Environmental Technologies to Treat Selenium Pollution: Principles and Engineering

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Edited by

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Cover photographs

Selenium reducing biomass in anaerobic granular sludge or attached onto surfaces of various laboratory scale reactors fed with selenite or selenate. **Top right:** Red color formation showing the presence of elemental Se(0) due to reduction of Se-oxyanions, while dark grey colour showing the formation of PbSe due to the interaction of Pb(II) with selenide (HSe^-) after the bioreduction of Se-oxyanions. Photograph of data published in Mal *et al.* (2021) *Journal of Hazardous Waste* (In Press). **Central:** Architectural image of a bacterial biofilm exposed to 0.1 mM selenate captured using a Leica TCS-SP2 acousto-optical beam splitter confocal laser scanning microscope stained with SYTO 9 (green) and propidium iodide (red). Photograph of data published in Tan *et al.* (2018) *Journal of Chemical Technology and Biotechnology* **93**(8), 2380–2389. **Bottom left:** Cathodic selenium recovery in selenite fed dual-chambered bioelectrochemical system. Photograph of data published in Shanthi Sravan *et al.* (2020) *Journal of Hazardous Materials* **399**, 122843. **Bottom right:** Study of the selenium removal efficiency, biofilm structure and microbial community structure in biofilms growing in selenate, sulfate and nitrate rich wastewater in six-panel drip flow reactors, i.e. plug flow systems utilizing low-shear, laminar flow. Photograph of data published in Tan *et al.* (2018) *Journal of Chemical Technology and Biotechnology* **93**(8), 2380–2389.

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Preface

Selenium is a naturally occurring yet scarce element with significant importance in health, electrical and manufacturing sectors. However, owing to its toxicity at a high concentration it is considered a double-edged sword. Selenium contamination in soil and water is a serious environmental concern, and it is attributed to growing industrial activities, in particular metal refining, nuclear and mining-related activities. Hence, with advancements in strict water quality requirements and pollution monitoring, the discharge limit of selenium in water is set as 5 μg/L. Several chemical and biological treatment strategies have been developed to treat selenium-contaminated water, and some of these techniques can even be applied to recover and reuse selenium for different applications.

Despite rigorous research in selenium removal/reduction being carried out at the laboratory scale as well as in the field, often understanding of the selenium cycle or of the mechanism of selenium reduction remains unclear for improving the treatment process efficiency. Hence, the first part of this book opens up by giving a clear account of the chemistry and biochemical mechanisms involved in selenium reduction. The second part of the book deals with various remediation technologies, including chemical and biological treatment techniques. Upcoming treatment techniques using plant systems are also presented in this book. Because of a strong history of selenium for its impact on the health sector, the book covers soil pollution and biofortification of agricultural crops with selenium. Finally, the synthesis of biologically-reduced selenium in the form of nanoparticles and quantum dots and its potential application is presented. Thus, the present book introduces its readers to the sources of selenium emissions up to the recovery of selenium based value-added products from wastewaters.

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Each contributed chapter is presented on a stand-alone basis, so that the reader will find it helpful to consider only the theme of each chapter. There are nevertheless many connections between what may at first seem to be quite different topics. As in all the books of the *Integrated Environmental Technology* series, it was one of our purposes to draw out and emphasize these interdisciplinary linkages. For this reason, a comprehensive index is included to facilitate cross-referencing. We hope that the work described in this book will inspire those working in the field and will encourage those who are beginning to investigate this field.

We wish to thank all contributors to this book for their valuable contributions by sharing their expertise in the form of the various chapters included in the book. We also thank all past and present co-workers as well as all collaborators who joined in unraveling parts of the selenium cycle and its application in environmental technology as described in this book, especially those at Wageningen University, UNESCO-IHE, Indian Institute of Technology Guwahati and National University Ireland Galway. In addition, the national and international granting agencies who supported this work on the selenium cycle over the years are gratefully acknowledged, in particular the Science Foundation Ireland (SFI), who financially supported the open access publication of this book volume through the SFI Research Professorship Programme *Innovative Energy Technologies for Biofuels, Bioenergy and a Sustainable Irish Bioeconomy* (IETSBIO^3; grant number 15/RP/2763). We are also grateful to the editorial team of IWA Publishing, in particular Niall Cunniffe and Mark Hammond, for their help and editorial support in realizing this book.

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