

**AGING AND COPPER CORROSION BY-PRODUCT RELEASE:  
ROLE OF COMMON ANIONS,  
IMPACT OF SILICA AND CHLORINE, AND  
MITIGATING RELEASE IN NEW PIPE**

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# **Aging and Copper Corrosion By-Product Release: Role of Common Anions, Impact of Silica and Chlorine, and Mitigating Release in New Pipe**

Kimberly A. Powers

## **ABSTRACT**

It is desirable to reduce leaching of copper from home plumbing because of environmental concerns and to comply with stringent regulation of copper in wastewater and drinking water. The solubility of the scale (oxidized copper rust layer) on the copper pipe wall, which directly contacts drinking water, is a key factor controlling the maximum soluble copper release. Gradual replacement of soluble  $\text{Cu}(\text{OH})_2$  scale to less soluble scale is desirable and occurs through a process known as “aging.”

The presence of sulfate, bicarbonate and orthophosphate in water can quickly convert  $\text{Cu}(\text{OH})_2$  to less soluble solids. In some cases, this produces a desirable short-term reduction in copper solubility, but over longer time periods formation of these solids can be detrimental because they interfere with formation of very low solubility tenorite ( $\text{CuO}$ ) or malachite phases. Likewise, silica present in water can sorb to  $\text{Cu}(\text{OH})_2$  and hinder aging to low solubility tenorite, while the presence of chlorine can hasten aging by a chemical reaction with cupric species that has never been previously observed in the drinking water field. Mild chemical treatments that might be used to accelerate aging, and which could be applied to reduce environmental impacts of newly installed copper pipe, were successfully tested. Chemical pretreatments using lime, caustic, soda ash or chlorine reduced copper release by as much as 84% compared to new pipes without pretreatment.

## DEDICATION

“ A Patience Poem for the Child that is Me”

Be patient child,  
Be patient, quiet.  
The rivers run into the center  
of the earth  
and around  
revolve all things  
and flow  
into the center.  
Be patient, child,  
quiet.

Simon Ortiz

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## AUTHOR'S PREFACE

This work combines elements of the Virginia Tech manuscript format with the traditional thesis. Traditional elements include a literature review in each section, as well as in the Introduction which is Chapter One of the thesis. Chapter I, III, and IV compose the final report for the Copper Development Association. A shortened version of Chapter IV will be submitted to *Materials Performance*. Chapter II and III are complete manuscripts written for submission to *Environmental Science & Technology*.

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