Water Treatment: Fundamentals and Practical Implications of Bubble Formation

Paolo Scardina

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Marc Edwards, Chair

Bill Knocke

John Little

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Paolo Scardina

Advisor: Dr. Marc Edwards

Abstract

Water utilities can experience problems from bubble formation during conventional treatment, including impaired particle settling, filter air binding, and measurement as false turbidity in filter effluent. Coagulation processes can cause supersaturation and bubble formation by converting bicarbonate alkalinity to carbon dioxide by acidification. A model was developed to predict the extent of bubble formation during coagulation which proved accurate, using an apparatus designed to physically measure the actual volume of bubble formation. Alum acted similar to hydrochloric acid for initializing bubble formation, and higher initial alkalinity, lower final solution pH, and increased mixing rate tended to increase bubble formation. Lastly, the protocol outlined in Standard Methods for predicting the degree of supersaturation was examined, and when compared to this work, the Standard Methods approach produces an error up to 16% for conditions found in water treatment.

Air entrainment and ozonation are the key causes of dissolved gas supersaturation and eventual bubble formation in water treatment plants. Total dissolved gas probes (TDGP) are now available to directly measure supersaturation and have many advantages compared to conventional techniques. Bubble formation during coagulation-flocculation hindered particle sedimentation, producing settled turbidities double that of solutions without dissolved gases. In a filtration study, run time to one half of initial flow was decreased by 54% when the source water was increased from 0.1 to 0.2 atm supersaturation. Indeed, even at 0.05 atm supersaturation, run length was only 21 hours in solutions without added particulate matter. A case study confirmed that bubble formation can interfere with coagulation and filtration processes at conventional treatment plants.

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AUTHOR'S PREFACE

Both chapters of this thesis are a separate manuscript and formatted to the specifications of the journal to which it will be submitted. The first chapter, entitled "The Fundamentals of Bubble Formation in Water Treatment," was submitted to *Journal of ASCE*. The second chapter, "The Practical Implications of Bubble Formation in Water Treatment," was submitted to *Journal American Water Works Association*.

Both chapters are aimed at better understanding bubble formation in water treatment plants. The first chapter describes the fundamental science of bubble formation at water utilities, and develops a model that can predict the volume of bubbles formed under various conditions. The second chapter describes how waters can become supersaturated, and for the first time illustrates consequences of bubble formation in coagulation and filtration processes.