

Wastewater Irrigation and Health

Assessing and Mitigating Risk in Low-Income Countries

Edited by
Pay Drechsel, Christopher A. Scott,
Liqia Raschid-Sally, Mark Redwood
and Akiça Bahri



International Development Research Centre
Ottawa • Cairo • Dakar • Montevideo • Nairobi • New Delhi • Singapore



London • Sterling, VA

Contents

<i>Figures, Tables and Boxes</i>	<i>ix</i>
<i>Foreword by Hillel Shuval</i>	<i>xv</i>
<i>Preface</i>	<i>xix</i>
<i>Contributors and Reviewers</i>	<i>xxi</i>
<i>Abbreviations</i>	<i>xxv</i>

PART 1 — SETTING THE STAGE

1 Wastewater, Sludge and Excreta Use in Developing Countries: An Overview	3
<i>Blanca Jiménez, Pay Drechsel, Doulaye Koné, Akişa Bahri, Liqa Raschid-Sally and Manzoor Qadir</i>	
2 Assessing and Mitigating Wastewater-Related Health Risks in Low-Income Countries: An Introduction	29
<i>Robert Bos, Richard Carr and Bernard Keraita</i>	

PART 2 — RISKS AND RISK ASSESSMENT

3 Risk Analysis and Epidemiology: The 2006 WHO Guidelines for the Safe Use of Wastewater in Agriculture	51
<i>Duncan Mara and Robert Bos</i>	
4 Approaches to Evaluate and Develop Health Risk-Based Standards Using Available Data	63
<i>Inés Navarro, Peter Teunis, Christine Moe and Blanca Jiménez</i>	
5 Tools for Risk Analysis: Updating the 2006 WHO Guidelines	89
<i>Duncan Mara, Andrew J. Hamilton, Andrew Sleigh, Natalie Karavarsamis and Razak Seidu</i>	

- 6 Non-Pathogenic Trade-Offs of Wastewater Irrigation 101
Manzoor Qadir and Christopher A. Scott
- 7 Risk Analysis Integrating Livelihood and Economic Impacts of Wastewater Irrigation on Health 127
Marites M. Tionoco, Clare A. Narrod and Kelly Bidwell

PART 3 — MINIMIZING HEALTH RISKS

- 8 Wastewater Treatment for Pathogen Removal and Nutrient Conservation: Suitable Systems for Use in Developing Countries 149
Blanca Jiménez, Duncan Mara, Richard Carr and François Brissaud
- 9 Low-Cost Options for Pathogen Reduction and Nutrient Recovery from Faecal Sludge 171
Doulaye Koné, Olufunke O. Cofie and Kara Nelson
- 10 Farm-Based Measures for Reducing Microbiological Health Risks for Consumers from Informal Wastewater-Irrigated Agriculture 189
Bernard Keraita, Flemming Konradsen and Pay Drechsel
- 11 Farm-Based Measures for Reducing Human and Environmental Health Risks from Chemical Constituents in Wastewater 209
Robert Simmons, Manzoor Qadir and Pay Drechsel
- 12 Applying the Multiple-Barrier Approach for Microbial Risk Reduction in the Post-Harvest Sector of Wastewater-Irrigated Vegetables 239
Sanja Ilic, Pay Drechsel, Philip Amoah and Jeffrey T. LeJeune
- 13 Cost-Effectiveness Analysis of Interventions for Diarrhoeal Disease Reduction among Consumers of Wastewater-Irrigated Lettuce in Ghana 261
Razak Seidu and Pay Drechsel

PART 4 — WASTEWATER GOVERNANCE AND ADOPTION OF RISK-REDUCTION OPTIONS

- 14 Challenging Conventional Approaches to Managing Wastewater Use in Agriculture 287
Frans Huibers, Mark Redwood and Liqa Raschid-Sally

- | | | |
|----|---|-----|
| 15 | Designing Reuse-Oriented Sanitation Infrastructure: The Design for Service Planning Approach | 303 |
| | <i>Ashley Murray and Chris Buckley</i> | |
| 16 | Facilitating the Adoption of Food-Safety Interventions in the Street-Food Sector and on Farms | 319 |
| | <i>Hanna Karg, Pay Drechsel, Philip Amoah and Regina Jeitler</i> | |
| 17 | Harnessing Farmers' Knowledge and Perceptions for Health-Risk Reduction in Wastewater-Irrigated Agriculture | 337 |
| | <i>Bernard Keraita, Pay Drechsel, Razak Seidu, Priyanie Amerasinghe, Olufunke O. Cofie and Flemming Konradsen</i> | |
| 18 | Multi-Stakeholder Processes for Managing Wastewater Use in Agriculture | 355 |
| | <i>Alexandra E. V. Evans, Liqa Raschid-Sally and Olufunke O. Cofie</i> | |

PART 5 — CONCLUSIONS AND OUTLOOK

- | | | |
|----|--|-----|
| 19 | Wastewater Irrigation and Health: Challenges and Outlook for Mitigating Risks in Low-Income Countries | 381 |
| | <i>Christopher A. Scott, Pay Drechsel, Liqa Raschid-Sally, Akiça Bahri, Duncan Mara, Mark Redwood and Blanca Jiménez</i> | |
| | <i>Index</i> | 395 |