

PLUMBING FAILURE AND SECURITY: CORROSION AND ITS CAUSES, ECONOMIC IMPACTS, CONSUMER SAFETY CONCERNS

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INDIVIDUAL TALKS IN THIS SESSION

- 1) “Complexity of Corrosion and Need for Interdisciplinary Solutions” by Andrea M. Dietrich and Andrew J. Whelton
- 2) “Causes of Corrosion” by Paolo Scardina and Marc Edwards
- 3) “Economic Impacts of Corroding Pipes” by G.V. Loganathan and Darrell Bosch
- 4) “Public Health and Consumer Concerns” by Sharon Dwyer
- 5) “Sensory Perception of Drinking Water and Corrosion By-Products” by Susan Duncan

THE PROBLEM

The session will demonstrate the essentialness of considering economic, health, and aesthetic effects as well as chemical/biological causes of corrosion to produce drinking water distribution systems that are sustainable, secure and acceptable to the public.

Water distribution systems, or “plumbing”, are part of the critical infrastructure that allows societies to flourish, citizens to survive, and nations to be secure. Quality treated water is needed to meet demands of the growing human population, including drinking, sanitation, food/industrial processing and fire fighting. Unfortunately, it is becoming more difficult to meet this growing demand due overuse of limited water resources and loss of quality drinking water due to uncontrolled contamination or leakage. Estimates are that in the in the USA alone, <10-32% of the drinking water is lost due to corrosion at a cost of \$22 billion per year for the public (utility) infrastructure. The cost for corrosion of private drinking water infrastructure, or plumbing in residential, commercial, and school buildings, is nearly twice that of the public infrastructure. Other countries have encountered similar experiences and costs due to corrosion. Contamination of drinking water from corrosion of home plumbing, whether metal or plastic piping, degrades the aesthetic, health, and economic value of the water for public consumption. If the drinking water is contaminated with detectable levels of taste-and-odor causing compounds, then it could create fear or even panic in the for the public. Using consumer assessment of distribution system water quality, including of taste- and- odor evaluation has been suggested as a means to ensure secure water systems.

The talks in this session will address bio/chemical causes, economic, health/consumer, and aesthetic issues related to corrosion because an interdisciplinary approach is critical to understanding and resolving this societal problem (Figure 1).

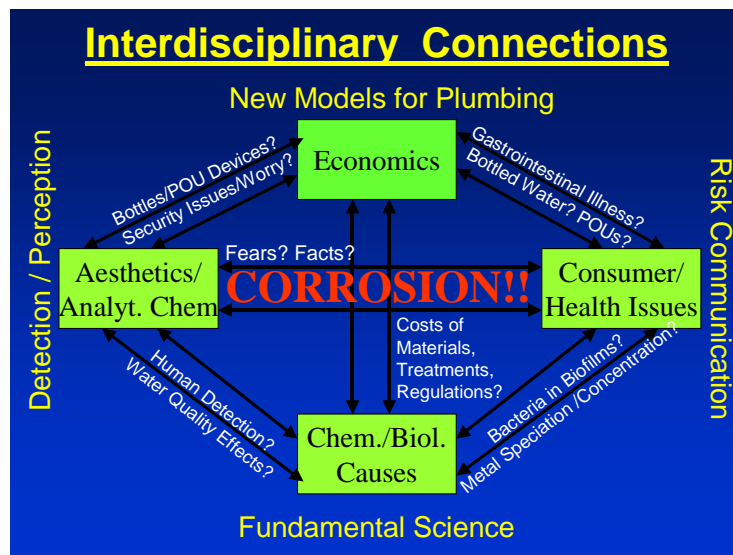


Figure 1: Diagram illustrating synergy between disciplines and connections to interdisciplinary research for advancing the science and public understanding of corrosion and its impacts on drinking water.

BACKGROUND

Though plastic pipe is gaining popularity in homes, a 1999 survey revealed that copper was still selected in 90% of new homes, followed by cross-linked polyethylene (PEX) at 7% and polyvinylchloride (PVC) at 4%. Private plumbing in homes, residential facilities, schools, and commercial buildings represents piping lengths that are a factor of >10 times more miles than used in the public infrastructure. Thus, drinking water contacts more private plumbing than public plumbing and the opportunities for water quality affects are proportionately magnified.

Copper pipes can cause copper concentrations in drinking water to vary significantly, primarily due to the corrosion which is influenced by variations in pH, hardness, dissolved oxygen, organic matter, oxidizing and complexing agents, stagnation time, and biofilms. Corrosion of copper pipe is not well understood, and the impacts of water quality on corrosion or corrosion of drinking water quality are cannot be readily predicted. Copper levels range from 0.005 to 18 mg/L in a variety of flushed and standing drinking-water samples from throughout the USA, Canada, and Europe, with concentrations in distributed drinking water often higher than those in source water. World Health Organization water quality guidelines are not to exceed 2.0 mg/L Cu while the United States Environmental Protection Agency established an action level of 1.3 mg/L Cu for drinking water. Situational and controlled studies implicate copper as a source of GI illness – causing nausea vomiting and cramping - at levels slightly above water quality guidelines. Copper is also a biocide that has value in controlling undesirable microorganisms and it has been implicated in reducing growth of undesirable drinking water pathogens. Like any potential toxic agent, for copper the dose will determine if the effects are beneficial or adverse. Depending on individual taste acuity, different copper concentrations may produce unpleasant sensations that are described as metallic, acidic, astringent, salty, or bitter, making taste a possible means of detecting safe levels of copper in drinking water.

After centuries of mostly good and more recently sometimes-bad experiences with copper piping, plastic pipes were introduced a few decades ago. Ironically, plastic pipes both solved and created problems, including catastrophic failure, unexpected taste-and-odor problems, and high organometallic concentrations all of which prompted increased testing of materials for plumbing. The drinking water industry continually considers consumer concerns. A survey of water utilities found that the distribution system was the number one cause of tastes-and-odors complaints and a major problem was compounds released from metal plumbing or plastic pipe (e.g., alkyl benzenes, naphthalene, and xylene isomers), and odorants released from storage facility coatings. Drinking water quality encountered by consumers often evokes concern than can range from low level to fear, and water quality at the tap can enhance or mitigate perception of sensory compounds. The taste, odor, and clarity of water are what the consumer sees, and when it is not as expected, anxiety can erupt. USEPA's "Consumer Confidence Rule" requires that utilities communicate with customers about water quality issues.

Consumers have risk perception that is increasing being address and quantified by the scientific community. Risk is an estimator of uncertainty defined as the probability of failure, which potentially affects consumer well-being. Objective risks are based on relative frequencies of occurrence obtained from historical or experimental studies. Perceived or subjective risk involves personal or subjective judgment and is a function of confidence. Subjective risk is

affected by consumer knowledge as well as trust in sources of risk communication. Because the interplay between subjective and objective risks affects consumer behavior, social scientists and engineers must work together to explore possibilities for better communication about drinking water risks to citizens. Consumers want to be informed about the risks associated with products they consume. Consumers' willingness to pay to avoid drinking water risks reflects their risk perceptions and knowledge of what the risks imply for their wellbeing. The public is more apt to accept risks over which it has control, are voluntary, and are perceived as being fairly distributed. Information should be provided on the implications of risks for consumers as individuals rather than as a group. For example, how do the risks of water-borne illness differ according to the age or health status of the homeowner? And how will risk and information affect consumer decisions regarding materials in their home plumbing? How can scientists inform the public about technical issues while the public informs scientists about their concerns and need for information? These issues must be evaluated, considering consumer's preferences for water quality improvements using contingent valuation, conjoint analysis, and expert decision panels.

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