

# Contaminated Sediments:

Characterization,  
Evaluation,  
Mitigation,  
Restoration, and  
Management  
Strategy  
Performance

**STP 1442**

**Editors:**  
Jacques Locat,  
Rosa Galvez-Cloutier,  
Ronald Chaney,  
Kenneth Demars



**INTERNATIONAL**

Standards Worldwide

STP 1442

***Contaminated Sediments:  
Characterization, Evaluation,  
Mitigation/Restoration, and  
Management Strategy Performance***

*Jacques Locat, Rosa Galvez Cloutier, Ronald Chaney,  
and Kenneth Demars, editors*

ASTM Stock Number: STP1442



ASTM International  
100 Barr Harbor Drive  
PO Box C700  
West Conshohocken, PA 19428-2959

Printed in the U.S.A.

**Library of Congress Cataloging-in-Publication Data**  
**ISBN: 0-8031-3466-5**

Contaminated sediments : characterization, evaluation, mitigation/restoration, and management strategy performance / Jacques Locat...[et al].

p. cm. — (STP ; 1442)

"ASTM stock number: STP 1442."

"Second International Symposium on Contaminated Sediments ... in Quebec City, Canada on May 26-28 May 2003"—Foreword.

Includes bibliographical references and index.

ISBN 0-8031-3466-5

1. Contaminated sediments-Management-Congresses. 2. Soil remediation-Congresses. I. Locat, Jacques. II. International Symposium on Contaminated Sediments (2nd : 2003 : Quebec, Quebec) III. Series: ASTM special technical publication ; 1442.

TD878.C663 2003

628.5'5-dc21

2003049606

Copyright © 2003 ASTM International, West Conshohocken, PA. All rights reserved. This material may not be reproduced or copied, in whole or in part, in any printed, mechanical, electronic, film, or other distribution and storage media, without the written consent of the publisher.

### **Photocopy Rights**

**Authorization to photocopy items for internal, personal, or educational classroom use, or the internal, personal, or educational classroom use of specific clients, is granted by ASTM International (ASTM) provided that the appropriate fee is paid to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923; Tel: 978-750-8400; online: <http://www.copyright.com/>.**

### **Peer Review Policy**

Each paper published in this volume was evaluated by two peer reviewers and at least one editor. The authors addressed all of the reviewers' comments to the satisfaction of both the technical editor(s) and the ASTM International Committee on Publications.

To make technical information available as quickly as possible, the peer-reviewed papers in this publication were prepared "camera-ready" as submitted by the authors.

The quality of the papers in this publication reflects not only the obvious efforts of the authors and the technical editor(s), but also the work of the peer reviewers. In keeping with long-standing publication practices, ASTM International maintains the anonymity of the peer reviewers. The ASTM International Committee on Publications acknowledges with appreciation their dedication and contribution of time and effort on behalf of ASTM International.

# Foreword

The Second International Symposium on Contaminated Sediments: Characterization, Evaluation, Mitigation/Restoration, and Management Strategy Performance in Quebec City, Canada on 26-28 May 2003 is sponsored by ASTM International Committee D18 on Soil and Rock. The symposium chairs and co-chairs of this publication are Jacques Locat, Laval University (CGS) and Rosa Galvez-Cloutier, Laval University (CSCE, ASTM); and Ronald C. Chaney, Humboldt State University (ASTM) and Kenneth Demars, University of Connecticut (ASTM).

# Contents

OVERVIEW	vii
SECTION I: SEDIMENT CHARACTERIZATION	
<b>The Origin and Behavior of a Flood Capping Layer Deposited on Contaminated Sediments of the Saguenay Fjord (Quebec)</b> —EMILIE PELLETIER, GASTON DESROSIERS, JACQUES LOCAT, ALFUNSO MUCCI, AND HÉLÈNE TREMBLAY (KEYNOTE PAPER)	3
<b>The Weathering Behavior of Contaminated Industrial Sediments after Their Exposure to Atmospheric Oxygen</b> —MICHAEL SCHUBERT, PETER MORGENSTERN, RAINER WENNRICH, KLAUS FREYER, ALBRECHT PASCHKE, AND HOLGER WEISS	19
<b>Deep-Freeze Sampling Methods for Soft Sediments</b> —MATHIAS RICKING AND TOBIAS SCHULZE	28
<b>Quality Evaluation of Eutrophic Sediments at St. Augustin Lake, Quebec, Canada</b> —ROSA GALVEZ-CLOUTIER, MARIE-EVE BRIN, GERARDO DOMINGUEZ, SERGE LEROUÉIL, AND SYLVAIN ARSENAULT	35
<b>Trace Metal Levels in Nearshore Sediments Close to Industrial Discharges off Cuddalore (Bay of Bengal)</b> —THRESIAMMA JOSEPH, K. K. BALACHANDRAN, MAHESWARI NAIR, V. KESAVADAS, K. K. C. NAIR, AND JOSEPH SEBASTIAN PAIMPILLIL	53
<b>Randomization Tests: A Statistical Tool to Assess Heavy Metal Pollution in Cai River Basin Sediments (RS, Brazil)</b> —MARIA LUCIA K. RODRIGUES, MARIA TERESA RAYA-RODRÍGUEZ, AND VALÉRIO D. PILLAR	62
<b>Study of the Geochemical Distribution of Heavy Metals in Sediments in Areas Impacted by Coal Mining</b> —ELBA C. TEIXEIRA, MARIA LUCIA K. RODRIGUES, MARTA F. C. ALVES, AND JANE R. BARBOSA	72
<b>Characterization of a Catastrophic Flood Sediment Layer: Geological, Geotechnical, Biological, and Geochemical Signatures</b> —HÉLÈNE TREMBLAY, GASTON DESROSIERS, JACQUES LOCAT, ALFUNSO MUCCI, AND ÉMILIE PELLETIER	87
<b>Characterization of Contaminated Sediments in Hamilton Harbour, Lake Ontario</b> —ALEX J. ZEMAN AND TIMOTHY S. PATTERSON	102

**In Situ Flume Measurements of Sediment Erodability in Saguenay Fjord (Quebec, Canada)**—ANN-LAURE MOREAU, JACQUES LOCAT, PHILIP HILL, BERNARD LONG, AND YVON OUELLET 119

SECTION II: MITIGATION AND RESTORATION METHODS

**Reclamation Using Waste Sediment by Sand Capping Technique**—THIAM SOON TAN, GODAKURU P. KARUNARATNE, VICTOR CHOA, AND MYINT WIN BO (KEYNOTE PAPER) 141

**Durability Study for Geotextile Tube Use in Talimu River Sediment Control**—DAVE TA-TEH CHANG, CHAO-PING SUNG, BOR-LING CHEN, AND NUAN-HSUAN HO 156

**Factors Controlling Contaminant Transport Through the Flood Sediments of the Saguenay Fjord: Numerical Sensitivity Analysis**—SIBYLLE DUERI AND RENÉ THERRIEN 167

**Steps for Restoration of a Polluted Egyptian Closed Lagoon on the Alexandria Mediterranean Coast**—OSMAN A. EL-RAYIS 183

**Rehabilitation of Brine-Saturated Sediments**—MOIR D. HAUG, S. LEE BARBOUR, AND CHRIS A. JOHNS 194

**Use of Selective Sequential Extraction for the Remediation of Contaminated Sediments**—CATHERINE N. MULLIGAN AND BEHNAZ DAHR AZMA 208

**Effects of Overburden Stresses on Soil Reclamation by Electroosmosis**—ANSM KABIR AND MIGUEL PICORNELL 224

**A Reactive Geocomposite to Remediate Contaminated, Subaqueous Sediments**—THOMAS C. SHEAHAN, AKRAM ALSHAWABKEH, LORETTA A. FERNANDEZ, AND KAREN S. HENRY 236

SECTION III: MONITORING AND PERFORMANCE

**Sediment Transport and Deposition Processes Near Ocean Outfalls in Southern California**—HOMA J. LEE, MARLENE A. NOBLE, AND JINGPING XU (KEYNOTE PAPER) 253

**Numerical Model for Contaminant Transport in Consolidating Sediments**—PATRICK J. FOX 266

**Assessment of the Lead Release from Cables Buried in Sediments into the Water Column**—ANTONINA DEGTIAREVA, MARIA ELEKTOROWICZ, AND TAGHI EBADI 282

**Numerical Modeling of Hydrodynamic Circulation and Cohesive Sediment Transport in Hartwell Lake, South Carolina/Georgia, USA**—ŞEBNEM ELÇİ AND PAUL A. WORK 296

**Retention of Heavy Metals in the Post '96 Flood Sediment Layer Deposited in the Saguenay River, Quebec, Canada**—ROSA GALVEZ-CLOUTIER, MYRIAM MURIS, JACQUES LOCAT, AND CYRIL BOURG 310

**Index** 323

# Overview

---

Recent advances in our understanding of contaminated sediments have been assembled in this Special Technical Publication, which is one of the major scientific contributions to the Second International Symposium on Contaminated Sediments held in Québec City from May 26 to 28, 2003. This volume is part of the overall technical program of ASTM Committee D18 on soil and rocks.

For many decades, waterways have been exposed to a wide variety of contaminants. Even if regulations and a better control of contaminants have been established to reduce their emission, many contaminants are still present in bottom sediments. In fact, some of them are persistent and continue to pose a potential risk to the environment with direct and cumulative toxic impacts on aquatic life, organisms, and eventually on human health.

In recent years, major advances have been made in the study and understanding of contaminated sediments, particularly via major projects in areas such as Los Angeles, California, Saguenay Fjord in Québec, and Singapore.

The symposium covers the areas of sediment characterization, contaminant evaluation, mitigation/restoration methods, and management strategy performance from the geological, geotechnical, biological, and geophysical perspectives. It reviews recent advances in contaminated sediments-management-related research and focuses on engineering aspects of contaminant transport, erosion, stability, monitoring, and modeling. The main goal of the symposium is to identify both established and innovative physico-chemical and biological tests and methods used to characterize and evaluate properties and behavior of contaminated sediments, as well as the potential for contaminant transfer.

The papers gathered in this publication cover the primary goal of the symposium and reflect research activities in many parts of the world. Keynote papers, selected for this volume, reflect recent work carried out on large coastal investigations (e.g., in the Los Angeles area), and on natural and artificial capping of contaminated sediments. Other papers in this volume have been assembled into three groups: (1) sediment characterization, (2) mitigation and restoration methods, and (3) monitoring and performance. Each of these sections begins with the corresponding keynote paper.

Sediment characterization of contaminated sediments has become more and more complex. It involves *ex situ* techniques from standard tests (e.g., physical properties) to biological analyses in addition to all the chemical analyses, but also *in situ* ones like erodability tests. Mitigation and restoration methods assembled herein are diversified and touch on many different environments from river sediments and harbor lagoons to land reclamation. It involves techniques ranging from the use of geotextiles and geocomposites to selective sequential extraction methods. The monitoring and performance aspects of contaminated sediments are largely supported by extensive site investigations, like the Southern California project, but also by the development of modeling tools.

A few papers included in this volume summarize a five-year research effort aimed at evaluating the performance of a catastrophic capping layer resulting from the major 1996 Saguenay flood disaster that proved to be very beneficial to the Saguenay Fjord environment and ecosystem by covering most of the ancient contaminated sediments!

Finally, the editors would like to thank all contributing authors for their effort and timely response. This book represents the achievements of a process strongly supported by various learning societies or agencies, including ASTM International (Committee D-18), the Canadian Geotechnical Society,

the Canadian Society of Civil Engineering, the Society for Environmental Toxicology and Chemistry (St. Lawrence Chapter), and the National Science and Engineering Research Council of Canada. The Editors are very grateful to Mrs. Hélène Tremblay, Secretary of the Symposium, and to Mrs. Crystal Kemp for their dedication towards ensuring the completion of this Special Technical Publication.

*Jacques Locat*  
Laval University (CGS)

*Rosa Galvez-Cloutier*  
Laval University (CSCE, ASTM)

ISBN # 0-8031-3466-5  
Stock #: STP1442