Demonstrating Impact: Efficacy of the MetalGuard PRS Corrosion and Metal Release Risk Alert System to Continuously Assess and Anticipate Fe/Pb/Cu Corrosion and Release into Water

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ABSTRACT: The report examines the implementation of the PRS Monitoring Station® across multiple U.S. water systems to investigate and monitor metal corrosion and release; and explores the development of the MetalGuard PRS real-time metal corrosion and release risk alert system. By integrating real-time water quality monitoring and pairing the PRS Monitoring Station with the online MetalGuard™ trace metals analyzer, the MetalGuard PRS provides a unique solution to drinking water utilities and commercial/industrial heating and cooling systems to continuously assess and anticipate iron, lead, and copper (Fe/Pb/Cu) corrosion and release into the water.

INTRODUCTION

Since 2006, PRS Monitoring Stations have been installed at more than 25 drinking water systems across the US and Canada to support corrosion and metals release control programs. All of the PRS projects have begun with the goal of answering the following questions:

- What significant factors affect the release of lead and copper in this water system?
- What role is phosphate dosing playing in preventing lead and copper release?

To answer these questions, not only is lead and copper release tracked in the stagnating water of the lead and copper test chambers of the PRS Monitoring Station, but also twenty or more water quality parameters are measured in the system water that refills the test chambers every seven to twenty-four hours. In this way, correlations are made between system water characteristics and lead and copper release in the test chambers. Additional data are important to interpret the monitoring station observations. They include:

- Analysis of pipe wall scale
- Comparison to Lead and Copper Rule compliance data
- Residential lead and copper investigations such as profile sampling
- Other distribution system regulatory data
- Timeline of events in the water system, including major changes to the system, customer complaints, current operational decisions

DEVELOPMENT OF A COMPREHENSIVE PERSPECTIVE ON DRINKING WATER QUALITY-THE IMPACT OF PRS MONITORING STATION

The results of these projects contributed to the development of the "comprehensive perspective of drinking water quality" described in the 2017 Water Research Foundation Report 4586. That is, the PRS Monitoring Station data pointed to similarities of significant factors occurring in distribution systems:

- The lead and copper carbonate solubility model, referred to in the Federal Lead and Copper Rule, is at work to varying degrees in water systems but is often lowered in significance of effect by interfering chemical scales and biofilms. There are also other lead and copper compounds that can form that are more soluble than the carbonate compounds, such as those with chloride and sulfate.
- Many water systems have significant iron, manganese, or aluminum scales on pipe walls that can enter service lines and building plumbing. The scales can obscure lead service line walls so that phosphate corrosion control chemicals cannot create a protective film of lead phosphate. Scales that form on lead pipe walls can trap lead compounds, including lead carbonate compounds, like insects in a spiderweb, so that when the scale is disturbed, particulate lead or copper becomes entrained in the water. Alternatively, the scales entrained in water, can flow past lead or copper compounds on a pipe wall, adsorb them, and carry them to faucets as particulate lead or copper.
- Microorganisms and biofilms on pipe walls play a role in every water system to a significant extent. Although biofilms are thin materials secreted by microorganisms, they protect millions of microorganisms throughout the water system on pipe walls, allowing microorganisms to live

their lives looking for food and consuming food. These metabolic life cycles all involve chemical secretions from microorganisms. It is the secretions that participate in the water chemistry and can cause the initial electrochemical corrosion of adjacent metal walls to occur. The biofilms, themselves, can trap lead and copper-laden corrosion by-products. When biofilms are disturbed, any trapped metals are released and entrained in the water as particulate forms of the metal.

These studies inevitably led to remedies for lead and copper control. Since much of the lead and copper release is dependent on chemical scales and biofilms, the concept of "water system hygiene", as described in Water Research Foundation Report 4586, was developed and applied to the project systems. It involves:

- cleaning of water mains, tanks, filters, and wells
- maintenance of a stable disinfection residual throughout a distribution system
- lowering of system water age
- and, control of microbiological nutrients (carbon, nitrogen, and phosphorus)

Depending on the system, water system hygiene actions may be the complete control strategy, or they may first control interfering chemical scales and biofilms on pipe walls, which then allow dosed corrosion control chemicals to form protective pipe wall films against corrosion of the piping material. In many of the studies, the offline dosing and comparison of corrosion control chemicals (e.g. orthophosphate, silicate, caustic soda for pH adjustment) was performed using the dosing ports and accessory dosing kits of the PRS Monitoring Station.

After implementing these control methods, PRS Monitoring Stations can be located in critical zones of a distribution system for continuous monitoring, serving as water quality sentinels to confirm their effectiveness.

THE IMPORTANCE OF CONTINUOUSLY MONITORING FOR CORROSION AND METAL RELEASE

After developing an understanding of a water system and actions are underway to lower lead and copper levels, the PRS Monitoring Station has become important to continue monitoring the water system, where the maximum lead and copper release potential can be estimated, and trends in release can be detected.

Projects with continued water quality sentinel monitoring of lead and copper release, have been able to document stable and safe operation and, where applicable, have been alerted to trends of lead and copper that are increasing or decreasing. Example alerts from the PRS Monitoring Station test chamber data have led to the discovery of elevated lead and copper:

- that can occur from incomplete water main flushing where remaining high turbidity represents chemical scale particulates that enter buildings, adsorb lead and copper from building plumbing walls, and result in elevated particulate lead and copper in the drinking water
- that can occur from closing a hydrant valve too quickly causing a hydraulic disturbance, in water mains and building plumbing, of chemical scales and biofilms on pipe walls with release of their stored lead and copper compounds
- from a broken disinfection dosing pump leading to inadequate disinfection in a zone where microbiological activity increases
- from quick changes in nutrient levels, such as when phosphate for corrosion control is first introduced into a distribution system
- from infrequent operational activities, such as the annual recycling of coagulant tank sludge lagoon supernatant to the head of the water treatment plant causing a suddenly high biological load on the system
- from leaving a well offline for several days and then suddenly pumping into the water system
- from neglect of water system component cleaning so that chemical scales and biofilms thicken and more easily slough particulate lead and copper
- from increasing water age, such as temporarily valving off sections of the piping network – an immediate response, or adding more water storage to a system – a longer-term response
- from changing various cleaning options at a membrane treatment plant
- from excessive biofilms in well casings

While these projects with the PRS Monitoring Stations have been greatly successful in anticipating and further lowering the potential for a recurrence of elevated lead and copper, the timing of obtaining measurements lags by weeks. Manual sampling with submission of the sample to a commercial laboratory for analysis is typically performed every other week in order to keep a monitoring budget manageable. Receiving the lead and copper data from the laboratory typically takes an additional three weeks.

ONLINE TRACE METALS ANALYZER INTEGRATED TO PROVIDE REAL-TIME ALERTS

The pairing of the PRS Monitoring Station with the online trace metals MetalGuard™ analyzer (manufactured by AMS) makes it possible to obtain at least one data point per day per metal with the measurement available within hours. The MetalGuard online analyzer provides accurate and reliable results on dissolved, particulate and total Fe/Pb/Cu. In 2024, the first pairing of the two technologies was performed at a wellhouse in the Madison, Wisconsin, water system (Figure 1).

As is typical, the installation of the PRS Monitoring Station was quick and straightforward. A PRS Monitoring Station is installed with a connection to a water line, a drain, and an electrical outlet. A disinfecting solution is pumped into the Station for a 24-hour disinfection period. After 24 hours, the metal plates internal to the test chambers are soaked briefly in acid so that metal compounds on the plate surfaces are reduced and all test pieces start in the same state. The plates are secured on internal connectors and placed into the test chambers. With the test chambers closed, there is a 15-minute soak of the Station with plates in the disinfecting solution. After that, the Station is set to forward flow, a specific flowrate is set, and a timer is set for specified flow and stagnation periods during the day.

Manual sampling can begin at any time, however, data characteristic of the distribution system maximum lead and copper release are obtained after chemical scales and biofilms have stabilized on the internal metal plates, typically in two to eight weeks. Statistical methods on the data are used to show when stabilization has occurred.

Figure 1- MetalGuard PRS Corrosion and Metals Release Risk Alert System Installation at Madison, WI.

For the 2024 project, the MetalGuard units – one for lead and one for copper – were installed during the PRS Monitoring Station's stabilization period. AMS ships the equipment to the site. An AMS technician arrives to set up the equipment within a day or two.

The connection between the equipment is quick and straightforward. A stopper with tubing is placed in a port at the top of the test chamber. The bottom of the tubing is placed near the bottom of the test chamber. A small peristaltic pump automatically operated by the MetalGuard pulls the test chamber sample to a flask connected to the MetalGuard system. Processes begin for sample preparation, quality control checks, and analysis of dissolved and total lead or copper. MetalGuard data and other information are connected to a cloud where the MetalGuard can be operated and data collected remotely.

The 2024 project demonstrated the ease with which the two technologies can be paired for daily feedback of lead and copper release.

The 2025 project is in progress. The equipment was set up in AMS's laboratories in Sunnyvale, California. The quality control protocols are being refined, and operational costs are being determined with the intention of the next step being an active monitoring program in a drinking water system.

CONCLUSION

Metal corrosion and release into water are significant issues that affect public health, as well as the integrity of service lines, building plumbing, water storage facilities, and commercial/industrial heating and cooling systems.

The MetalGuard PRS system is a novel solution that allows water utilities and commercial/industrial facilities to continuously assess and anticipate the risk of Fe/Pb/Cu corrosion and release into the water, enabling faster decision-making and proactive control.

Using two proven technologies, the PRS Monitoring Station and the MetalGuard analyzer, this integrated solution provides ongoing and daily alerts for corrosion and metals release of Fe/Pb/Cu needed to proactively manage health and infrastructure risk. Full-scale demonstration of the MetalGuard PRS system in 2024 and through 2025 has continued to validate the performance and unique operational benefits of real-time metal corrosion and release risk alerts.

AUTHORS

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Rick Bacon PhD, CEO of AMS since 2012, leverages extensive experience in energy, industrial, technology, and water sectors to drive AMS' mission to transform water treatment. With a focus on innovation, Dr. Bacon has led the commercialization of cutting-edge analytical and remediation solutions, ensuring safer drinking water and more efficient water treatment processes. His academic achievements include a degree in Land Economy from the University of Cambridge, United Kingdom, and a PhD from the University of California Santa Barbara.