

BIOLOGICAL WASTEWATER TREATMENT SERIES

VOLUME 6

# SLUDGE TREATMENT AND DISPOSAL

Cleverson Vitorio Andreoli,

 

**Published by IWA Publishing, Alliance House, 12 Caxton Street, London SW1H 0QS, UK**

---

Telephone: +44 (0) 20 7654 5500; Fax: +44 (0) 20 7654 5555; Email: [publications@iwap.co.uk](mailto:publications@iwap.co.uk)  
Website: [www.iwapublishing.com](http://www.iwapublishing.com)

First published 2007

© 2007 IWA Publishing

Copy-edited and typeset by Aptara Inc., New Delhi, India

Printed by Lightning Source

Apart from any fair dealing for the purposes of research or private study, or criticism or review, as permitted under the UK Copyright, Designs and Patents Act (1998), no part of this publication may be reproduced, stored or transmitted in any form or by any means, without the prior permission in writing of the publisher, or, in the case of photographic reproduction, in accordance with the terms of licences issued by the Copyright Licensing Agency in the UK, or in accordance with the terms of licenses issued by the appropriate reproduction rights organization outside the UK. Enquiries concerning reproduction outside the terms stated here should be sent to IWA Publishing at the address printed above.

The publisher makes no representation, expressed or implied, with regard to the accuracy of the information contained in this book and cannot accept any legal responsibility or liability for errors or omissions that may be made.

#### **Disclaimer**

The information provided and the opinions given in this publication are not necessarily those of IWA or of the editors, and should not be acted upon without independent consideration and professional advice. IWA and the editors will not accept responsibility for any loss or damage suffered by any person acting or refraining from acting upon any material contained in this publication.

#### *British Library Cataloguing in Publication Data*

A CIP catalogue record for this book is available from the British Library

#### *Library of Congress Cataloguing-in-Publication Data*

A catalogue record for this book is available from the Library of Congress

ISBN: 1 84339 166 X

ISBN 13: 9781843391661

# Contents

---

<i>Preface</i>	vii
<i>The authors</i>	xiii
1 Introduction to sludge management	1
<i>M. von Sperling, C.V. Andreoli</i>	
2 Sludge characteristics and production	4
<i>M. von Sperling, R.F. Gonçalves</i>	
2.1 Sludge production in wastewater treatment systems	4
2.2 Sludge characteristics at each treatment stage	6
2.3 Fundamental relationships in sludge	12
2.4 Calculation of the sludge production	16
2.5 Mass balance in sludge treatment	28
3 Main contaminants in sludge	31
<i>S.M.C.P. da Silva, F. Fernandes, V.T. Soccol, D.M. Morita</i>	
3.1 Introduction	31
3.2 Metals	32
3.3 Trace organics	39
3.4 Pathogenic organisms	40
4 Sludge stabilisation	48
<i>M. Luduvica</i>	
4.1 Introduction	48
4.2 Anaerobic digestion	49
4.3 Aerobic digestion	67

5	Sludge thickening and dewatering	76
	<i>R.F. Gonçalves, M. Ludovice, M. von Sperling</i>	
5.1	Thickening and dewatering of primary and biological sludges	76
5.2	Sludge thickening	78
5.3	Sludge conditioning	81
5.4	Overview on the performance of the dewatering processes	90
5.5	Sludge drying beds	92
5.6	Centrifuges	99
5.7	Filter press	107
5.8	Belt presses	114
5.9	Thermal drying	118
6	Pathogen removal from sludge	120
	<i>M.T. Pinto</i>	
6.1	Introduction	120
6.2	General principles	121
6.3	Mechanisms to reduce pathogens	123
6.4	Processes to reduce pathogens	127
6.5	Operation and control	144
7	Assessment of sludge treatment and disposal alternatives	149
	<i>F. Fernandes, D.D. Lopes, C.V. Andreoli, S.M.C.P. da Silva</i>	
7.1	Introduction	149
7.2	Sustainable point of view	150
7.3	Trends in sludge management in some countries	150
7.4	Aspects to be considered prior to the assessment of alternatives	152
7.5	Criterion for selecting sludge treatment and final disposal alternatives	155
7.6	Sludge management at the treatment plant	160
8	Land application of sewage sludge	162
	<i>C.V. Andreoli, E.S. Pegorini, F. Fernandes, H.F. dos Santos</i>	
8.1	Introduction	162
8.2	Beneficial use	163
8.3	Requirements and associated risks	169
8.4	Handling and management	177
8.5	Storage, transportation and application of biosolids	186
8.6	Operational aspects of biosolid land application	191
8.7	Landfarming	201
9	Sludge transformation and disposal methods	207
	<i>M. Ludovice, F. Fernandes</i>	
9.1	Introduction	207
9.2	Thermal drying	208
9.3	Wet air oxidation	209

9.4	Incineration	212
9.5	Landfill disposal	215
10	Environmental impact assessment and monitoring of final sludge disposal	226
	<i>A.I. de Lara, C.V. Andreoli, E.S. Pegorini</i>	
10.1	Introduction	226
10.2	Potentially negative environmental impacts	227
10.3	Monitoring indicators and parameters	230
10.4	Monitoring plan	232
	References	237