were taken from the tank's single inlet/outlet, the data needed to be filtered by tank level readings from SJW's supervisory control and data acquisition (SCADA) system to determine if a given measurement was from a sample taken during a fill cycle versus a drain cycle. With the removal system operating, SJW's analysis showed that higher THM levels corresponded to the cycle's fill portion and the lower levels corresponded to the cycle's drain portion. The data were consistent with what would be expected from a tank with an active THM removal system.

Comparing the maximum and minimum THM levels before and after starting the mixing system confirmed that SJW's mixing was actually having an effect. Before mixing, some fluctuation in THM levels can be observed, but a clear increase in daily variation occurs after the implementation of mixing.

For evaluation purposes, the project team defined daily percent THM removal (*X*) as the difference between the daily maximum (THM_{max}) and minimum (THM_{min}), divided by the daily maximum THM level:

THM removal (*X*) under steady-state conditions:

$$X = \frac{THM_{max} - THM_{min}}{THM_{max}}$$

This formula neglects THM formation in the tank, which usually isn't significant for chloraminated water, making SJW's removal estimates conservative. To evaluate the system's THM removal capacity across its operating range, two variables were assessed: mixing energy and venting energy. The experiment started with the vent set at 100% power while stepping down the mixer power. This experiment was followed by setting the mixer back to 100% power while stepping down the ventilation power.

For the constant ventilation setting, an increase in removal was observed that was proportional to the mixer speed. SJW observed a range of approximately 11% removal when mixing at 50% speed up to nearly 22% when mixing at 100% speed. For a constant mixing setting, a decrease in removal was observed at lower ventilation speeds, with no significant difference between 50% and 75%.

THM REMOVAL VERSUS ENERGY COSTS

In terms of operating costs, SJW broke down the mixer speed into THM percent removal per horsepower. As expected, better efficiency was measured at lower energy usage. The system provided as much as 12% removal/hp when running at 50% power, whereas only around 3% removal/hp was observed at 100% power. Interestingly, there wasn't much of a difference in efficiency when changing the ventilation power. This observation is likely because, with only a 1.5-hp ventilation system, the changes in horsepower were relatively small. The observed removal efficiency is affected by the THM composition, water temperature, tank size, and surface area–to-volume ratio. Therefore, these specific efficiency percentages may have limited applicability to other tanks (Figure 2).

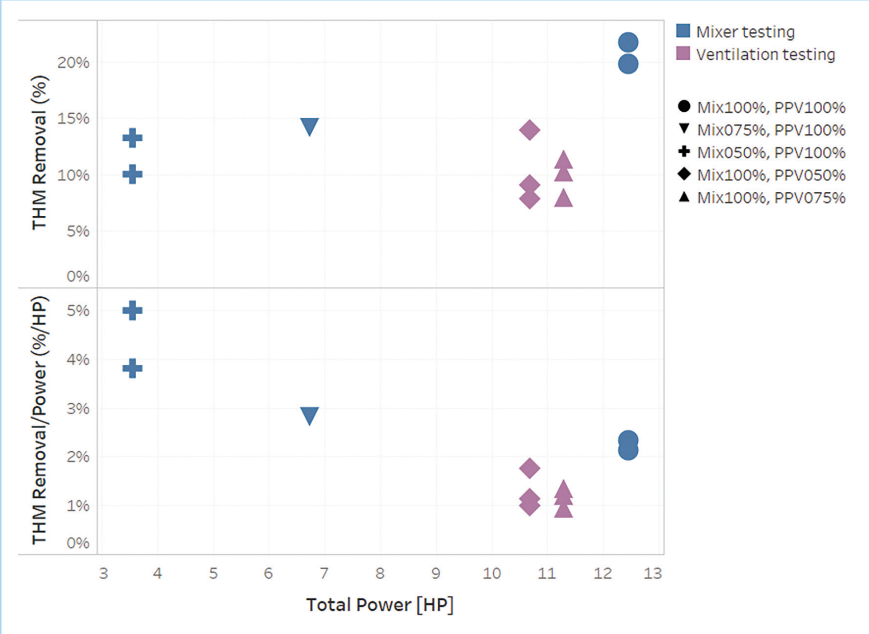
NEXT STEPS

Understanding this cost-to-removal ratio is key in minimizing energy usage. In the past, SJW has programmed an intelligent feedback system to optimize energy usage to maintain a set THM target. This way, when a lower removal percentage is sufficient to keep the THM levels at the specified target, energy usage can be minimized. SJW was able to realize a 55%–65% reduction in energy costs when used elsewhere and would expect to see a similar savings when implemented at Mercedes.

Further understanding the energy usage and mass transfer coefficient will allow SJW to evaluate the economic feasibility of installing these hybrid mixing/removal systems at other locations. Similarly, using the removal efficiency data will help PSI design more efficient THM removal systems.

Figure 2. Observed THM Removal Efficiency

Many factors affect THM removal efficiency, so SJW's results may have limited applicability to other tanks.



SJW installed a variable mixer of 3–15 hp to upsize the system for THM removal.

PHOTOGRAPH: © 2021 SAN JOSE WATER