Abstract

Background: By complying with specific key performance indicators (KPIs), wastewater treatment plants (WWTPs) reduce pollutants from wastewater before discharge into water bodies. However, its potential negative impacts during the operational phase are often overlooked. The sector's demand for wastewater quality and sustainability practices is growing. The obligation is to satisfy nitrogen removal and map greenhouse gas (GHG) emissions to align with the EU and Norway's net-zero ambitious target (up to 95% reduction by 2050). Life Cycle Assessment (LCA) based quantitative environmental impact assessment (EIA) is in high demand. Nevertheless, most studies utilize commercial LCA tools such as SimaPro, less accessible to WWTPs.

Purpose: Using the case study of municipal WWTP, Søndre Follo Renseanlegg (SFR) in Norway, this thesis aims first to identify and evaluate the environmental and economic performance of several WWTP operations, e.g. and additional biological treatment using membrane aerated biofilm reactor (MABR). The innovative aspect of this thesis is assessing SFR's new technological investment against sustainability performance. The second is to build sustainability innovation and insights for both the client/end-use, i.e., the WWTP, and the company in the wastewater sector, DOSCON AS /thesis scholar host.

Methods: ISO 14040/44:2006 LCA is used for heavily technical environmental impact evaluation. The system boundary includes wastewater pumping to the WWTP, energy, and mass input-output from WWTP operations to by-product transport (gate-to-gate). SimaPro v.9.5.0.1 (UiA' faculty license), Excel spreadsheet with 80% on-site primary data, and Ecoinvent v3 database for secondary data are used. Life Cycle Cost Assessment (LCCA) and net present value (NPV) are performed for economic valuation, highlighting the investment's importance in alternative WWTP operations. The comprehensiveness, sensitivity, and uncertainty of data and results in LCA are evaluated; however, such efforts are comparatively limited in LCCA.

Findings and value-added: The life cycle impact assessment (LCIA) results identify global warming potential (GWP, 87%) and photochemical oxidation creation potential (POCP, 11%) as the key impact indicators in existing WWTP operations. Which was identified in the biogas production phase. These impacts are significantly lessened by more than 90% compared to the future alternative WWTP operation (Scenario 2), which uses an additional biological treatment and combined heat power generation. At the same time, it effectively reduces nitrogen content and achieves more than 50% eutrophication potential (EP) reduction. The scenario also requires less investment, environmental costs, and operational expenses, despite its negative NPV, making the full-scale practical implementation of Scenario 2 practically viable for SFR.

The added value for academics and business is that comparing the results between the commercialized LCA tool and simplified modeling for LCA in an Excel spreadsheet depicts satisfactory alignment with a minor difference (<1%) for the identified hotspots, GWP, and POCP. The latter approach is deemed sufficient and practically viable for WWTP; however, more datasets are still required to confirm other impact indicators that significantly drifted from SimaPro results, particularly for EP-related substances.

Keywords: site-specific LCA; manual LCA calculations; Norway's WWTP operations