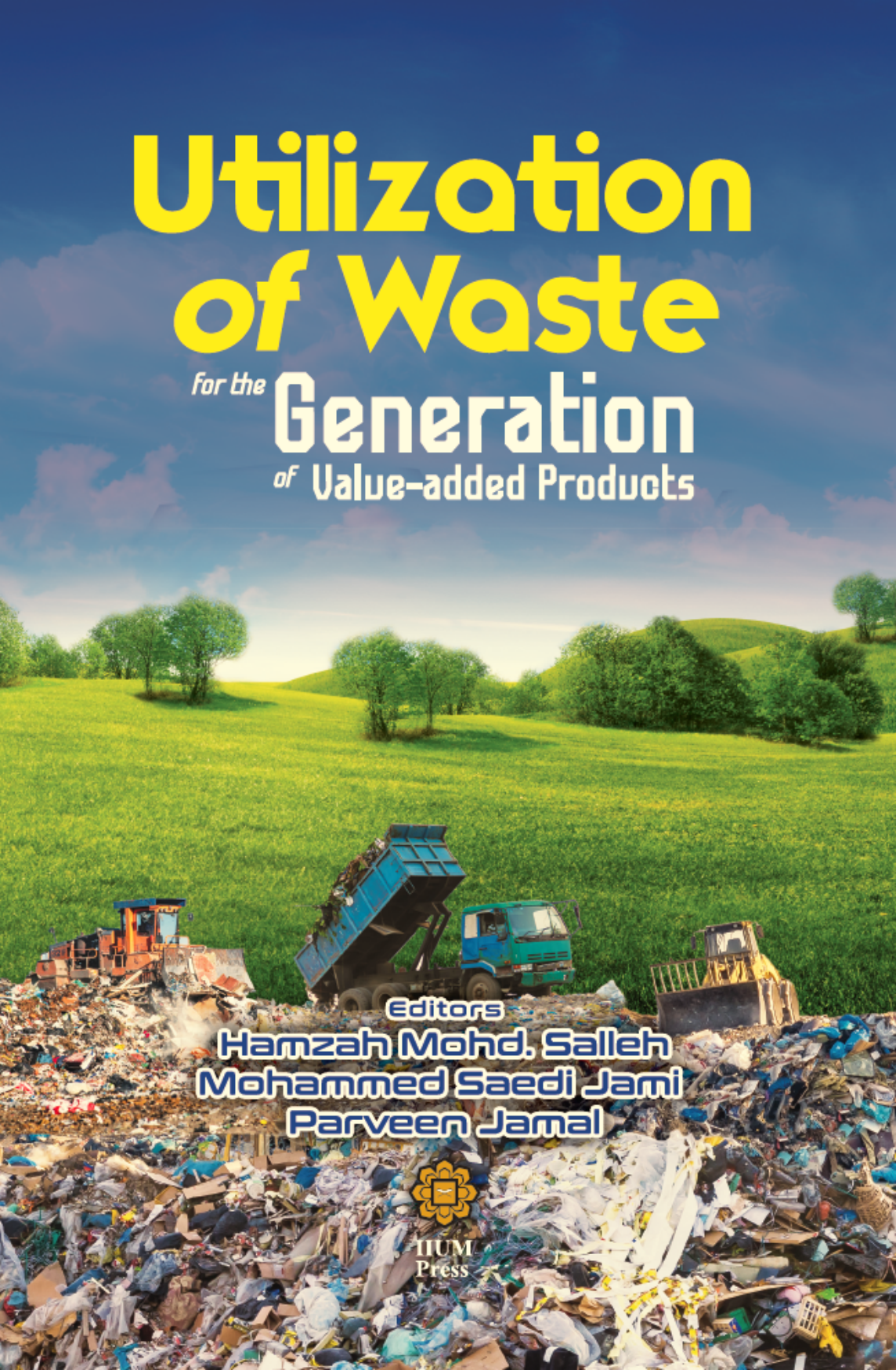
Utilization of Waste for the Generation of Value-added Products



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PREFACE

Utilization of renewable biomass waste for the production of value-added products is one of the pertinent sustainable strategies. There are various waste materials abundantly available which are harmful if discharged to the environment untreated. The backlash of waste generation from settlements and industries poses serious waste management problem causing health hazards and degradation of the environmental quality. This prompted biotechnologists, engineers and scientists to engage in materials and biotechnology research aiming at turning waste to wealth. For that to be realized conversion process became quite pertinent. Progress in this area was augmented in the localities which did not have enough lands for waste disposal. This way, waste utilization became the integral part of waste reduction and waste management strategies. The utilization of waste helps alleviate degradation of the quality of the environment. This became popular in developing and least developed countries because waste to wealth efforts has high potential of income generation. The best example is producing biodiesel from empty fruit bunches and ethanol manufacturing from sugar industry wastes.

The purpose of bringing out this volume is to present a conglomeration of articles comprising a variety of researches related to conversion of waste into value added products and some treatment methods. As no book on biochemical research can cover all its areas, this concise book will discuss some of the pertinent aspects of this branch of science and engineering.

The authors would like to acknowledge the contributions of Dr. Amal A. Elgharbawy, Nik Rashida Nik Abdul Ghani and Mohd Nazri Mohd Nawi during the preparation of the book.

HAMZAH MOHD. SALLEH
MOHAMMED SAEDI JAMI
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INTRODUCTION

Global warming has many consequences including the water crisis and land desertification that lead to food shortage due to the low productivity of lands, which impacts the world's economy. Moreover, excessive consumption of fossil fuels, particularly in large urban areas, has resulted in the generation of high levels of pollutants in the air, water and soil. The level of greenhouse gasses in the earth's atmosphere has drastically increased. With the expansion of human population and increase of industrial prosperity, global energy consumption also has increased drastically.

Human activities produce wastes that are hazardous or nonhazardous. In the waste hierarchy set by the European Union Waste Framework Directive, the following order is prioritized for any waste unit: reduce–reuse–recycle–recover–landfill. This implies that waste should mostly be at a minimum, while products should be reused as they are, or their materials should be recycled whenever possible. Otherwise, waste should be recovered for energy which can serve as a good alternative to using fossil fuels or harvesting biological materials. The least desirable option is to discard the waste to a landfill which indeed is not encouraged as waste emissions could still leach into the environment.

There is a wide range of waste discharged into the environment daily. Current waste treatment methods to minimize undesirable environmental effects are divided into two categories: conventional and novel methods. Conventional methods embrace (1) bioremediation; including anaerobic fermentation, methanogenesis and initial remediation; (2) land fertilizer and animal feed; (3) biotransformations and bio-peroxidase catalysts; (4) biochemical reactions such as biofuels and biodegradable plastics; (5) separation and components recovery. On the other hand, novel methods could consist of the same categories with rather upgraded technologies such as membrane technologies, supercritical and subcritical fluid extraction[1]. Although such approaches are promising, the cost still stands in the way of widespread applications.

In this context, this book covers three main sectors of waste management, which include the utilization of waste, production of energy, and finally wastewater treatment. Topics include various bioprocess technologies encompassing the production of carbon source, biofuel, biodiesel and food application from natural resources or waste products.

The first few chapters (**Chapters 1-4**) depict the adoption of the waste management strategies to give certain benefits to the ecosystem in the form of clean environment and economic sustainability. Under the theme **"waste to wealth"**, the first four chapters reviewed fruit waste, such as banana, papaya and mango as a potential carbon source for animal feed production and isolation of active compounds such as polyphenols, carotenoids, dietary fibers, enzymes, phytosterols and tocopherol, which can be used in food fortification and medicinal applications. Waste does not only include natural waste, as industrial wastes are part of the daily wastes. Sludge palm oil (SPO), a difficult-to-be-used solid by-product of the palm oil milling industry, is one of the major contributors to environmental issues. Oil palms are the most efficient oil-bearing crop in the world, producing 4 to 5 tons crude palm oil/hectare annually in Malaysia, the second largest palm oil producer in the world after Indonesia[2]. This shows the large amount of SPO generated by the palm oil industry every year, which can be utilized for fatty acids production and

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[1] Arvanitoyannis, I. S., & Varzakas, T. H. (2008). Fruit/Fruit Juice Waste Management: Treatment Methods and Potential Uses of Treated Waste. In I. S. B. T.-W. M. for the F. I. Arvanitoyannis (Ed.), *Food Science and Technology* (pp. 569–628). Amsterdam: Academic Press.

[2] Thinagaran, L. & Sudesh, K. Waste Biomass Valor (2019) 10: 709. https://doi.org/10.1007/s12649-017-0078-8

animal feed supplements. SPO can also be a source of many useful microbial cultures for extracellular enzymes such as amylase, gelatinase, cellulase and lipase. These four chapters highlighted the development and applications of waste utilization in such a way to keep the cost at minimum while generating valuable products.

Waste-to-energy is the process of generating energy by treating or processing of waste into a fuel source. Most processes generate electricity or heat directly, or produce fuels such as biogas, bioethanol or biodiesel. The Limitation of natural resources of fossil fuel is one of the leading global concerns to be tackled. Primary sources such as corn and starch are preserved due to food competition; hence, biomass is currently used to generate second and third generation fuels. Empty fruit bunch (EFB) generated from palm oil plantations is one example of biomass. Under **"waste-to-energy", Chapters 5-9** cover the biotransformation of waste to any energy form. The first chapter of this category discusses the chemical vapor infiltration process for production of carbon-rich biochar from oil palm empty fruit bunch (EFB).

It shows the ability of EFB to be utilized efficiently for production of solid biofuel, which can be a sustainable solution for resource and energy problem. Noting the large amount of EFB produced annually, for instance in Malaysia, it reached around 30 million tons of EFB[3], hence, it serves as a rich carbon source for many applications, including activated carbon production. There are more raw materials generated by the palm oil industry such as oil palm biomass (OPB), palm oil mill effluent (POME) and Indah Water Konsortium (IWK) wastewater treatment plant (WTP) sludge. Those three are regarded as the major biomaterials of concern to be utilized for biofuels production through the development of bioprocess using various potential microbes isolated locally, and several in-house produced enzymes with promising activities. Many approaches have been introduced for the pretreatment of the biomass from the palm oil industry, which include physical, chemical and biological treatments, using milling, hot water, acids, alkali, ionic liquids, microbes and enzymes. Each of which has its advantages and drawbacks. Moreover, waste is not merely refuse or garbage, as commonly assumed; non-edible plant oil, for example (which some consider as waste), is one of the main sources of energy production, i.e. biodiesel. The United States and Brazil were among the largest biodiesel producers in the world, totaling some 6 and 4.3 billion liters,

[3] MPOB; Malaysia Palm Oil Board 2018

respectively, in 2017. The United States is projected to reach production levels of over 3.8 billion liters of biodiesel by 2025[4]. Development of clean energy from second generation of biodiesel entitles it to a lot of research attention covering many aspects in terms of reaction and the raw material itself.

Wastewater, as one of the major issues facing the environment, is highlighted under the theme "**blue economy**" in **Chapters 10-13**. The blue economy is the sustainable use of ocean resources for economic growth, while maintaining a healthy ocean ecosystem. Regrettably, human activities have benefited from the first while destroying the latter. Wastewater is generated from countless industries and it is distressing the balance of the water ecosystem. As a consequence, efforts have to be made in order to preserve the resources for the next generation. Wastewater treatment methods have recently been developing, and it includes several technologies such as electrochemical (e.g. electrocoagulation), chemical (e.g. coagulants, catalytic processes and adsorption) and biological technologies (e.g. microbial treatment). In this section, plant extract, graphene from palm oil mill effluent (POME) and adsorption membrane are discussed as approaches for wastewater treatment.

[4] https://www.statista.com; Energy & Environmental Services, Major biodiesel producing countries 2017. Release date: 2018.

Utilization of Waste for the Generation of Value-added Products

Utilization of Waste for the Generation of Value-Added Products deals with various methods of bioconversion of waste to wealth. The purpose of bringing out this volume is to present a conglomeration of articles comprising a variety of researches related to conversion of waste into value-added products and some treatment methods. The book consists of topics under broad areas of water and wastewater management to recent advances in bioenvironmental engineering. The book also covers diverse technologies including bioprocess technologies encompassing production of carbon source, biofuel, biodiesel and food application from natural resources or from waste products. Some novel disinfectants from natural sources such as Moringa oleifera in the context of their synthesis and applications are also discussed.

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