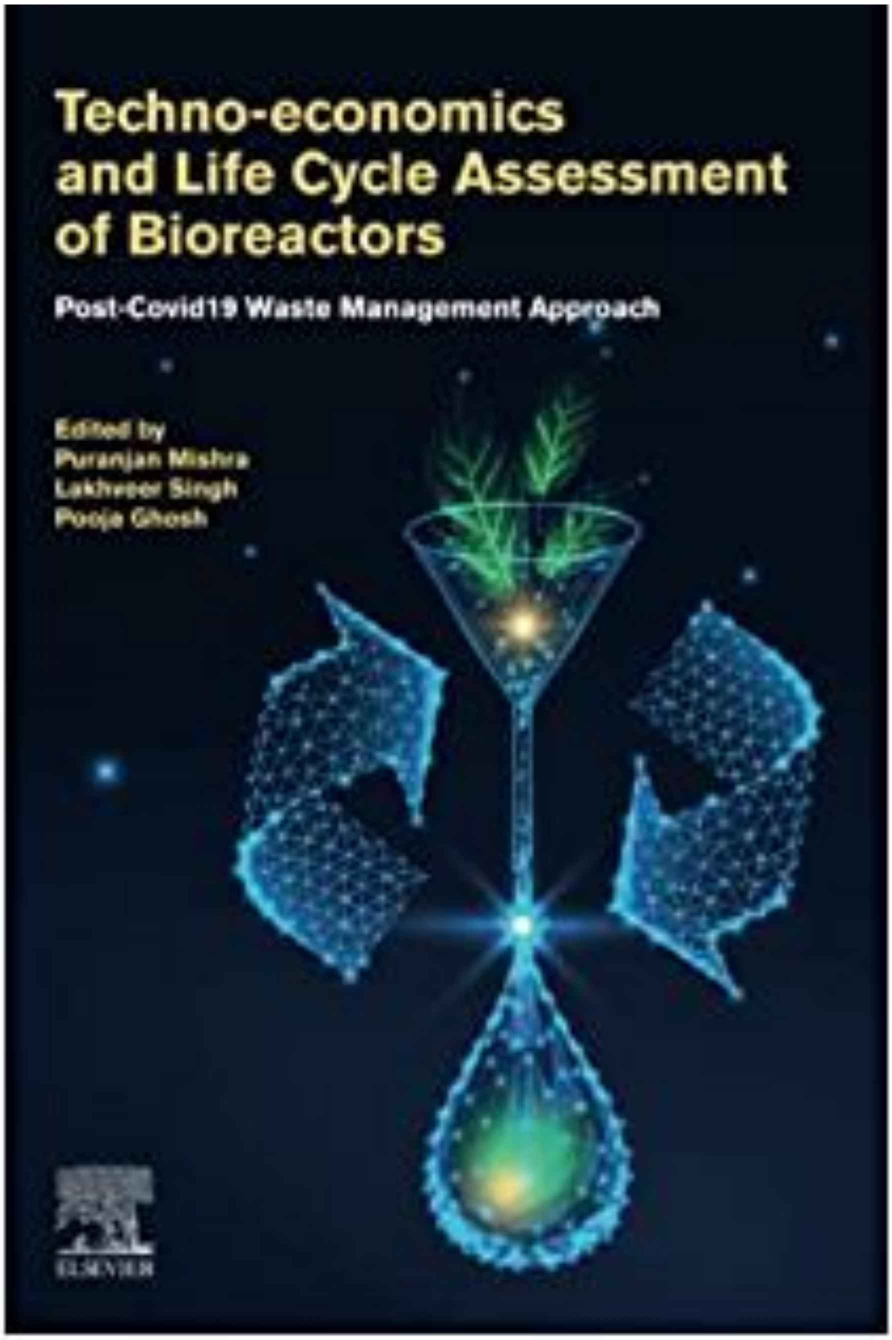

Techno-economics and Life Cycle Assessment of Bioreactors

Post-Covid19 Waste Management Approach

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Puranjan Mishra, Lakhveer Singh and Pooja Ghosh

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CHAPTER 11

Environmental and economic life cycle assessment of biochar use in anaerobic digestion for biogas production

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11.1 Introduction

Because many individuals working in urban society consume energy on a regular basis, it is an important aspect of everyday life. Environmental deterioration, on the other hand, is far worse than previously assumed. Energy scarcity and trash creation are two of the most pressing concerns in modern life. Traditional emission reduction technologies consume a lot of power and produce a lot of CO_2. Recycling materials and generating power from wastewater hold a new trend (Lam et al., 2020). Anaerobic digestion (AD) is a biological treatment that employs microorganisms to convert organic waste into bioenergy. Over the last few decades, AD has been researched in a variety of wastewater treatment applications for real-time wastewater decontamination and bioenergy yield (Wu et al., 2020; Zaied, Siddique, Nasrullah, et al., 2019). While chemical—biological interactions account for the majority of AD's efficacy, there are still substantial limitations to its wider use (Chen et al., 2020; Zaied, Siddique, Zularisam, et al., 2019). Combining a chemical—biological solution with traditional wastewater treatment technologies is presumed to improve the efficiency of natural wastewater treatment. However, a number of unfavorable elements in the AD system constantly disrupt microbial behavior, resulting in inadequate energy recovery. The build-up of free ammonia and volatile fatty acids (VFA) restricted methanogenic archaea activity, limiting the total organic loading rate (OLR) of AD methods, for example, due to intermediate metabolites (Jiang et al., 2019). Industrial wastewaters contained phenol and

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polymeric aromatic hydrocarbons resistant to biodegradation and toxic microbes (Chen et al., 2014). Antibiotic overuse in the livestock business has as well raised the prospect of bacterial deactivation in AD procedures for the treatment of manure waste (Lee et al., 2020). Consequently, designing realistic solutions to these hurdles is crucial for increasing energy production and expanding AD techniques to real-world functions.

Biochar (BC) is a carbon-rich material formed from the pyrolysis of biomass. BC has been a research hot spot in the area of soil improvement, useable substance planning, ecological monitoring, and biowaste reduction because of its unique carbon sequestration role and flexibility (Liu et al., 2019; Palansooriya et al., 2019). Since it is a low-cost component, BC may be employed as an additive to increase AD systems' functioning (Qiu et al., 2019). First, the eco-compatibility of the BC surface, as well as its established porous structures, offer effective locations for the adsorption of gaseous by-products, ammonium, and hazardous pollutants, as well as a haven for bacterial adhesion (Ahmad et al., 2014). BC's alkaline composition and organic functional groups also showed a robust buffering capability, that helped to offset pH drops triggered through VFA aggregation in AD procedures. On the other hand, BC has electrochemical characteristics that allow it to operate as a mediator in syntrophic metabolism, allowing for interspecies electron transfer. Combining the biological and thermochemical conversion systems, which are both promising waste biomass conversion processes, necessitates adding BC to the AD approach in order to increase process productivity and stability (Pecchi & Baratieri, 2019).

However, when considering the process's environmental feasibility, utilizing BC in an anaerobic bioreactor is more cost-effective. In this case, a comprehensive life cycle assessment (LCA) for the entire process is required. From conception to disposal, LCA stands as a comprehensive technique for exploring the potential implications of a product's life cycle (Vondra et al., 2019). LCA presents a complete and new unambiguous image of the genuine ecological benefits in the final stage. The International Organization for Standardization (ISO) created the ISO 14040 sequence as an international standard for LCA (Chan et al., 2016). An LCA analysis that includes upstream, downstream and waste valorization is required to provide a comprehensive and accurate picture of the business. With respect to energy concentration, environmental consequences, and economic repercussions, new advances must be considered (Máša et al., 2013). The economic viability of LCA incorporation is influenced by a number of factors. There are other expenses, such as digested transportation and application, liquid digested dry matter quality, evaporator energy utilization, and so on, in addition to the spending expense.

The completion of method modeling by limited information and understanding, as well as the creation of relevant LCA findings for identifying strategic environmental decisions, are the key difficulties of LCA. LCA has to be used to determine the most ecologically acceptable technical factors and create biomolecules to assure the ecological consequence of this technology from an environmental perspective (Chopra et al., 2020). Some challenges would be solved, such as design concerns caused by stream limits in manufacturing, the necessary molecules, and sensitivity testing of certain parameters at the AD plant size. The output restrictions should be considered while designing the method (nature and quantity of biomolecule). As a result, modeling the entire process with these constraints is unusual in LCA studies of AD facilities, where modeling is often based on the amount of waste handled (Foulet et al., 2019). For sensitivity studies, the selection of principles for each investigated factor is required. This familiarity of performance, however, is still absent in the issue of developing technology.

11.2 Life cycle assessment technology

LCA has been acknowledged as an advanced way to analyze its by-products' cumulative effect across its life cycle considering environmental aspects. LCA is being carried out in a variety of domains in order to provide the most accurate feasible evaluation (Parra-Saldivar et al., 2020). The usage of LCA in waste and wastewater treatment technologies, as well as new breakthroughs in LCA and their effective use to identify the destiny of dangerous compounds, are all important problems that must be addressed. According to the available literature, the production of various pollutants is a hot spot throughout the life cycle of different manufacturing processes. Synergies between various industrial sectors, combined with LCA techniques, result in highly productive, accurate, effective, and long-lasting manufacturing processes with minimal environmental impact. A well-designed LCA protocol often delivers detailed knowledge to manufacturers, customers, regulators, and regulatory bodies, allowing LCA to be used in more realistic ways, mitigate environmental insecurity, and reduce human health risks.

As a result, assessing the environmental impact of many production units that create and release a variety of undesired chemicals into the

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