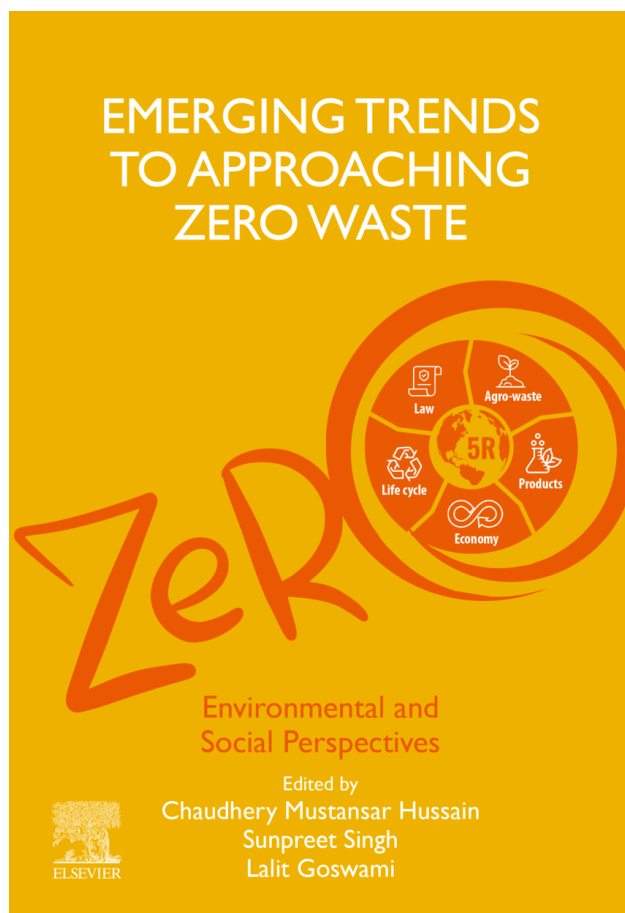


BOOKS REVIEW



EMERGING TRENDS TO APPROACHING ZERO WASTE

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The book "Emerging Trends to Approaching Zero Waste" is a collection of contributions that shed light on different possible approaches for waste minimization and, ideally, zero waste production. Strategies to approach zero waste generation have been studied and continuously proposed since the end of last century, with a number of publications on this topic that has grown exponentially, following the same pattern of the academic works on circular economy, whose principles are tightly connected to the zero-waste concept. However, the achievement of zero-waste targets is hindered by many political, cultural and industrial barriers. The topic investigated in the book is therefore challenging, but many solutions proposed by the authors

could be successfully applied both to India (the affiliation country of the authors) and globally.

The book is divided into 16 chapters written by 43 contributing authors. Each chapter either contains dissertations on general, organic and policy-driven approaches that may facilitate the achievement of zero-waste targets or discusses specific examples of strategies that could be implemented locally or globally.

Chapter 1 starts with the definition of "zero waste" given by the Zero Waste International Alliance, i.e. "the conservation of all resources by means of responsible production, consumption, reuse and recovery of products, packaging and materials without burning and with no discharges to land, water or air that threaten the environment or human health", prevention being the priority target rather than reuse or recycle. Soon after, the focus moves to zero-waste principles in the construction and demolition sector. An initial characterization of the different types of construction and demolition waste (CDW) and the related processes that generate it is followed by the presentation of the current practices for CDW minimization, conversion to energy, software-aided smart management, assessment tools (e.g.: Life Cycle Assessment), recycling and recent policies set by governments for sustainable construction. The chapter discusses the main challenges towards zero CDW generation, including the costs of sustainable buildings and the consequent low level of acceptance by stakeholders, favored by the lack of policies in many countries.

Chapter 2 focuses on rural indigenous populations in India as an example of communities historically devoted to sustainability, nature preservation, and waste reduction, reuse and recycling, i.e. concepts that seem relatively new to current generations but that have their roots in pre-industrialized communities worldwide. The chapter recalls the principles of Hindu philosophy, stressing the importance that Indian populations have given to environmental sustainability.

Aquaponics is the subject of Chapter 3. Aquaponics is a natural food-growing method based on the symbiosis between fish, plants, bacteria and other organisms. Such method does not require the use of fertilizers, does not generate waste and produces fish and vegetables in a sustainable and safe way. The chapter describes the aquaponic process detailing the different phases: fish feeding, microbial conversion of fish waste (nitrification), absorption of nutrients from the root systems of plants and return of clean water to the system.

Chapter 4 is a review of Indian regulations and policies on waste management. The review recalls the waste management system in India, the bodies involved, the main reg-

ulations on sanitary landfilling, but also the main barriers towards the full compliance with the regulations, especially the lack of laws on the selective collection of waste, improper behaviors by users, the fractionation of India in its federal structure and the low level of e-waste recycling in industries. The ideal zero-waste target is extremely challenging in big Indian cities, as the authors conclude that an appropriate legislation supporting the achievement of zero-waste targets is lacking in India. However, virtuous examples of Indian regions and other international locations attaining high selective collection rates (> 90%) are presented and discussed.

The focus of Chapter 5 is on the recent advances in technologies for the valorization of agricultural and food wastes. The chapter starts with an introduction on the environmental issues caused by the exponential increase in the global population and the consequent production of agricultural and food waste, which, if not properly managed, are significant contributors to greenhouse gas emissions. The chapter then focuses on the possible solutions for a correct management of biodegradable waste. Thermochemical (pyrolysis, gasification, torrefaction, hydrothermal carbonization and supercritical fluid extraction) and biological technologies (anaerobic digestion, enzymatic hydrolysis and fermentation) for food and agricultural waste management are discussed in detail, including the products that can be obtained in biorefineries, and the main advantages and disadvantages of each process are presented.

Chapter 6 deals with the remediation of a specific pollutant category in wastewater: chlorinated organic compounds (COCs), i.e. persistent organic pollutants like polychlorinated phenyl, chlorobenzenes, polychlorinated alkanes, polychlorinated alkenes and polychlorinated phenols, used in many industrial applications. The authors present the origins of COCs and their effects on human health. Most of the chapter is dedicated to a detailed presentation of the removal technologies that can be applied to wastewater. Besides conventional (adsorption) and established methods (membrane separation, advanced or electrochemical oxidation, cold-plasma discharge), novel options are presented, based on catalysis. Specifically, catalytic process involving zero-valent metals and transition metal oxides, the latter also used as photocatalysts. Nanocomposite materials based on metal oxides have shown great potential for COC removal at accessible costs.

Chapter 7 firstly describes the zero-waste concept, stressing the importance of re-designing production and supply chains rather than investing in reuse or recycling. Afterwards, the chapter focuses on the role of non-governmental organizations (NGOs) in promoting a zero-waste culture and, in some contexts like India, contributing to the achievements of targets that municipalities cannot reach alone, like door-to-door collection, promoting producers' responsibility, promoting awareness campaigns among citizens or employing waste pickers as specialized waste-management personnel. Specific examples of Indian NGOs operating in the field of waste management are given.

Chapter 8 discusses the role of carbonaceous materials in the removal of pharmaceutical and personal care

products (PPCPs) from wastewater. The authors firstly present the origin, physical and chemical properties, toxicity, fate and typical concentrations of the most common PPCPs found in water environments, including wastewater treatment plants (WWTPs). In the second part of the chapter, carbonaceous materials (activated carbon, carbon nanotubes, graphene and derivatives, biochar and mesoporous carbons) and their effectiveness in removing specific PPCPs are reviewed. The authors conclude that activated carbon is still the preferred option due to its price and its well-known properties.

In the following chapter (Chapter 9), the authors analyze the factors influencing household waste management from the social and cultural points of view. Specifically, the selective collection rate at home is influenced by social factors like demographic characteristics of the users, the users' psychology (e.g., required effort and sensitivity to environmental issues), economic convenience and the level of compliance with existing policies. Strategies to improve household waste management include the involvement of NGOs, persuasive communication, investing in public education and any other measure to facilitate separate disposal of waste (e.g., strategic placement of waste bins, providing a positive image of waste management officials). The chapter ends with considerations on the potentials of Internet of Things for supporting waste collection.

Chapter 10 deals with the recent advances in the fashion and textile industries in terms of product sustainability and waste management. This sector generates 2.1 billion tons of clothes disposed of every year and is considered as the second main contributor to the global environmental impacts after the oil industry. The concepts of zero-waste fashion (i.e. a way of producing textiles that makes use of techniques allowing for no discard of textiles) and re-fashion (i.e., the reuse and upcycling of used clothes) as well as the role of fashion designers are then discussed. Afterwards, the authors present possible recycling pathways, including fabrics to fabrics, plastics to fabrics, food/agricultural waste to fabrics and leather, and fabrics to construction materials. However, due to the high costs currently involved, the market is still not ready to accept the complete reprocessing of clothes.

Chapter 11 focuses again on agricultural waste, but with the purpose of exploring the current barriers in waste management. The chapter presents the unexploited great potentials for fuel and energy production of the agricultural waste produced in USA, Africa, Asia and Europe. The authors then review additional biological treatments (solid-state fermentation for the production of enzymes, antioxidants and antibiotics, dark fermentation for hydrogen production, composting, vermicomposting and larvae-mediated bioconversion to produce biofertilizers and animal food) and chemical treatments (acid/base-catalyzed transesterification to produce biodiesel from oils and fatty acids). The authors identify logistics and its economy as the biggest hurdles in agricultural waste management. Increasing energy efficiency, subsidies and policies from governments, strategic location of biorefineries and promoting awareness on the value of agricultural waste are regarded as key steps to support a circular economy in this sector.

Though not directly related to the zero-waste concept, Chapter 12 introduces the ongoing research on ammonia (NH₃) synthesis, intended as a sustainable carrier of renewable energy. Specifically, NH₃ can be produced through different approaches, namely homogeneous catalysis, heterogeneous catalysis and electrochemical methods exploiting renewable energy sources that are not constant by nature (e.g., photovoltaic and wind energies). The first two routes are particularly promising in terms of reaction rates and selectivity, providing that catalyst durability is improved and costs are reduced.

Chapter 13 deals with the management of solid waste through the zero-waste concept. Solid waste is reviewed as a potential source for different purposes: food waste can be used for the production of bioenergy; food, plastic, electronic and industrial (e.g., waste tyres) waste can be used for the production of intermediate materials for energy storage and conversion (e.g., carbonaceous materials, sunlight conversion films); plastic waste can be used as construction materials (blocks, bricks, flooring, wood walls or pavements); plastic waste and fly ash can be used in cementitious composites; plastic, agricultural and textile waste may be used as insulation materials; food and agricultural waste can be converted into biodegradable bags, films and packaging materials. The main barrier is represented by the need for a very efficient selective collection system, since waste separation at the source is essential to avoid material contaminations.

Economic aspects related to waste management are discussed in Chapter 14. Figures on the global market values of municipal solid waste, electronic waste, plastic waste, hazardous waste, automobile waste and waste-to-energy streams are given. The authors review the factors influencing the failure of the waste market under a zero-waste perspective: the absence of governance and policy interventions (e.g., landfill taxation schemes and support to sustainable production and reuse/recycling strategies), illegal waste dumping and a lack of planning regarding infrastructures. Recycling would create jobs and revenue and, thus, it represents a great opportunity for every country. The authors present the Life Cycle Cost analysis as a useful tool for both economic and environmental perspectives regarding recycling. Afterwards, the focus moves to policy instruments, which are crucial to ensure the transition towards a circular economy. The authors start describing the challenges in developing countries, mainly related to lack of public financial resources to support the private sector. Then, some policy instruments are presented: compulsory recycling of recyclable materials, fees for residual solid waste production, communication campaigns, subsidies and green public procurement.

Chapter 15 highlights the role of microalgae in the production of biofuels, food and valuable chemicals. This interest is justified by the potentials of microalgae: indeed, the mass-specific assimilation of CO₂ by microalgae is about 200 times higher than other plants and microalgae do not require freshwater or cultivable land. The main microalgae constituents, products and their uses are listed. Opportunities for the direct utilization of secondary products and the methods for their conversion are reviewed. In

addition, the authors present in detail the best approaches available in microalgae biorefineries, focusing on closed-loop and self-sustainable models, which make biorefinery processes viable also from the economic point of view. Furthermore, different available options for the sustainability assessment of microalgae biorefineries are presented: Life Cycle Assessment, techno- and socio-economic analyses and multi-criteria decision analysis.

The last section (Chapter 16) focuses on the removal technologies of melanoidin from wastewater. Melanoidin is released by distillery, fermentation, coffee extraction and pharmaceutical industries. Once in the environment, it may form stable complexes with metal ions, reduce soil alkalinity and the availability of magnesium. In the first part of the chapter, the main sources and properties of melanoidin are presented, including its genotoxicity and cytotoxicity. Furthermore, physicochemical (coagulation, flocculation, electrocoagulation, adsorption and membrane filtration) and biological (anaerobic digestion, bio-trickling filtration, bio-oxidation and constructed wetlands) treatments, with their advantages and disadvantages, are discussed in detail. A combination of physicochemical and biological treatments, rather than single processes, allows for the best results in melanoidin removal. Finally, recovery options for the reuse of melanoidin in the production of cosmetics and biosurfactants are presented.

Overall, although some chapters are specifically dedicated to recycling, renewable energies and remediation techniques more than waste prevention, the book provides the readers with interesting examples of zero-waste approaches in several production sectors, policies and socio-economic tendencies that have been or are currently applied in different countries, highlighting differences between developed and developing countries.

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