

Article

Control of Bromate Formation in Desalinated Seawater Production and Transmission with Ammoniation

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Abstract: Bromate is a potentially carcinogenic disinfection by-product of potential concern in desalinated waters, where bromide derived from seawater can be converted to bromate by the oxidising species used for disinfection. Historically, it has been difficult to maintain complete adherence to national standards of no more than 10 ppb for bromate at all locations served with desalinated seawater by the Saline Water Conversion Corporation (SWCC) in the Kingdom of Saudi Arabia. In this full-scale study, the addition of 100–200 ppb of ammonia to the produced water of a Multi-Stage Flash Desalination plant effectively controlled the formation of bromate in the transmission system supplying inland centres in the Makkah Province of the Kingdom of Saudi Arabia (Arada, Taif) on a time scale sufficient for the distribution of water to the consumer, even when the bromide content of the produced water was artificially enhanced (up to 132 ppb) via the addition of seawater.

Keywords: ammonia; bromate; desalination; multi-stage flash; transmission



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1. Introduction

A significant public health concern in any system where potable water is stored or transported is the possibility of the formation of disinfection by-products. Disinfection is a necessity to avoid the bacterial contamination of drinking water, but the oxidising species used can generate a range of potentially toxic and carcinogenic species from trace components of the produced water [1–4]. When water contains bromide ions, these disinfection by-products can include the bromate ion as well as brominated organic species such as bromoacetic acid, bromoform, and bromodichloromethane [5,6]. Historically, bromate control has been an issue primarily in surface and ground water treatment with ozonation, and there is a considerable body of research literature addressing control measures for this problem [7–15].

Recent interest in bromate control in the Kingdom of Saudi Arabia in waters treated by chlorination rather than ozonation arises from a unique combination of two factors: (1) increasing use of seawater desalination by reverse osmosis (SWRO), rather than thermal methods, which leads to product water with a higher concentration of bromide; (2) transmission of the majority of produced water over lengthy pipelines (>100 km) at relatively high temperatures, as the formation of disinfection by-products increases with both temperature and time. While SWRO is a well-established technology in many parts of the world, outside of the Kingdom of Saudi Arabia it is used almost entirely to serve coastal centres, where it is consumed in close proximity to its point of production. These two factors have led to challenges in consistently meeting the 10 ppb maximum limit set by regulatory authorities in the Kingdom of Saudi Arabia [16,17].

Strategies To Control Bromate And Bromide

Ying-Ying Zheng



Strategies To Control Bromate And Bromide:

Strategies to Control Bromate and Bromide Gary L. Amy, Mohamed S. Siddiqui, 1999 Bromate Formation and Control During Ozonation of Low Bromide Waters Thomas Gillogly, 2001 The primary purpose of this research was to evaluate the formation of bromate and the efficacy of control strategies for low to moderate **Water and Wastewater Treatment Technologies** Xuan-Thanh Bui, Chart Chiemchaisri, Takahiro Fujioka, Sunita Varjani, 2018-11-07 This book discusses major technological advances in the treatment and re use of wastewater. Its focus is on both novel treatment strategies and the modifications and adaptations of conventional processes to optimize the treatment of a complex variety of pollutants including organic matter, chemicals, and micropollutants in different water resources as well as the integration of water treatment with bioelectricity production. Written by leading researchers in the field, it will be of interest to a wide range of researchers in both industry and academia. **Disinfection By-Products in Drinking Water** M. Fielding, M. Farrimond, 1999-01-01 This volume brings together contributors from water regulators and water suppliers in Europe and North America to discuss the main issues associated with reaching a cost-effective balance between microbial and chemical risks. Overviews of research are presented alongside illuminating case studies of the practical approaches taken by water companies and regulators on both sides of the Atlantic. *Research plan for microbial pathogens and disinfection byproducts in drinking water*, Bromide, Bromate, Brominated Disinfection By-products, Oh Brother!, 1993 *Fiscal Year 1999 EPA R&D Budget Authorization* United States. Congress. House. Committee on Science. Subcommittee on Energy and Environment, 1998 **Fiscal Year 2001 Budget Authorization Request** United States. Congress. House. Committee on Science. Subcommittee on Energy and Environment, 2001 Improvement of the Ozonation Process Through the Use of Static Mixers C. Mysore, J. Leparc, Daniel W. Smith, S. Craik, G. Finch, R. Lake, P. Agutter, C. de Traversay, D. Wolbert, Gary Amy, 2004-01-01 Among the known disinfectants, ozone has been demonstrated to be very effective in inactivating protozoans. Current and proposed regulations impose additional treatment requirements for *Cryptosporidium parvum*. These regulatory trends tend to place more stringent performance demands on disinfection systems and have therefore increased the need for improvements in the design. The static mixer offers one alternative method for improving the efficiency of the dissolution of ozone and optimizing its use in the disinfection process. The overall objective of this research was to quantify the potential benefits of ozone application through the use of static mixers in terms of increased transfer efficiency, disinfection capacity, and enhanced chemical reactions at laboratory pilot and full-scale systems. Specific goals were to identify and quantify the effect of several water quality parameters and environmental/engineered factors on the disinfection capacity of the ozone static mixer system and assess bromate formation under optimum conditions for microbial inactivation. Originally published by AwwaRF for its subscribers in 2003, this publication can also be purchased and downloaded via Pay Per View on Water Intelligence Online; click on the Pay Per View icon below. **Formation and Control of Brominated Ozone By-products**

Gary L. Amy, AWWA Research Foundation, 1997 **Disinfection By-Products in Water Treatment** The Chemistry of **Their Formation and Control** Roger A. Minear, Gary Amy, 2017-11-22 Disinfection By Products in Water Treatment describes new government regulations related to disinfection by products It explains the formation of microorganism by products during water treatment and the methods employed to control them The book includes several chapters on chlorine by products and discusses techniques for the removal of chloroform from drinking water It also describes gamma radiation techniques for removing microorganism by product precursors from natural waters and the removal of bromate from drinking water American Book Publishing Record Cumulative 1998 R R Bowker Publishing, 1999-03 **Analysis and Formation of Disinfection Byproducts in Drinking Water** , 2021-04-01 Drinking water disinfection has markedly reduced diseases causes by waterborne pathogenic microorganisms However an unintended consequence of disinfection and or oxidation processes is the generation of disinfection byproducts DBPs which are formed from the reactions of disinfectants oxidants with water matrix components This volume of the Comprehensive Analytical Chemistry Handbook presents recent advances about the formation identification and quantification of inorganic and organic DBPs during oxidative processes The book begins with a first chapter reviewing the most recent non targeted screening approaches and workflows to characterize DBPs using low high and ultra high resolution mass spectrometry The second chapter discusses the analysis of inorganic chloramines in waters using on site and or in lab analytical methods The third chapter provides an overview of the current knowledge about the mechanisms of chlorine dioxide reactions and byproducts formation The fourth chapter presents some fundamental and practical aspects about ozonation processes in water treatment and provides an overview about ozone reaction mechanisms and byproducts formation The fifth chapter focuses on the reactivity of halide ions particularly bromide and iodide with common oxidants and the role they play in determining the speciation of DBPs in treated waters The chapter also presents strategies to mitigate the formation of DBPs during oxidation processes Finally the last chapter tackles the topic of DBPs formation during potable water reuse It discusses the formation of DBPs of major concern in both membrane based and non membrane based potable water reuse treatment schemes Researchers water treatment specialists and regulators will find in this book a valuable and compact resource on several key topics regarding the formation identification quantification and mitigation of DBPs Identification and quantification of known and unknown DBPs Formation of DBPs during different disinfection oxidation processes DBPs of concern in new technologies and or new applications of existing technologies in water treatment **Stantec's Water Treatment** John C. Crittenden, R. Rhodes Trussell, David W. Hand, Kerry J. Howe, George Tchobanoglous, 2022-11-08 The updated third edition of the definitive guide to water treatment engineering now with all new online content Stantec's Water Treatment Principles and Design provides comprehensive coverage of the principles theory and practice of water treatment engineering Written by world renowned experts in the field of public water supply this authoritative volume covers all key aspects of water treatment engineering including plant design

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CALFED Bay-Delta Program Programmatic EIS, Long-Term Comprehensive Plan to Restore Ecosystem Health and Improve Water Management, San Francisco Bay - Sacramento/San Joaquin River Bay-Delta D.Dsum; Program Goals and Objectives, Dapp1; No Action Alternative, 2000

Empirically Based Models for Predicting Chlorination and Ozonation By-products, 1998

Water Disinfection and Natural Organic Matter R. A. Minear, 1996 As part of the effort to balance water treatment processes between allowing pathogenic infection by doing too little and raising the risk of cancer with by products of the treatment 20 papers from a symposium in Chicago August 1995 present information on the chemical identity of natural organic matter and its interactions with the inorganic precursor bromide ion They review the history of natural organic matter in water treatment and the impact of regulations then plunge into reports on an economical experimental approach to developing predictive models for by products of disinfection a comparison of analytical techniques for determining cyanogen chloride in chloraminated drinking water the effect of ozonation and biotreatment on molecular size and hydrophilic fractions of natural organic matter removing bromate ion by electric arc discharge and high energy electron beam processes and other topics Annotation copyrighted by Book News Inc Portland OR

Organic Pollutants in the Water Cycle Thorsten Reemtsma, Martin Jekel, 2006-12-13 This first in depth and comprehensive reference on the most pertinent polar contaminant classes and their behavior in the whole water cycle includes among others industrial chemicals consumer products polar herbicides and pharmaceuticals All chapters are uniformly structured covering properties pollution sources occurrence in wastewater surface water and groundwater as well as water treatment aspects while ecotoxicological and assessment aspects are also covered Among the authors are leading experts in their relevant fields many of whom provide here groundbreaking research results The result is an up to date

information source for researchers and professionals working in water quality monitoring water supply or wastewater treatment as well as environmental and water chemists geochemists ecologists chemists and engineers **Aqua**, 1996

Applications of Environmental Chemistry Eugene R. Weiner, 2010-12-12 Up until the 1950s waste disposal meant discharging it to the nearest river burning it up or shipping it out to sea Now we are paying the price Current disposal and cleanup regulations have a different focus correcting the problems caused by earlier misguided attitudes and maintaining a non degrading environment State and Federal clean air an

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