CHAPTER 3
TRANSFORMING WASTEWATER INTO VALUE-ADDED BY-PRODUCT

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3.1 INTRODUCTION

Innovation has emerged as our most effective defence against the looming disaster in an era characterised by the twin problems of growing population expansion and environmental degradation (Azelee et al., 2020). Chemical and biological approaches are some of the important methods that can be utilised to cater to environmental issues (Dailin et al., 2019). The often-overlooked but important field of wastewater management, a space rife with complex issues that go beyond conventional concepts of trash disposal, lies at the junction of these difficulties (Dailin et al., 2022a). The need to handle this complicated environment has led to the development of groundbreaking ideas for turning wastewater into useful fertiliser products. This approach not only addresses the urgent wastewater problem but also has the potential to transform agricultural sustainability and environmental harmony (Khan et al., 2022). According to how they manage their water resources, civilisations have either prospered or failed throughout history. Urbanisation and industrialisation have increased the amount of wastewater produced while simultaneously increasing its complexity and

loading it with a variety of pollutants, from organic matter to heavy metals (Qin et al., 2014). Discharging treated or untreated wastewater into rivers and oceans is a common practice known as the "out of sight, out of mind" strategy. This strategy has shown itself to be increasingly unsustainable. The consequences, including ecosystem disruption, soil erosion, and water contamination, have cast a long shadow over human progress.

Considering this sobering reality, there has been a tremendous increase in interest in the concept of turning wastewater, a term associated with impurity and waste, into a resource filled with possibilities. This paradigm change exemplifies the spirit of the times, which is to reframe obstacles as possibilities, alter how we view waste, and use science and technology to promote regeneration. The transformation of wastewater into fertiliser is evidence of human ingenuity and imagination, converting a seemingly unsolvable issue into a ray of hope (Glasser, 2019). This article sets off an investigation into this intriguing journey, probing the origins of wastewater treatment and its development into a catalyst for reviving agriculture. It skirts the complex scientific issues, cutting-edge technological developments, and ecological effects that underlie this transition. The deep advantages offered by this approach will become evident as progress is made across these domains, encompassing benefits that extend beyond mere effective wastewater management to fostering a more resilient and enduring agricultural sector. Innovative technologies that take advantage of wastewater's untapped potential are what distinguish the journey from waste to wonder. Science is paving the path for a future where waste is reinvented as a cornerstone of growth, from the chemical process of recovering nutrients to the cultivation of microbes that transform toxins into precious resources. These innovations perfectly encapsulate the circular economy, which is a regenerative system that collects, processes, and repurposes resources while reducing waste and maximising utility. The switch from wastewater treatment to fertiliser production is complicated by legal frameworks, public opinion, economic viability, and long-term ecological effects. These difficulties will not be avoided in this article; rather, they will be addressed head-on to illuminate both the benefits and the dangers of this transforming journey.

There are several facets to the complex link between fertiliser, wastewater, and agriculture, and these relationships have important consequences for both the environment and human civilisation. Research has shown that wastewater from urban areas, agricultural runoff, and industrial activities contains nutrients that may be applied to crops as fertiliser (Zhang & Shen, 2017). Sewage sludge from wastewater treatment plants is also utilised as fertiliser; the usage of wastewater as a source of nutrients for agriculture dates back millennia (Zahra et al., 2020). Although wastewater is often used in agriculture, it poses challenges such as heavy metal accumulation in soil and crops, which can be harmful in the long run (Alnaimy et al., 2021).

There is significant concern regarding agriculture's contribution to water pollution since agricultural activities are notorious for adversely affecting surface and groundwater quality (Stoyanova & Harizanova, 2019). The use of wastewater for irrigation can also introduce chemical and biological contaminants into the soil, thereby reducing fertility and posing health risks to humans and the environment (Becerra-Castro et al., 2015). Additionally, the practice of using wastewater in agriculture has been associated with a rise in antimicrobial resistance in both soil and water, highlighting the inherent risks involved (Slobodiuk et al., 2021).

Conversely, crop yields can actually be increased by agricultural wastewater that contains nutrients like phosphorus and nitrogen (Syafrudin, 2023). Furthermore, recovering phosphorus from wastewater for use in agriculture is a viable means of creating a sustainable loop, as it permits the recycling of this essential nutrient from urban settings back into agriculture, contributing to a more sustainable cycle of nutrients (Lam et al., 2022). Furthermore, cutting-edge technologies, such as producing biofertiliser from algae-treated wastewater, offer promising avenues for environmentally and resource-conscious agricultural practises (Zou et al., 2020).

To summarise, the complex relationships between fertiliser, wastewater, and agriculture necessitate careful management in order to balance the advantages of recycling nutrients with the possible hazards to the environment and public health. Technological advancements,