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Analysis of the Energy Use in Wastewater Treatment Facilities from an Economic Perspective

Asad Iqbal*

Department of Industrial and Systems Engineering, De La Salle University, 1004, Manila, Philippines

Abstract

The primary operational expense for wastewater treatment is energy. In North America, wastewater treatment facilities use 1-4 percent of the nation's overall energy output, while in Europe, they use about 1 percent. The primary energy users were identified as the aeration equipment connected with biological treatment (58 percent), intake pumping (9 percent), deodorization (8 percent) and sludge treatment equipment in a funded project in the north of Portugal (6 percent). For the survival and expansion of water service organizations as well as for improving management practices, it is crucial to evaluate the efficacy of wastewater treatment plants (WWTPs). Management in a circular economy context entails implementing circular economy business models (CEBMs), which ought to result in more affordable, ecologically friendly and sustainable technology.

Keywords: Wastewater treatment station • Energy consumption • Bioenergy

Introduction

While WWTP energy reductions have been studied in recent years, there is currently little published data on their operational expenses. Instead of cost-savings, the emphasis is on process optimization. Studies have shown that additional research is still needed in order to fully understand the nutrient removal, polishing treatments and operational costs of nature-based wastewater treatment solutions. Despite the large range of chemical and biological methods available for nutrient removal, these procedures often have substantial operating and investment costs that reduce profit margins [1]. Therefore, studies that compare the operating costs of various wastewater technologies are essential for determining the most effective management of WWTPs.

Description

Diverse activities (such as household, urban, industrial, runoff, agricultural and sanitary landfilling) can create waste water, which can lead to different physical, chemical and microbiological properties. Conventional WWTPs use physical processes like ultrafiltration and ion exchange, chemical processes like chemical precipitation, electrochemistry and biological filters, as well as biological processes like activated sludge, biological filters, stabilisation ponds, constructed wetlands and anaerobic digestion. For the essential removal of organic materials and nutrients, these traditional biological treatment procedures need to overcome financial and technological constraints. In order to improve treatments, it is sometimes required to add artificial aeration or chemical additives, which consumes a lot of energy and is useless for sequestering carbon.

Wastewater treatment is a resource-intensive process that consumes a lot of resources, mostly electricity and costs between 15% and 40% more to operate than traditional wastewater treatment facilities. If there are no adjustments made to the processes, the energy consumption tends to rise further due to the anticipated demographic growth and the tightening trend in quality criteria for effluent disposal [2]. In an effort to map the processes and aid in decision-making when looking for more effective options, the literature compiles data on the energy consumption of various wastewater treatment systems. The recovery of energy from sewage is one of these options. A global trend is the hybrid treatment system, which treats wastewater and generates electricity at the same time. Recent research in Brazil has demonstrated the energy feasibility of anaerobic-aerobic systems with algae production. This study compares the energy usage of several wastewater treatment facilities in an effort to better understand and manage the processes. The findings revealed that there aren't many published Brazilian statistics, indicating that the nation still needs more research on the topic to enhance its procedures. The majority of research on wastewater treatment identify the aerobic process as the biggest energy user. Efforts are concentrated on improving the traditional system, but so far with little success. Water supply plans and environmental objectives are not well integrated with energy handling, which results in inefficient usage and has negative economic and environmental effects [3].

For the treatment and reuse of wastewater, novel microalgae-based technologies have recently emerged that use one or more microalgae species or work in conjunction with bacteria that have been colonised in photobioreactors (PBRs). Tanks, channels and lagoon/pond reactors are examples of PBRs. Particularly for a 1:5 microalgae:bacteria ratio with lower energy requirements, microalgae consortiums are advantageous in removing organics, nitrogen and phosphorous through biodegradation pathways, assimilation and plant uptake. Additionally, within the context of CEBMs, these technologies enable the creation of goods with added value from the biomass. As a result, there is growing interest in algae-based wastewater treatment technologies, such as high-rate algal pond systems, which can effectively remove organics and nutrients from wastewater and produce algae biomass that may be valued. Studies on HRAP operational costs and comparisons with those of traditional systems are few and far between, particularly in terms of population equivalent and quantities of treated wastewater. In comparison to typical pond systems, HRAPs are shallow ponds with low-power paddle wheels that circulate wastewater to produce high algal biomass and quick nutrient removal. However, a shallow depth operation reduces the pond's overall volume but also raises running expenses since a bigger surface is needed for a given effluent flow [4].

Utilizing a biorefinery, circular economy and the valorization of organic waste biomass, the algal biomass may be utilised to create goods that are carbon-neutral, such as biofuel, feed, and fertiliser and plastic. Combining

***Address for Correspondence:** Asad Iqbal, Department of Industrial and Systems Engineering, De La Salle University, 1004, Manila, Philippines; E-mail: aiqbal01@connect.ust.hk*

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algal treatment with wastewater treatment would allow for a reduction in the cost of WWTPs, either via the sale of the algal biomass as a product or by joint use of it to enhance the biofuel. In order to make biofuel, CO_2 must be taken out of the equation in order to create a high-purity CH_4 stream (bio methane), which can take the place of conventional natural gas [5].

Conclusion

The study's findings suggest that HRAP-based solutions, particularly for small settlements, might be a promising alternative technology for wastewater treatment. In addition to being effective in removing pollutants, they may produce goods with added value by valorizing algal biomass, which can result in energy cost reductions of 0.05-0.41 EUR/m^3, 15.4 EUR/person and 180.8 EUR/person. Additionally, this technique not only offers financial benefits but also reduces carbon emissions by saving around 45 kg CO_2 eq/inhabitant year, indicating that biotechnology is beginning to establish itself as a crucial future option in the wastewater treatment industry.

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Conflict of Interest

The authors declare that there is no conflict of interest associated with this manuscript.

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