Advances in Water and Wastewater Treatment







ADVANCES IN WATER AND WASTEWATER TREATMENT

SPONSORED BY Environmental and Multi-Media Council and Environmental and Water Resources Institute (EWRI) of the American Society of Civil Engineers

> EDITED BY Rao Y. Surampalli K. D. Tyagi





Published by the American Society of Civil Engineers

This is a preview. Click here to purchase the full publication.

Data on file with the Library of Congress

Published by American Society of Civil Engineers 1801 Alexander Bell Drive Reston, Virginia 20191 www.pubs.asce.org

Any statements expressed in these materials are those of the individual authors and do not necessarily represent the views of ASCE, which takes no responsibility for any statement made herein. No reference made in this publication to any specific method, product, process or service constitutes or implies an endorsement, recommendation, or warranty thereof by ASCE. The materials are for general information only and do not represent a standard of ASCE, nor are they intended as a reference in purchase specifications, contracts, regulations, statutes, or any other legal document. ASCE makes no representation or warranty of any kind, whether express or implied, concerning the accuracy, completeness, suitability, or utility of any information, apparatus, product, or process discussed in this publication, and assumes no liability therefore. This information should not be used without first securing competent advice with respect to its suitability for any general or specific application. Anyone utilizing this information assumes all liability arising from such use, including but not limited to infringement of any patents.

ASCE and American Society of Civil Engineers-Registered in U.S. Patent and Trademark Office.

Photocopies: Authorization to photocopy material for internal or personal use under circumstances not falling within the fair use provisions of the Copyright Act is granted by ASCE to libraries and other users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service, provided that the base fee of \$18.00 per article is paid directly to CCC, 222 Rosewood Drive, Danvera, MA 01923. The identification for ASCE Books is 0-7844-0741-X \$18.00. Requests for special permission or bulk copying should be addressed to Permissions & Copyright Dept., ASCE.

Copyright 2004 by the American Society of Civil Engineers. All Rights Reserved. ISBN 0-7844-0683-9 Manufactured in the United States of America.

This is a preview. Click here to purchase the full publication.

Contents

Wastewater Treatment

Impact of Global Warming Concerns on Wastewater Treatment Plant Design
Glen T. Daigger, Ralph A. Peterson, Jay Witherspoon, and Eleanor Allen
Decision Making for Sustainable Development of Wastewater Infrastructure
Bacterial Production of Bioplastics
Determining the Fate and Biodegradation Kinetics of Toxic Organic Compounds in Activated Sludge Treatment Systems
Recent Advances in Biological Nutrient Removal Technology
Nutrient Removal in Fixed-Film Processes: Current Design Practices
Nutrient Removal Technologies / Alternatives for Small Communities
Recent Advances in Wastewater Treatment in Sequencing Batch Reactor
Free-Surface Wetland Technology Assessment
Subsurface-Flow Constructed Wetlands Wastewater Treatment
Constructed Wetlands for Small Community Wastewater Treatment
Use of Constructed Wetlands in Water Quality Management

.....

This is a preview. Click here to purchase the full publication.

Update on Secondary Clarifiers: Design, Operation, and Performance244 Eric J. Wahlberg
Simultaneous Sewage Sludge Digestion and Metal Leaching
Pathogen Reduction in Municipal Biosolids Treatment Systems
Biosolids Composting
Water Reclamation and Reuse Criteria
Elimination of Overflows and Bypasses in Separate Sanitary Sewer Systems
Utility Competitiveness: A Benchmarking Study
Water Treatment
Watershed Management: Its Importance to Solving Water Supply and Wastewater Treatment Challenges
Occurrence and Control of Altrazine in Midwestern Surface Water Supplies
Radon Removal Technologies for Small Communities
Modeling Water Quality Changes in Distribution Systems
Innovative Methodologies and Technologies for Water Main Rehabilitation and Replacement Program Development
Characterizing Microbial and DBP Risk Tradeoffs in Drinking Water: Application of the CRFM

Innovative Methodologies and Technologies for Water Main Rehabilitation and Replacement Program Development
Characterizing Microbial and DBP Risk Tradeoffs in Drinking Water: Application of the CRFM
Emerging Pathogens and their Relationship to Drinking Water
Cryptosporidium and Giardia Contamination and Removal
Alternative Disinfection Technologies and Strategies for Inactivating Protozoan Cysts
Control of Disinfection By-Product (DBP) Precursors
Management of Water Treatment Plant Residuals
Subject Index
Author Index

۷

This is a preview. Click here to purchase the full publication.

Impact of Global Warming Concerns on Wastewater Treatment Plant Design and Operation

Glen T. Daigger¹, Ralph R. Peterson¹, Jay Witherspoon¹, Eleanor Allen¹

Abstract

This paper provides an overview of the impact of global warming concerns on wastewater treatment plant design and operation. The issues surrounding global warming concerns are discussed, along with the linkage between global warming and greenhouse gas emissions. US greenhouse gas emission inventories are reviewed. along with the role of wastewater treatment plants in reducing such emissions. It is found that process related emissions from wastewater treatment plants are less than 1 % of total greenhouse gas emissions. Limited flexibility exists to reduce processrelated emissions. One of the principal options is to minimize CH₄ emissions at the expense of CO₂ emissions by stabilizing biodegradable organic matter aerobically rather than anaerobically, or by capturing and combusting any CH₄ produced. The global warming potential of CH₄ is 21 times higher than that of CO₂. Principal options for reducing greenhouse gas emissions involve selection of biosolids reuse options and energy consumption measures. Landfilling of waste biosolids should be avoided as this leads to CH₄ emissions. Agricultural reuse can reduce greenhouse gas emissions if land management practices increase soil organic carbon content and/or if crops are grown that can be used to produce renewable fuels (such as ethanol). Greenhouse gas emissions can also be reduced by energy conservation measures that reduce the use of fossil fuels, or the consumption of energy produced from them. Greenhouse gas emissions may be considered during the evaluation of alternatives for upgrading wastewater treatment plants, or as part of an overall emissions inventory.

Keywords

Global warming, greenhouse gases, emissions, wastewater treatment plants, design, operation, carbon dioxide, methane

¹CH2M HILL, 6060 South Willow Drive, Greenwood Village, CO 80111 USA, gdaigger@ch2m.comß

Introduction and Purpose

With the on-going publicity that greenhouse gas emissions and their potential impact on global warming has produced, we have all become sensitized to this global environmental issue. As discussed immediately below, concern exists that the earth's temperature is increasing and that this is a result of emission of the so-called greenhouse gases such as carbon dioxide (CO₂) and methane (CH₄). Since one of the principal objectives of wastewater treatment is the stabilization of biodegradable organic matter (i.e. its conversion to CO_2 and CH_4), it is reasonable to expect that global warming concerns may affect wastewater treatment plant design and operation. The purpose of this paper is to provide an overview of global warming concerns and discuss their potential impact on the design and operation of wastewater treatment plants.

Overview of Global Warming

What is Global Warming?

Evidence suggests that the earth's temperature is increasing. Figure 1 presents global mean surface temperatures for the period of 1861 to 1996 using the year 1930 as a reference point, as developed by the IPPC (1996).



Figure 1 Global Temperature Changes from 1881 to 1998

Temperatures varied randomly in the early part of this data record, but they have increased steadily since about the turn of the century for a total increase on the order of 0.3 to 0.6 °C (0.6 to 1.2 °F). The nine warmest years in the 20^{th} century have occurred in the last fourteen years. In fact, 1998 was the warmest. The snow cover in the Northern atmosphere and floating ice in the Arctic Ocean have reduced, and sea level has risen between 10 and 25 cm (4 and 10 inches) over the past century. Weather patterns have changed, with an increase in average precipitation as well as in

the frequency of extreme rainfall events. All of these changes are symptomatic of a general increase in the average temperature of the planet.

What is Causing These Changes?

This question is a cause of intense scientific debate. Are these global changes just natural fluctuations with a variety of natural causes? Possibly yes. As illustrated in Figure 2, global temperatures have historically fluctuated with a primary cycle of about 100,000 years and mixed or secondary cycles ranging from 23,000 to 41,000 years (Masters, 1991). We are all aware that ice ages have occurred which caused vast glaciers to cover significant portions of the Northern Hemisphere. But, the on-set of the temperature changes described above at about the same time as increased global industrialization suggests that it is a result of anthropogenic (i.e., human-induced) activity. Moreover, changes to the atmosphere that are a result of anthropogenic activities provide a potential explanation for these increasing temperatures.

The earth's atmosphere contains gases with heat trapping properties, including water vapor but also compounds such as carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). Sunlight reaches the earth in the form of short wavelength radiation. The wavelength for emitted radiation is a function of the temperature of the body emitting it (Masters, 1991). The median wavelength for solar radiation is 0.5 µm (since the mean temperature of the sun is 6.000 °K, about 10.000 °F). A portion of the solar energy reaching the earth is reflected, while the remainder passes through the atmosphere and is adsorbed by the earth. The earth radiates some of this adsorbed energy since its temperature is higher than the surrounding space. Because the earth's temperature is lower than that of the sun (the mean temperature of the earth is about 15 °C, equal to 60 °F or 288 °K), it radiates energy at a much longer median wavelength of 10.1 µm. The greenhouse gases (CO₂, CH₄, and N₂O) adsorb energy within the wavelength spectrum of the energy emitted by the earth and prevent its passage back into space. This is referred to as the "greenhouse" effect, as illustrated in Figure 3. Without this effect, the earth's temperature would be about 60 °F (33 °C) lower than it is, making life as we know it impossible. Thus, this energy-trapping feature of the atmosphere is positive with respect to life on earth.

Industrialization has caused increased releases of greenhouse gases into the atmosphere, resulting in increased concentrations of these energy-trapping gases in the atmosphere. Figure 4 presents long-term trends in atmospheric CO₂ concentrations, while Figure 5 presents shorter-term trends in atmospheric CO₂ concentrations. Atmospheric CO₂ concentrations are currently increasing at a rate of about 0.5 %/yr. Figure 6 illustrates similar trends in CH₄, which is currently increasing at a rate of about 0.8 %/yr. Comparison of the trend in short-term atmospheric CO₂ concentrations with the trend in global mean temperatures presented in Figure 1 clearly illustrates a correlation between them. Controversy exists whether a direct cause and effect relationship exists between anthropogenic CO₂ emissions and the global temperature increase currently occurring. However, with the known mechanistic relationship between greenhouse gas concentrations and temperature it is

3