

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

**Mohammad Reza
Rahimpour, Mohammad Amin
Makarem, Maryam Meshksar**



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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

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

American Book Publishing Record Cumulative 1998 R R Bowker Publishing, 1999-03 *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 microorganic by product precursors from natural waters and the removal of bromate from drinking water

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

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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

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United States. Congress. House. Committee on Science. Subcommittee on Energy and Environment,2001 *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 Advances and Technology Development in Greenhouse Gases: Emission, Capture and Conversion Mohammad Reza Rahimpour,Mohammad Amin Makarem,Maryam Meshksar,2024-07-20 Advances and Technology Development in Greenhouse Gases Emission Capture and Conversion is a comprehensive seven volume set of books that discusses the composition and properties of greenhouse gases and introduces different sources of greenhouse gases emission and the relation between greenhouse gases and global warming The comprehensive and detailed presentation of common technologies as well as novel research related to all aspects of greenhouse gases makes this work an indispensable encyclopedic resource for researchers in academia and industry Volume 6 titled Methane Nitrox Oxide and Ozone Conversion and Applications studies the applications of any greenhouse gases GHGs other than carbon dioxide This book reviews the applications of methane nitrox oxide and ozone It investigates any valuable product fabricated with the inclusion of methane nitrox oxide and ozone The book also reviews recent advances the largest operating plants and pilots for methane conversion the economic assessments and cost analysis and environmental impacts and challenges that are faced when developing these processes Introduces applications and chemicals produced from methane Describes nitrous oxide conversion and applications Discusses about various applications of ozone

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web 7 answer the following questions a how does the brook sparkle b bicker means to quarrel why does the poet use this word here c how many hills and bridges does the brook pass during its journey d where does it finally meet the river e why has the word chatter been repeated in the poem f with many a curve my banks i

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web 3 who is i referred to in the poem the brook ans here i is referred to the brook in the poem brook because the poet made the brook as the speaker of the poem 4 what

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web the poem is about a brook a dictionary would define a brook as a stream or a small river read the poem silently first after the first reading the teacher will make you listen to a recording of the poem what do you think the poem is all about i come from haunts of coot and hern i make a sudden sally and sparkle out among the fern

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web the message of the poem is that the life of a brook is i temporary ii short lived iii eternal v momentary answer iii eternal question 6 b the poet draws a

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web jun 30 2018 q1 who is i referred to as in the poem ans i in the poem is referred to as the brook although the writer of the poem is alfred tennyson but he has made

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