Eliminating scope 1 emissions from wastewater treatment

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WATER INFRASTRUCTURE AND RESILIENCE WIRe
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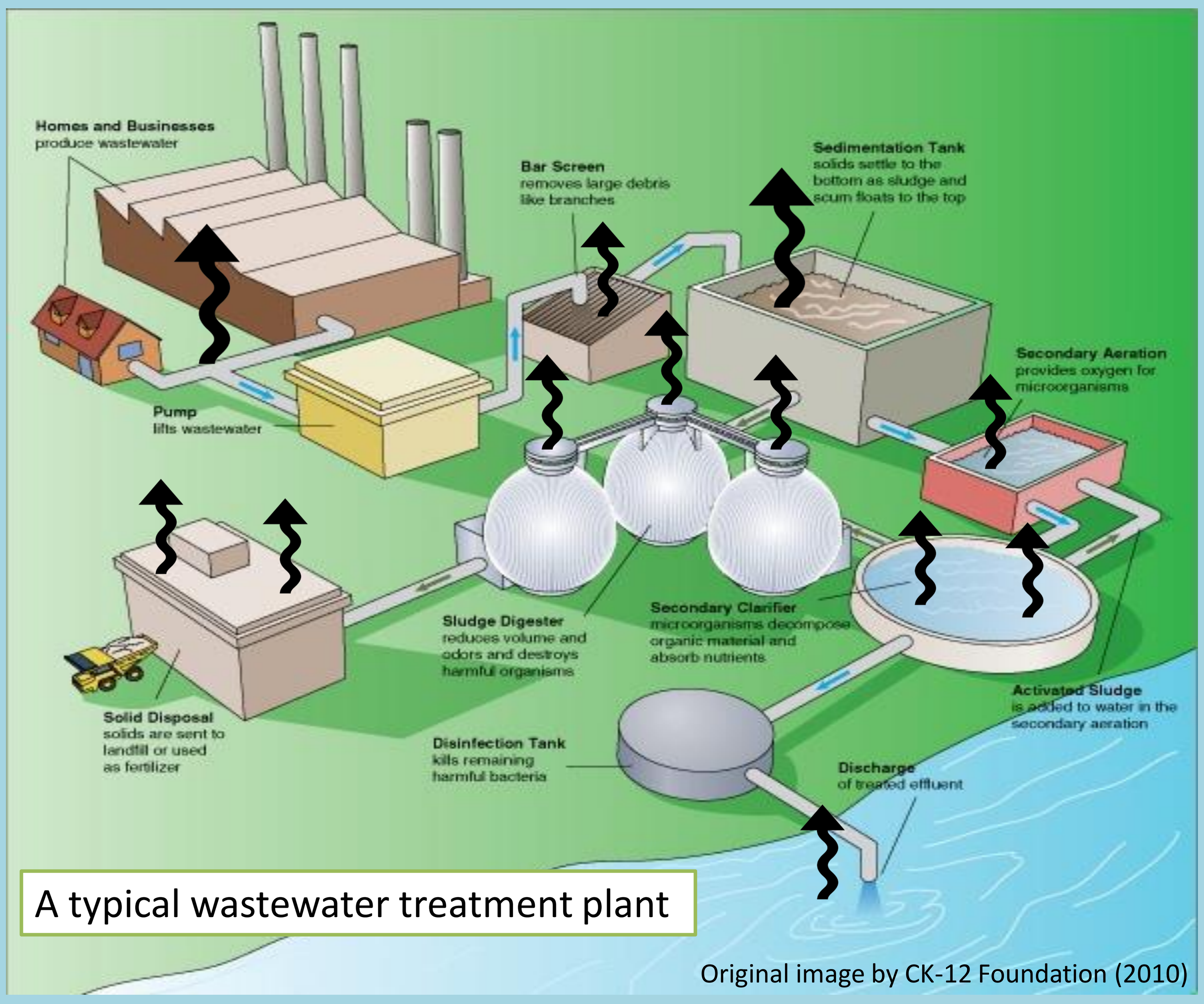
1. Background

Dominant greenhouse gases (GHGs) such as methane (CH_4) and nitrous oxide (N_2O) are emitted from several processes throughout a wastewater treatment plant (WWTP) (black arrows – indicative image). Nitrous oxide and methane are 298 and 34 times "worse" when it comes to Global Warming Potential (GWP) than carbon dioxide (CO_2) (IPCC, 2014). These direct GHG emissions are classified as scope 1. Process-specific emission factors for the majority of a WWTP have not been set yet, although significant variations have been observed in past studies.

- Current approaches in quantifying emissions do not reflect changes in operation and control
- UK water companies plan to reduce emissions and become operationally carbon neutral
- Practicality and efficacy of utilizing abiotic processes for wastewater treatment is unclear
- Majority of current works is based around biological processes



A typical wastewater treatment plant

Original image by CK-12 Foundation (2010)

2. Aim

The aim of this project is to initially investigate and understand how and where GHGs are currently emitted, as well as document their variability. By establishing the evidence base for minimisation of GHGs from existing assets, the potential key future technologies that help deliver net zero carbon will be identified and understand how compatible they are with the existing future urban and rural strategies to introduce a way to reduce and/or eliminate scope 1 emissions from wastewater treatment.

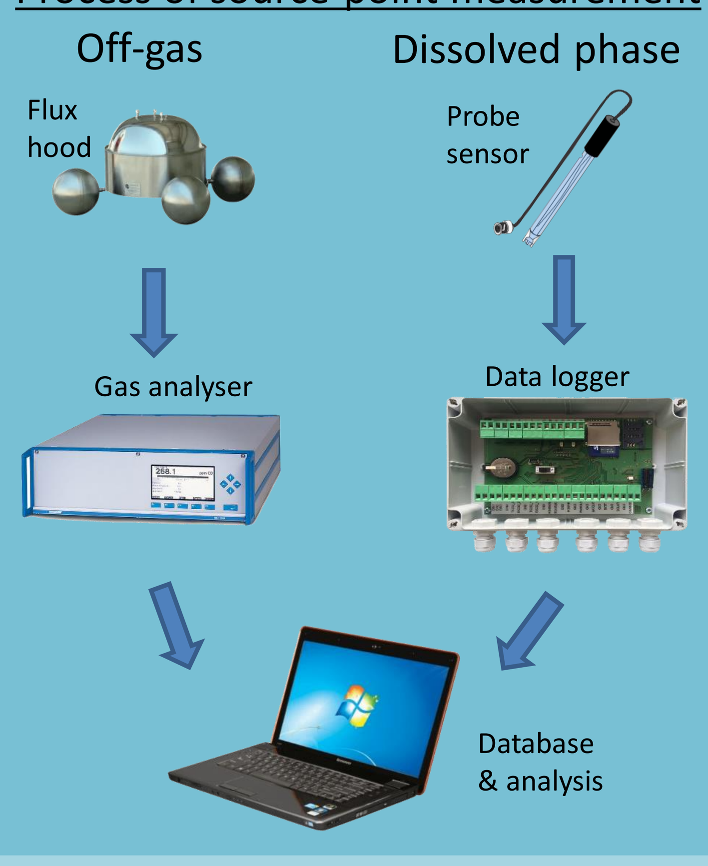
3. Challenges

- Limited data exist on process-specific emission factors and the impact that several mitigation techniques might have on them.
- The appropriate model combination is yet to be determined, as biological processes that contribute to emissions cannot be fully predictable.
- Future mitigation measures will have to become cost neutral
- Long-term monitoring (>12 months) is fundamental for an accurate variability estimation

4. Objectives

- Review the literature on emission rates from different processes and compare to standard rates.
- Develop a measurement system that can accurately determine emission rate from both force gas flow and passive systems.
- Measure emission rates from a series of existing (focus is on trickling filters) and emerging technologies to understand their contribution to the overall GHG emission
- Combine the findings to develop guidance on the most appropriate ways to minimise GHG over the near, medium and long term.

Process of source-point measurement



5. Methodology

- Literature review
- Adaptation of a mass transfer model
- Selection of plants and monitoring campaign
- Analyse data and model process mitigations
- Development of novel flowsheets
- Identify future technologies and their compatibility

6. Key findings to date

N_2O emissions

- Significant variability of more than 4 orders of magnitude of the total influent nitrogen
- Emissions are affected by loading rate, temperature, DO levels, SRT, C/N ratio and microbial stratification
- Aerobic zones contributed substantially more to N_2O fluxes
- Emissions show daily and seasonal variation

CH_4 emissions

- Measurements vary a bit more than 4 orders of magnitude of the total influent organic carbon
- Dissolved CH_4 is emitted in the early stages of WWTPs
- Loading rates and ORP values are major factors of CH_4 emissions

- Sampling methods are not coherent in the literature and frequency of samples can render results incomparable
- Very limited data exist for emissions from trickling filters

7. Key remarks for future consideration

- There is no standard set of equipment, nor specific guidelines on monitoring emissions from wastewater processes
- Temporal emission variation is significant for all process configurations
- Mechanistic models for N-removal have been extended to include N_2O and NO production but the variability of the mathematical description of N_2O production is limited

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