Evaluating the Environmental Impacts of Wastewater Treatment using Life Cycle Analysis Software

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Overview

- Sustainability / LCA Overview
- Introduction to SimaPro Software
- LCA Modeling Examples
  - 20 mgd WWTP
  - Biosolids Disposal Alternatives
Traditional Approach to Planning & Design

Meet Regulatory Requirements and Manage Costs
State of the Industry

- Environmental protection has been regulated for nearly 40 years in the US
  - Definitions and standards have evolved significantly

- Recent focus on sustainability, carbon footprinting, and energy efficiency
  - Accurate and defensible means to quantify these parameters is needed
Sustainability Drivers

- Population growth
- Dwindling water supplies
- Energy costs
- Climate change
How Do You Measure Sustainability?

- Sustainability Tools:
  - LEED
  - LCA
  - TCA
- EPA Tools:
  - Energy Star Rating System
Life Cycle Assessment (LCA)

CO2 Emissions

Transport: 31 kg

Extraction & Manufacture: 15 kg

Use: 0 kg

Disposal: 1.2 kg

Source: Pre Consultants
What is LCA?

• LCA has emerged as the standard for quantifying the environmental impacts of a particular product or process.

• The goal of LCA is to account for the full range of environmental impacts attributable to processes.

• The term “life cycle” requires cradle-to-grave assessment, including raw material, production, manufacture, distribution, use and disposal.
Benefits of An LCA Approach

- A holistic approach to alternative selection
- Emphasis on environmental impacts
- Helps avoid burden-shifting
- Ability to quantify and prioritize impacts
What Environmental Impacts are Defined?

- Global Warming Potential/Ozone Depletion
- Air Pollution and Acidification Impacts
- Ecotoxicity and Human Health Impacts
- Habitat Loss and Resource Consumption
What is Simapro?

- Simapro 7.0 LCA Software developed by PRé Consultants
- Tool to collect, analyze and monitor the environmental performance of products/processes
- Large databases
- EarthShift consultants have provided training and support
Life Cycle Assessment Process

- Initial scope definition
- Data collection and impact inventory
- Impact assessment
- Interpretation of results and stakeholder engagement
- Revision of the scope, if necessary
Using Simapro Means Having to Rely on Experts in Other Fields

- Methodologies rely on studies conducted by experts in their respective fields
- Not feasible for water professionals to become experts in all of these areas
Industries and Regulators Worldwide Trust and Utilize Simapro

- Used in Europe since 1990, in US since 1994
- Most active users: Europe, US, Japan, Australia
- Many users in energy, chemical, building and food sectors
- Regulatory users include: EPA, USDA, US Forest Service
Impact 2002+ Methodology

- Best describes environmental impacts in terms of U.S. terminology and units
- Developed by the Swiss Federal Institute of Technology Lausanne and the University of Michigan
## Damage Categories Assessed

<table>
<thead>
<tr>
<th>Human Health</th>
<th>Ecosystem Quality</th>
<th>Climate Change</th>
<th>Resources</th>
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<tbody>
<tr>
<td>Human Toxicity</td>
<td>Aquatic Ecotoxicity</td>
<td>Global Warming Potential</td>
<td>Non-Renewable Energy Use</td>
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<tr>
<td>Respiratory Impacts</td>
<td>Aquatic Acidification</td>
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<tr>
<td>Ionizing Radiation</td>
<td>Aquatic Eutrophication</td>
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<tr>
<td>Ozone Layer Depletion</td>
<td>Terrestrial Ecotoxicity</td>
<td></td>
<td></td>
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<tr>
<td>Photochemical Oxidation</td>
<td>Terrestrial Acidification/ Nutrification</td>
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<td></td>
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<tr>
<td></td>
<td>Land Occupation</td>
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Case Study #1 - Environmental Impacts of a 20 mgd WWTP
Project Objectives:

1. Quantify the environmental impact of a wastewater treatment plant by unit process using Simapro 7.0
2. Assess the applicability of this tool to the water and wastewater industry.
3. Assess environmental impacts of various supplemental carbon alternatives
Facility Background

- South Durham WRF
  - City of Durham, North Carolina
- 20 mgd WRF
  - 5-stage BNR
  - 23-hour HRT

<table>
<thead>
<tr>
<th>Facility</th>
<th>Current Permit Limits @ 20 mgd</th>
<th>2016 Permit Limits @ 20 mgd</th>
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<tbody>
<tr>
<td></td>
<td>TN (lb/yr)</td>
<td>TN (mg/L)</td>
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<tr>
<td>SDWRF</td>
<td>334,850</td>
<td>5.5</td>
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</table>
South Durham WRF Process Flow

**Liquid Train**
- Influent
- Screens
- Influent Pump Station
- Grit Removal Channel
- Grit
- Parshall Flumes
- Primary Sludge (PS)
- Rectangular Primary Clarifiers
- Anaerobic Tanks
- 4 Stage BNR
- Secondary Clarifiers
- WAS
- RAS

**Solids Train**
- Primary Sludge (PS)
- Anaerobic Digesters In Series
- Belt Filter Press
- Cake
- BFP Filtrate
- GT Filtrate
- Gravity Thickener
- GT Filtrate
- UV Disinfection
- Post-Aeration Parshall Flume
- Effluent

**SDWRF Process Flow Diagram**

*Figure 3-2*
Unit Processes Modeled

- Influent pumping
- Preliminary treatment
- Primary treatment
- Activated sludge facilities
- Tertiary treatment
- UV disinfection
- Treated effluent (emission)
- Anaerobic digestion
- Solids thickening and dewatering
- Sludge disposal to land application
- Odor control
- Pipes
- Miscellaneous facilities
Model Incorporates Construction and Operations Impacts

- Period of analysis assumes 20 mgd treated for one year

- Construction impact spread out over 30-year period (1/30\textsuperscript{th} of the impact included in each unit process)
  - Changes to land use attributed to “treated effluent” category
  - Other construction impacts (i.e., excavation) attributed to individual unit processes
LCA Results

- Activated sludge and anaerobic digestion show the greatest environmental burden associated with one unit process.
- Total environmental impacts from all other unit processes are responsible for more environmental damage than activated sludge and anaerobic digestion combined.
- Impacts to human health are about twice as large as impacts to ecosystem quality, climate change, or resources.
Activated sludge and AN digestion responsible for 40% of climate change and resource impacts.
Environmental Impact by Unit Process

Relative Environmental Burden

- Human Health
- Ecosystem Quality
- Climate Change
- Resources

Units: Effluent, Activated Sludge, Anaerobic Digestion, Odor Control, Preliminary Treatment, Primary Treatment, Solids Thickening, Disinfection, Influent Pumping, Misc Facilities, Methanol Facility, Biosolids Land App.
Case Study#2 - Evaluation of Biosolids Management Alternatives

- Incineration
- Landfilling
- Land Application
Incineration

Dewatered Solids

Transport

$\text{N}_2\text{O}$

$\text{CO}_2$

Energy

Ash

Transport

Disposal
Land Application

Dewatered Solids

Transport

\( \text{N}_2\text{O} \)

\( \text{CO}_2 \)

\( \text{CH}_4 \)

Fertilizer Production Avoided
Landfill Disposal

Dewatered Solids

Transport

CH₄
Capture
For Electricity Production

N₂O

Leachate

CH₄
Approach

- Functional Unit for Analysis: 1 ton Biosolids
- Emissions: Methane, Nitrous Oxide, CO₂
- Metal Concentrations in Biosolids
- Energy Input
  - Incineration
  - Transportation
- Credits
  - Fertilizer Production Avoidance
  - Electricity Production from Landfill Gas
Environmental Impacts w/o Credits

Relative Environmental Burdens

- Incineration
- Land Application
- Landfill

Global Warming
Respiratory in Organics
Non-Renewable Energy
Carcinogens
Summary

• LCA is a useful decision making tool for utilities and permitting agencies to develop holistic environmental impacts
  – Requires significant resources to develop
  – Simpler models may be better suited to GHG analysis, unit process comparison
Acknowledgements

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Questions?

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