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L. Fitzsimons, M. Horrigan, G. McNamara, E. Doherty, T. Phelan, B. Corcoran, Y. Delauré, Eoghan Clifford



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Benchmarking the thermodynamic performance of Irish municipal wastewater treatment plants using exergy analysis

L.Fitzsimons^{*,1}

¹School of Mechanical and Manufacturing Engineering
Dublin City University, Dublin, Ireland
e-mail: lorna.fitzsimons@dcu.ie

M.Horrigan¹, G.McNamara¹, E. Doherty², T.Phelan¹, B.Corcoran¹, Y.Delauré¹ and Eoghan Clifford²

¹School of Mechanical & Manufacturing Engineering
Dublin City University, Dublin, Ireland

²College of Civil Engineering and Informatics, Ryan Institute,
National University of Ireland, Galway, Ireland

ABSTRACT

Wastewater treatment is a resource intensive process utilising several inputs such as energy, chemicals and water to produce an effluent that meets designated environmental standards. It is predicted that increasingly stringent discharge requirements will include better treatment of nutrients and the need to treat emerging pollutants, i.e. pollutants not commonly monitored in the environment currently, but which have the potential to cause environmental damage. One expected outcome of increased effluent standards is higher energy consumption. Coupled with this, fluctuating energy costs and the need to mitigate fossil fuel based carbon emissions have led to a greater focus on the energy efficient operation of wastewater treatment plants. Exergy Analysis has been identified as a useful tool to assess the resource efficiency of thermal and other energy systems. The exergy approach provides a rational basis for process optimisation, where, in theory, the processes with the greatest exergy destruction represent the greatest energy efficiency opportunities. In this research, exergy analysis has been used to assess and compare the energy/resource efficiency of two Irish wastewater treatment plants. One important objective is to investigate the appropriateness of exergy analysis as a potential benchmarking approach for wastewater treatment plants. Although the two wastewater treatment plants are of similar scale, and use similar technologies, the results of the exergy analysis were significantly different. For example, the secondary treatment exergy destruction differed by as much as 67% between the two wastewater treatment plants. Furthermore, the coupled pre-treatment and secondary treatment exergetic efficiencies of both plants differed significantly: one wastewater treatment plant had an exergetic efficiency of 27.5% in comparison with 40.2% for the second plant. One important mitigating factor was identified: the difference between their incoming wastewater concentrations. These results indicate that metrics such as exergy destruction when combined with consideration of water quality can be a useful tool in the comparing the overall performance of wastewater treatment plants.

KEYWORDS

Exergy analysis; wastewater treatment; resource efficiency; energy efficiency; benchmarking.

1. INTRODUCTION

Wastewater treatment is a resource intensive process, with three main resources being identified as those of greatest concern: energy, chemicals and water. According to the United States Environmental Protection Agency (United States EPA, 2006), wastewater treatment accounts for approximately 1% of the world's total energy consumption and 3% of the

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