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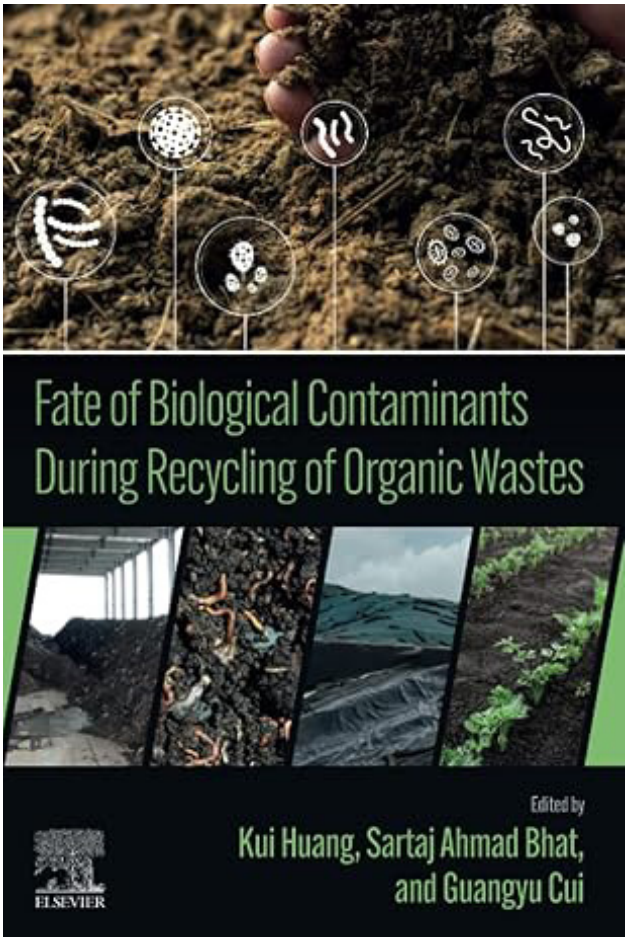
BOOKS REVIEW



FATE OF BIOLOGICAL CONTAMINANTS DURING RECYCLING OF ORGANIC WASTES

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The book "Fate of Biological Contaminants During Recycling of Organic Wastes" presents the results of recent research on the presence of pathogenic microorganisms, antibiotic resistant bacteria (ARBs) and antibiotic resistance genes (ARGs) in different organic waste types and illustrates the most appropriate waste management strategies to abate those microorganisms and immobilize antibiotic-resistant genetic material.

More in detail, the book is divided into 16 chapters. Each chapter is dedicated to a specific topic, namely specific bio-contaminants, specific waste types and/or appropriate consolidated or innovative processes to abate them in the organic waste being treated. Chapters 1, 2, 6, 10, 11, 12 and 14 discuss both the presence of bio-contaminants in different organic waste types and applicable treatments. Chapters 3, 5, 7, 8, 13, 15 and 16 focus more on innovative processes based on vermicomposting, entomocomposting and combinations with conventional processes. Chapter 9 analyzes waste management during the COVID-19 pandemic and suggests solution to minimize the risk of transmission.

Specifically, Chapter 1 provides an overview on the occurrence of ARGs in organic waste undergoing biological treatments. Food waste, activated sludge and animal manure are reservoirs of ARGs, but also ARBs and mobile genetic elements (MGEs). Conversion of organic waste into fertilizers can spread this problem to soil and then to the food chain again. Anaerobic digestion and composting, are critically reviewed. The results of literature studies – mostly carried out at a laboratory scale though – show that thermophilic conditions reduce ARGs and indicated the potential role of inocula from sewage sludge in ARG enrichment. On the other hand, vermicomposting could be beneficial, since digestion in earthworms' gut can inactivate bacteria encoding ARGs and MGEs. Addition of clay, lignite or biochar during biological treatments can alter the bacterial composition and reduce ARGs and MGEs.

Chapter 2 deals with the fate of pathogens in sewage sludge, which can contaminate soils if sludge is reused in agriculture. After an overview of the most common pathogenic microorganisms in sewage sludge, treatment options to abate their content are described. Thermophilic anaerobic digestion enables a reduction of pathogens of up to 3 log, but is not particularly effective against enteroviruses and parasites, while composting is able to reduce parasites, ARGs and MGEs. Chemical methods (at pH > 12) and physical methods (at temperature > 70°C) allow reducing pathogens but do not stabilize the sludge.

The role of entomocomposting in reducing the content of pathogens in soil is the object of Chapter 3. The chapter presents the main pathogens found in compost and move the focus on insect-mediated composting producing frass fertilizer. Black soldier fly (BSF) larvae and mealworms can accelerate the process, abate pathogens and increase the nutrient content of compost. The mechanism seems to rely on the secretion of antimicrobial peptides by insects. When frass fertilizer is applied to soil, the recognition of chitin and/or chitinase enzymes by the plants' cellular receptors could induce systemic resistance to pathogens. Recent studies have demonstrated that frass fertilizer increases soil fertility and plant productivity.

Chapter 4 focuses on fish waste valorization and the potential issues related to ARGs. In 2018, fish production reached 178.5 million tons, a 2%-4% increase over the

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previous decade. However, this surge has led to substantial fishery-derived waste, equivalent to the total fish consumed, posing severe environmental challenges, including antimicrobial resistance. Fish waste includes various components such as scales, bones, and organs, with 30%-45% of fish weight wasted in processing industries. Valorization methods are here reviewed to extract bioactive compounds from fish waste for pharmaceuticals, nutraceuticals, and food technology, promoting environmental sustainability and economic benefits, and degrading ARGs and resistome complexes.

In Chapter 5, vermicomposting is discussed in detail in terms of the fate of biological contaminants. The chapter begins with an overview of the different earthworms used in vermicomposting. The increased microbial biodiversity compared to conventional compost promotes plant growth, mineral solubilization, nitrogen fixation and prevents pathogenic bacteria and fungi. In addition, different earthworms and their gut microbes are reported to effectively degrade organic contaminants (including microplastics) and immobilize heavy metals forming complexes. Gut microbes, especially Staphylococcus and Pseudomonas strains, also take part to antibiotic degradation if earthworms' exposure to antibiotics is not excessive. Finally, vermicompost is reviewed in terms of plant growth promotion and disease management, thanks to the release of plant hormones and the presence of microbes showing an antagonistic effect on pathogens.

The focus of Chapter 6 is on bio-contaminants and treatment techniques in organic waste. After an overview of the main biological contaminants (including pathogens), the chapter focuses on aerobic/anaerobic biodegradation processes to abate their concentration in waste. The parameters affecting the treatment efficiency are reviewed (biological factors, nutrient availability, oxygen concentration, toxic compounds, moisture content and temperature) and some challenges are highlighted.

The following chapter (Chapter 7) focuses on the advantages of coupling composting with vermicomposting for the removal of both organic and inorganic contaminants. In addition, a strategy based on synchrotron radiation mapping was proposed to identify the binding sites and distribution characteristics of metal and functional groups in earthworms and organic wastes at the micro-scale.

Chapter 8 goes more into details concerning vermicompost and report on the broad diversity of bacterial communities that can be present. In particular, the chapter discuss a critical issue concerning the challenge of how to eliminate harmful microorganisms with ARGs and pathogens, and simultaneously increase the concentration of beneficial microorganisms for biodegradation.

Chapter 9 reviews global research on solid waste management during the pandemic, focusing on China's experience. Since the outbreak of COVID-19 in early 2020, epidemic-related waste has surged, posing infection risks and straining waste disposal systems. This waste, rich in plastics and chlorine, differs significantly from regular municipal waste, impacting incineration and disposal processes. Proper management is crucial to prevent environmental contamination. Various countries have issued guidelines for managing such waste, tailored to their unique conditions. The chapter highlights the increased attention on waste management in academic publications and underscores the need for effective strategies to mitigate virus transmission through waste.

Chapter 10 focuses on the effects of bio-contaminants from organic waste on soil. The increasing generation of organic wastes, such as livestock manure, food waste, and sewage sludge, is driven by economic growth and population escalation. While over 90% of organic waste products are applied directly to land, composting, anaerobic digestion, and vermicomposting offer sustainable recycling methods. However, bio-contaminants like viruses, harmful bacteria, and antibiotic resistance genes (ARGs) pose significant risks when organic waste is improperly managed. The authors conclude that effective waste management strategies, including waste collection, waste characterization, waste reduction and segregation, labeling and packing, storage, transport, decontamination, recycling, staging, treatment, disposal, tracking, and reporting are crucial to mitigate these risks and minimize soil contamination.

Chapter 11 discusses recent studies on bio-contaminants in soil and proposes future research directions and remediation strategies. Soil contamination by bio-contaminants, including viruses, human pathogenic bacteria, and ARGs, is a global concern, especially in waste disposal sites, industrial wastelands, and agricultural farmlands. Contaminants enter soil systems through wastewater irrigation, sludge application, and livestock manure use. Major contamination sources include landfill leakage, industrial waste discharge, pesticide overuse, and improper waste disposal. These contaminants pose significant risks to human, plant, and animal health. Effective remediation methods, in particular bioremediation, biochar amendment, and nanomaterial application, are essential for mitigating soil contamination.

The widespread use of antibiotics in poultry and livestock farming has led to the presence of antibiotic residues and ARGs in animal manure, which is the subject of Chapter 12. Manure enhances soil quality by adding nutrients, but also poses significant environmental and health risks. Antibiotic residues in manure exert selective pressure on soil bacteria, promoting the development and spread of ARGs. These genes can transfer to human pathogens, posing a public health threat. Effective manure management, including proper treatment and controlled application avoiding excess use, is essential to mitigate these risks and ensure soil and food safety.

In Chapter 13, the book discusses again vermicomposting, but focuses on its role in the removal of ARGs. Earthworms' digestive systems, characterized by neutral pH and low oxygen, help reduce ARGs by altering microbial populations and reducing mobile genetic elements. Vermicomposting has shown a significant decrease in ARGs, particularly from sewage sludge. However, the process's efficiency can vary based on raw materials and composting conditions. Research continues to optimize vermicomposting techniques for better ARG mitigation and environmental safety.

Chapter 14 deals with the pathogens present in municipal solid waste landfills, open dumpsites and leachate. The last two, specifically, harbor pathogens like bacteria, viruses, and fungi, posing risks to human and animal health. Pathogens such as fecal coliforms, enteroviruses, and protozoan parasites proliferate in waste, contaminating soil, water, and air. Vectors like rodents and insects spread these pathogens. Effective waste management, including sanitary landfills and advanced detection methods, is crucial to mitigate health risks and ensure environmental safety. Proper training and protective measures for waste workers are essential.

Chapter 15 presents the bioconversion of hazardous organic wastes using invertebrates, such as earthworms and insect larvae. Conventional agriculture's reliance on synthetic agrochemicals has led to significant soil contamination, impacting soil health and biodiversity. Vermicomposting and insect-based bioconversion are nature-based strategies that transform hazardous organic wastes into nutrient-rich composts. Both methods mitigate soil threats, including organic matter decline and contamination. However, the authors conclude that further research is needed to understand pollutant dynamics and ensure the safety of the resultant organic fertilizers.

The final chapter (Chapter 16) discuss the potential advantages of combining the activity of earthworms with wetlands for the biological treatment of sewage sludge. The authors investigate the impact of plant density on the reduction of ARGs in a vermi-wetland system treating excess sludge. Vermi-wetlands offer a sustainable approach to sludge treatment. Higher plant densities, particularly of Acorus calamus, enhance the removal rates of total solids and chemical oxygen demand through improved root interception and microbial activity. However, the effect on ARGs varies, with some genes like sulfonamide resistance genes showing higher removal rates at increased plant densities.

Overall, the book provides interesting insights into the fate of bio-contaminants in organic waste and related management activities. On the side of bio-contaminants, particular consideration is given to antibiotic resistance and ARGs, while, on the side of management strategies, the role of vermicomposting (alone or in combination with other processes) received most attention. Other processes reviewed are conventional composting, entomocomposting, anaerobic digestion. The book also considers different organic waste types, including food waste, activated sludge, animal manure, fish waste and municipal solid waste in landfills, dumpsites and related leachates. Although the organization of book chapters may appear sometimes confusing, since they do not follow a logical sequence, each chapter provides valuable and detailed information on the specific topic it discusses, paving the way for further research on biodegradation processes and analytical methods.

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