



## Review

## Life cycle cost analysis of wastewater treatment: A systematic review of literature

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## ABSTRACT

The last two decades have witnessed a substantial increase in literature on the life cycle costing of Wastewater treatment. Lack of commonly agreed methodology of life cycle costing resulted in the use of different frameworks and methodologies. Methods and approaches in conducting life cycle cost analysis are also evolving, and a gradual shift from conventional to environmental and societal life cycle costing is witnessed in the last decade. However, a detailed systematic review of methods and approaches of life cycle costing in Wastewater treatment is still lacking. A comprehensive and systematic review provides an opportunity to record existing development in the field and identify areas where more research is needed. For this purpose, this paper systematically reviews the literature on the life cycle cost analysis of wastewater treatment, focusing on purpose, approach, methodology, integration with life cycle assessment, cost estimation, and dealing with uncertainty. The analysis of 83 identified case studies indicated that most of the studies are conducting for affordability and comparative analysis. A gradual shift from conventional to environmental life cycle cost analysis is also observed. 44% of the studies are integrated with Life cycle assessment through different methods. However, in these integrated studies, life cycle cost analysis is used as a secondary tool to supplement the life cycle assessment. Analytical and statistical methods are generally used for cost estimation. Deterministic methods are most common to deal with uncertainties. Based on the comprehensive review of case studies, it is suggested that future research should aim at developing a framework for life cycle cost analysis that could consider and allocate all costs associated with the Wastewater treatment process.

## 1. Introduction

Over the past two decades, increasing awareness and sensitization have been observed globally in various cost-effective models of wastewater treatment (WWT). Various public and private authorities are required to find efficient and effective ways of industrial wastewater treatment. Researchers have been investigating WWT processes from the technological, economic, social, and environmental perspective. Attempts have been made to combine these perspectives in a single case study.

The lifecycle approach represents tools for economic and environmental evaluation of products, services, or processes. Life cycle assessment (LCA) and Life cycle cost analysis (LCCA) are used for environmental and economic assessment, respectively. Both of these techniques are used to measure and quantify the impacts (environmental and economic) associated with all stages of the product, process, or service from cradle to grave.

The Society of Environmental Toxicology and Chemistry (SETAC) classified LCC into Conventional, Environmental and Societal LCC. Multiple methodological frameworks and established theory of the computational structure on Conventional LCC exists. Moreover, industry-specific international standards and guidelines (ISO 15686-5, ISO 15663-2, IEC 60300-3-3, BS 3843, AS/NZS 4536) have been developed for these methods. The case of Environmental LCC is less clear, though its theory and methods are evolving but still lack uniformity in methodology. Even the recent Code of Practice does not specify any framework to use (Heijungs et al., 2013). Environmental LCC, which Rebitzer et al. (2003) called as economic “cousin” of LCA, has not had any widely established framework and commonly agreed methodology. Although SETAC scientific group on LCC developed a methodology for Environmental LCC (Hunkeler et al., 2008; Swarr et al., 2011), the technique is still complicated and difficult to implement, data-intensive and inherently imprecise. While societal LCC is still at an early stage of development, and more research work is required.

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