United States Environmental Protection Agency

Aging Water Infrastructure Research Program SAB Consultation

Cross-Cutting, Integrative Research

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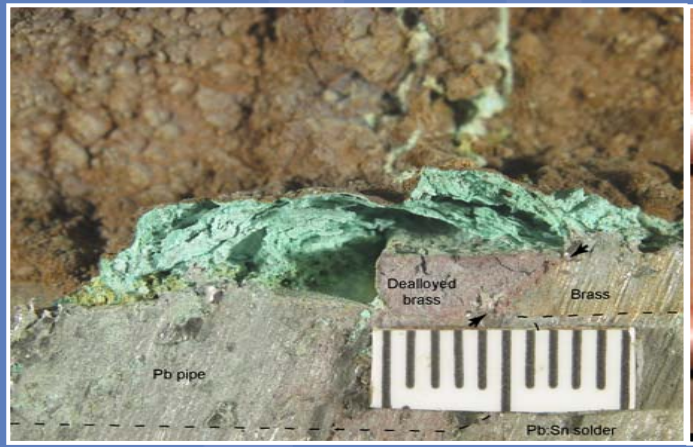

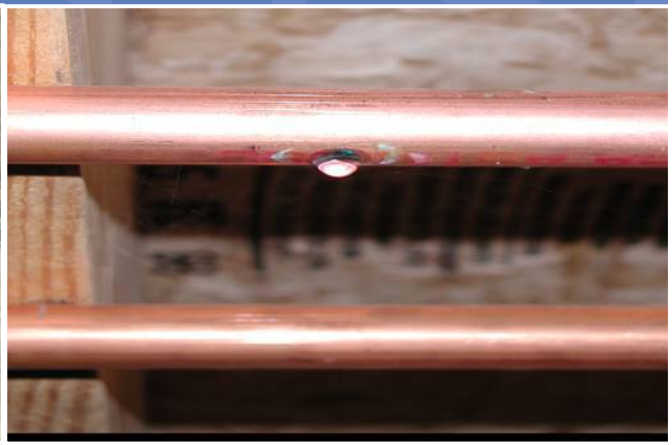

Office of Research and Development
National Risk Management Research Laboratory

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Cross-Cutting, Integrative Research

Corrosion, Dissolution, and Leaching of Distribution System Materials

- Degradation of material
- Material failure
- Leaching of hazardous components
- Flow restrictions
- Energy (e.g., pumping) costs
- Aesthetic issues
- Biofilm

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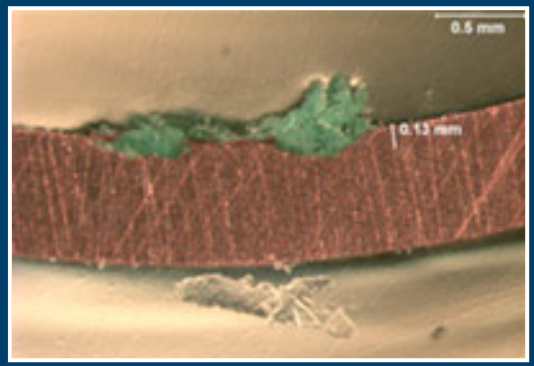
Impact of Water Chemistry on the Localized Corrosion of Copper Pitting

Strategies:

- Develop qualitative models for predicting pitting corrosion that lead to leaks of copper plumbing.
- Improve understanding of mechanism(s) responsible for pit initiation and propagation.
- Develop methods to prevent pitting corrosion and repair existing pits.



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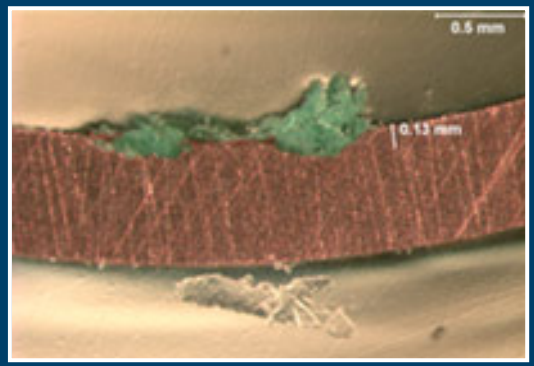
Impact of Water Chemistry on the Localized Corrosion of Copper Pitting

Expected Outcomes:

- Provide water utilities, engineers and others a guide to types of waters that support copper pitting corrosion.
- Establish approaches and protocols to investigate full-scale copper pitting case studies.
- Provide new details regarding the nature of copper pitting corrosion in water with emphasis the structural and morphological characteristics of active pits.
- Improve our understanding of pitting corrosion.
- Develop strategies to reduce copper pitting corrosion in water.

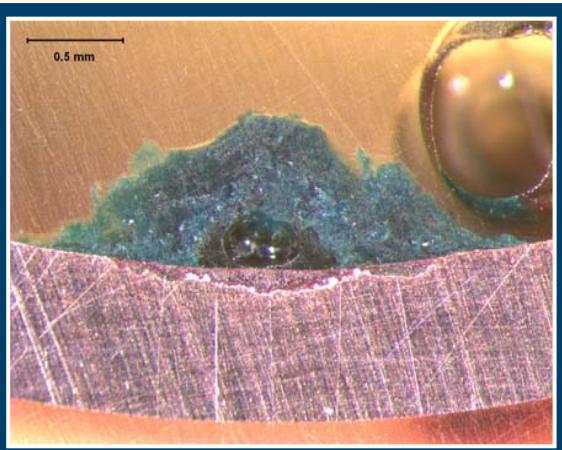


Experimental Approaches

Impact of Water Chemistry on the Localized Corrosion of Copper Pitting

Pilot-Scale:

- Pipe rigs
- Recirculation pipe systems



Experimental Approaches

Impact of Water Chemistry on the Localized Corrosion of Copper Pitting

- **Full-Scale:**
  - Distribution system evaluation
- **Solids analysis of failed pipe**

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In-house Iron, Copper and Lead Solubility/Corrosion Studies

Strategies:

- Develop quantitative predictive models for metal release from corrosion of infrastructure materials, particularly lead, copper and iron.
- Test, adjust and refine the selection of chemical species and thermodynamic data for well-documented existing chemical equilibrium models.

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In-house Iron, Copper and Lead Solubility/Corrosion Studies

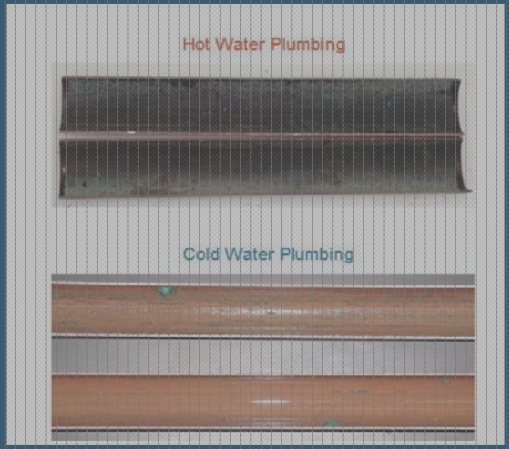
Expected Outcomes:

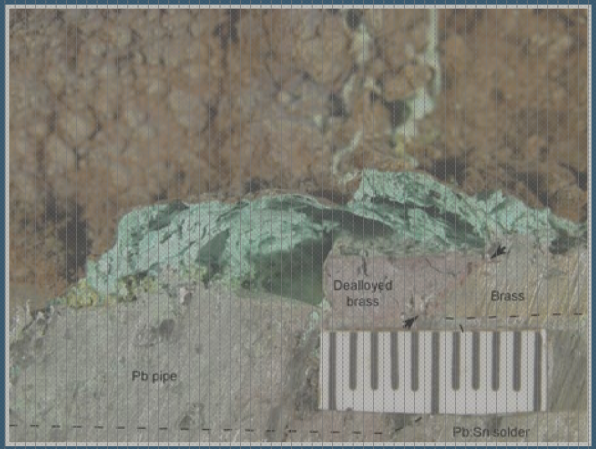
- Better future compliance with the Lead and Copper Rule.
- Fewer detrimental secondary impacts of corrosion control treatment.
- Fewer treatment mistakes that cause high metal release episodes.
- Extended service life and functionality of existing conveyance systems.
- Improved guidance on the selection of appropriate plumbing materials for a given water quality or treatment capability.
- Improved prioritization of critical infrastructure to inspect, monitor and assess the performance of rehabilitation.
- Reduced infrastructure failures caused by corrosion.

Experimental Approaches

In-house Iron, Copper and Lead Solubility/Corrosion Studies

- **Pilot-Scale:**
  - Pipe rigs
  - Recirculation pipe systems
- **Benchtop Precipitation Experiments**





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Analysis of Distribution System and Domestic Drinking Water Distribution System Materials to Understand Water Treatment/Metal Release/Corrosion Relationships

Strategies:

- Samples tested for this research include pipe samples, scales from storage tanks, failed plumbing devices and distribution system sediments.
- These samples are obtained through technical support efforts by water systems, consultants, state regulators, and EPA regional offices.
- Tests performed primarily by the on-site contractors using a variety of on-site techniques.
- Tests performed through an interagency agreement with the U.S. Geological SurveyAdvanced Photon Source (DOE) for XANES, XAFS.

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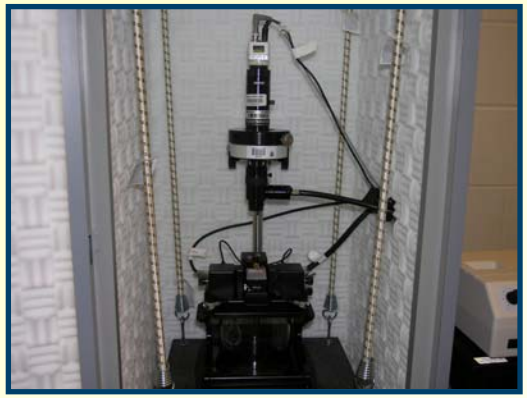
Analysis of Distribution System and Domestic Drinking Water Distribution System Materials to Understand Water Treatment/Metal Release/Corrosion Relationships

Expected Impacts:

- Understanding of operable corrosion, corrosion inhibition, metal accumulation and metal release mechanisms.
- Ability to predict the impact of various proposed changes in water sources, disinfection, or other treatments, on the stability of existing pipe scales and deposits.
- Guide regulatory revisions.
- Provide information for guidance manuals for simultaneous compliance with the Lead and Copper Rule, the Arsenic Rule, the Ground Water Rule, D/DBP regulations, and other water systems regulations.
- Puts EPA into a unique position to apply advanced analytical tools to solve or anticipate future drinking water infrastructure water quality and material performance problems, where little application expertise exists in either universities or the private sector.

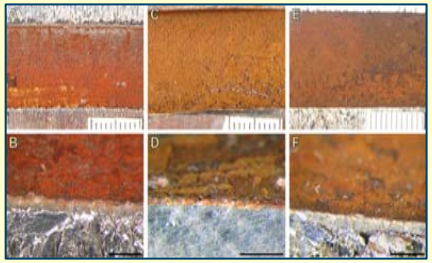
Solids and Materials Analysis

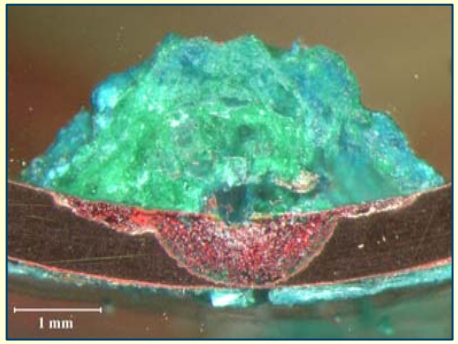
Equipment

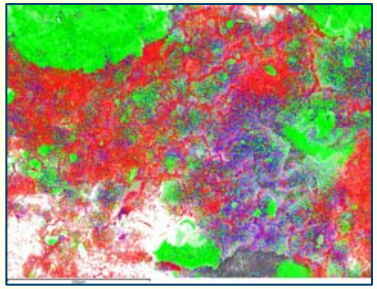


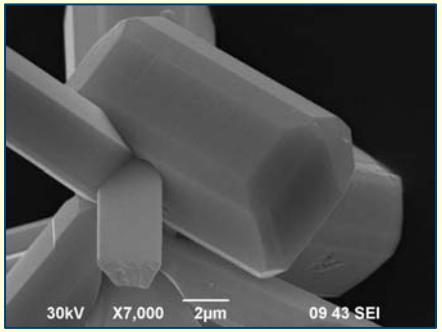
Solids and Materials Analysis

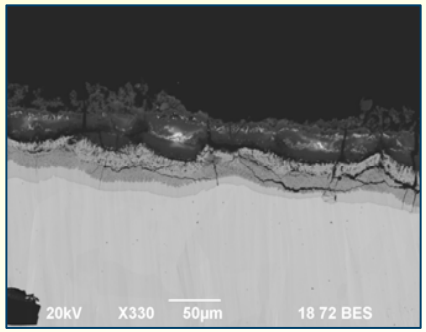
Results and Microscopy Images

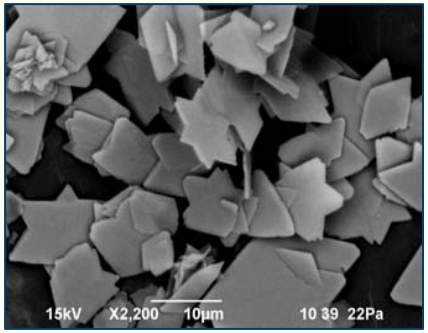


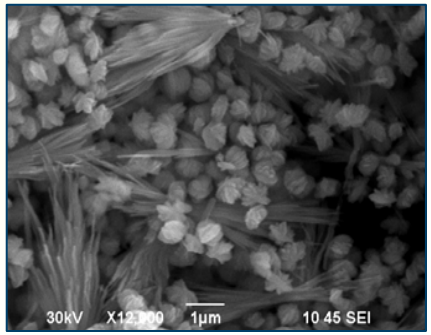












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Molecular Characterization of Microbial Induced Concrete Corrosion (MICC)

Why Study MICC?

- Concrete corrosion has enormous economic impact worldwide.
- MICC suggested to play important part in biodeterioration of concrete sewers.
- Important to identify mechanism in order to develop protocols/metrics for innovative condition assessment tools.

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Molecular Characterization of Microbial Induced Concrete Corrosion (MICC)

What Do We Know About MICC?

- Relatively high bacterial numbers.
- Some bacteria populations have been identified.
- Most identified organisms based on culture-based techniques.
- Overall, little is known about bacteria implicated in MICC.

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Short and Long Term Goals

Molecular Characterization of Microbial Induced Concrete Corrosion (MICC)

- Establish partnership (MOU) with MSD and identify key issues.
- Develop protocol for sampling.
- Study bacterial community structure associated with different stages of MICC using 16S rDNA-based techniques.
- Study MICC of sewers receiving different waste sources.
- Study key microbial functions associated with MICC using PCR targeting functional genes.
- Establish rapid detection of key players.
- Develop predictive models associated with different levels of MICC.

Deliverables

Molecular Characterization of Microbial Induced Concrete Corrosion (MICC)

- MICC literature review (report).
- Develop sampling protocol.
- Phylogenetic (molecular) survey of concrete biofilm communities (peer-review manuscript).
- Detection of corrosion bacteria in biofilms using off-the-shelf and novel genetic assays (peer-review manuscript).
- Succession/dynamics of corrosion associated bacteria (peer-review manuscript).

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Questions?