Executive Summary

WERF

What is the potential for fugitive greenhouse gas – methane and nitrous oxide – emissions from wastewater treatment processes and conveyance?

Greenhouse Nitrogen Emissions from Wastewater Treatment Operation: Phase I (U4R07)

Methane Evolution from Wastewater Conveyance (U2R08a)

Methane Evolution from Lagoons and Ponds (U2R08c)

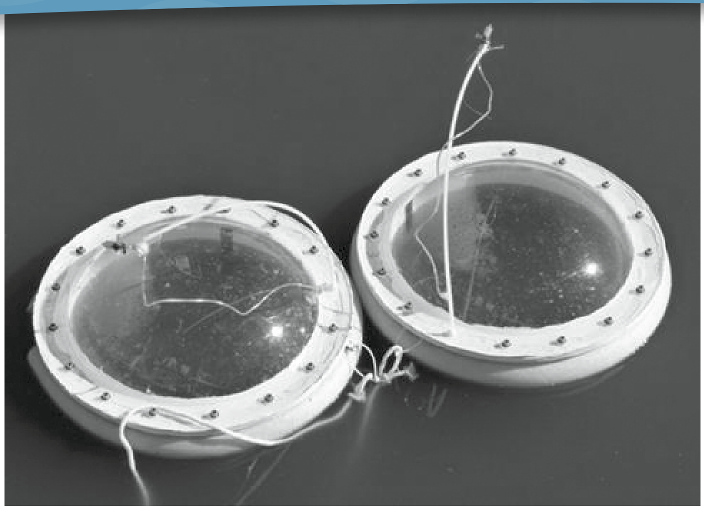
Flare Efficiency Estimator and Case Studies (U2R08d)

The Central Issue

Global climate change concerns are focusing attention on sources and levels of greenhouse gas emissions. Thus, it is important to the wastewater sector to identify and quantify the direct greenhouse gas (GHG) emission during conveyance and wastewater treatment. Organizations including the Intergovernmental Panel on Climate Change (IPCC) and the U.S. EPA are using default emission factors to describe/predict the contribution of GHG from the various sources and sectors. There are two compounds with the potential for fugitive emission from wastewater treatment and conveyance: methane (CH_4) and nitrous oxide (N_2O).

Context and Background

Methane has a global warming potential (GWP) 25 times that of CO_2 over a 100-year time frame (IPCC, 2007). Nitrous oxide has a global warming potential 300 times that of CO_2. In national inventories of GHG, CH_4 accounts for approximately10.3% of the total amount of GHGs emission in the U.S. 4% of this CH_4 is attributed to wastewater treatment activities (EPA, 2011).



Floating flux chambers capture GHG emissions at the water-air surface.

Biogenic CH_4 evolves when organic matter is metabolized by anaerobic microbes, known as methanogens. These methanogens are quite diverse and widely distributed in wastewater. In aquatic systems, CH_4 is produced under conditions where oxygen is limited, such as in lagoons below the surface and in closed conveyance systems. While the generation of CH_4 is possible in many types of wastewater units which do not contain sufficient oxygen levels, any methane produced may also be consumed by microorganisms. Due to this unmeasured consumption, it is unclear actually how much methane is emitted. Regardless, the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* state that "In most developed countries and in high-income urban areas in other countries, sewers are usually closed and underground. Wastewater in closed underground sewers is not believed to be a significant source of CH_4."

Engineered biological nutrient removal (BNR) processes could be a potential contributor to atmospheric nitrous oxide emissions. Based on several international studies, engineered BNR facilities could emit up to 7% of the influent nitrogen load as gaseous nitrous oxide (N_2O) and nitric oxide (NO) (Kampschreur et al., 2008b). Unfortunately, these previous studies used different monitoring methods, often based on single discrete samples, to extrapolate potential N_2O emissions from various wastewater treatment processes. Further research was necessary to thoroughly characterize nitrogenous GHG emissions from treatment facilities. Further research was also necessary to develop a methodology to collect full-scale plant data from BNR facilities.

These four research projects advance our understanding of: nitrous oxide generation and emissions from BNR treatment processes and methane generation and emissions from conveyance systems, lagoons, and solids management ponds. They also demonstrate the inefficiency of candlestick flares to convert methane gas to carbon dioxide (CO_2) to benefit from CO_2's lower global warming potential.

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Findings and Conclusions

- In all of these WERF GHG studies, especially those involving dynamic biologic processes, methane and nitrous oxide emissions are highly variable. Any quantification studies must be based on continuous, online measurement over diurnal periods of time. While online devices are able to measure the concentrations of GHG emissions, the measurement of the gaseous flux is much more difficult to obtain. Since quantification is based on mass times flux, the uncertainty in flux data contributes to uncertainty in the quantification of emissions.
- Both methane and nitrous oxide are highly soluble in water. Studies into the generation and emissions of these GHG must include sampling of the liquid phase.
- Contrary to the IPCC guidelines, the methane emissions from pumping stations and force main receiving manholes can be significant, although it appears to be only a small fraction of the carbon footprint of a typical treatment facility.
- N_2O emissions from biological nutrient removal processes emanate primarily from aerated zones. Denitrification, as previously thought, is not the primary source of N_2O emissions. N_2O emission is a separate phenomenon from N_2O generation. N_2O generation is a recovery response from rapid anoxic-oxic transition as the microorganism try to rebalance.
- The prospect of operations and engineering-based minimization of N_2O emissions from treatment facilities is highly likely.

Management and Policy Implications

Given the substantial spatial and diurnal variability observed during these studies from different wastewater units, the concept of any "single lumped" emission factor to describe dynamic biologic generation of either methane or nitrous oxide generation and emission, as followed by the U.S. EPA and the IPCC, is inadequate and misleading. Additionally, given the high degree of spatial and temporal variability, the development, calibration, validation, and use of dynamic mechanistic process models to capture such variability would be the most accurate approach to predict fugitive greenhouse gas emissions from wastewater facilities.

Related WERF Research

Project Title	Research Focus
Carbon Heat Energy Plant Evaluation Tool – CHEApet (OWSO4R07cT)	Provides predictive models to quantify plant operating energy requirements and predict the carbon footprint from wastewater treatment plants. CHP-SET tool complements the CHEApet tool output.
Greenhouse Nitrogen Emissions from Wastewater Treatment Operation: Phase II (U4R07b)	Builds upon the results obtained in the initial phase of research. Two directions have been recommended for more detailed study. ■ The implementation of process engineering measures to minimize N_2O emissions during BNR operation. ■ Further investigation of N_2O generation by separate centrate systems and during simultaneous D/DN processes.
Combined Heat and Power System Evaluation Tool (U2R08b)	This spreadsheet-based calculator evaluates combined heat and power (CHP) system performance. It is intended for use by facilities already operating CHP systems. CHP-SET calculates total system efficiencies, inclusive of appurtenant equipment electrical demands, to produce electricity and collect heat. The tool also provides conversion of exhaust emissions (NOx, CH_4, CO_2, CO, and N_2O) into units of mass per unit of net energy output.
Evaluation of Greenhouse Gas Emissions from Septic Systems (DEC1R09)	Determined the emission rates of greenhouse gases from individual onsite septic systems used for the management of domestic wastewater.
N2O and CH_4 Emission from Wastewater Collection and Treatment Systems – Technical and State of the Science Reports (CC6C10a/b)	Brings together the Global Water Research Coalition individual research program results into collaboration with their individual research partners to produce both a state of the science report and a research strategy report.
Quantifying Nitrous Oxide and Methane Emissions from Biofilm Systems (U2R10)	Will investigate the N_2O and NO generation and accumulation in integrated fixed film activated sludge (IFAS) systems.

Greenhouse Nitrogen Emissions from Wastewater Treatment Operation: Phase I
Methane Evolution from Wastewater Conveyance
Methane Evolution from Lagoons and Ponds
Flare Efficiency Estimator and Case Studies

Unconfined "candlestick" flares can be a source of methane when combustion of biogas is done under suboptimal (windy) conditions.

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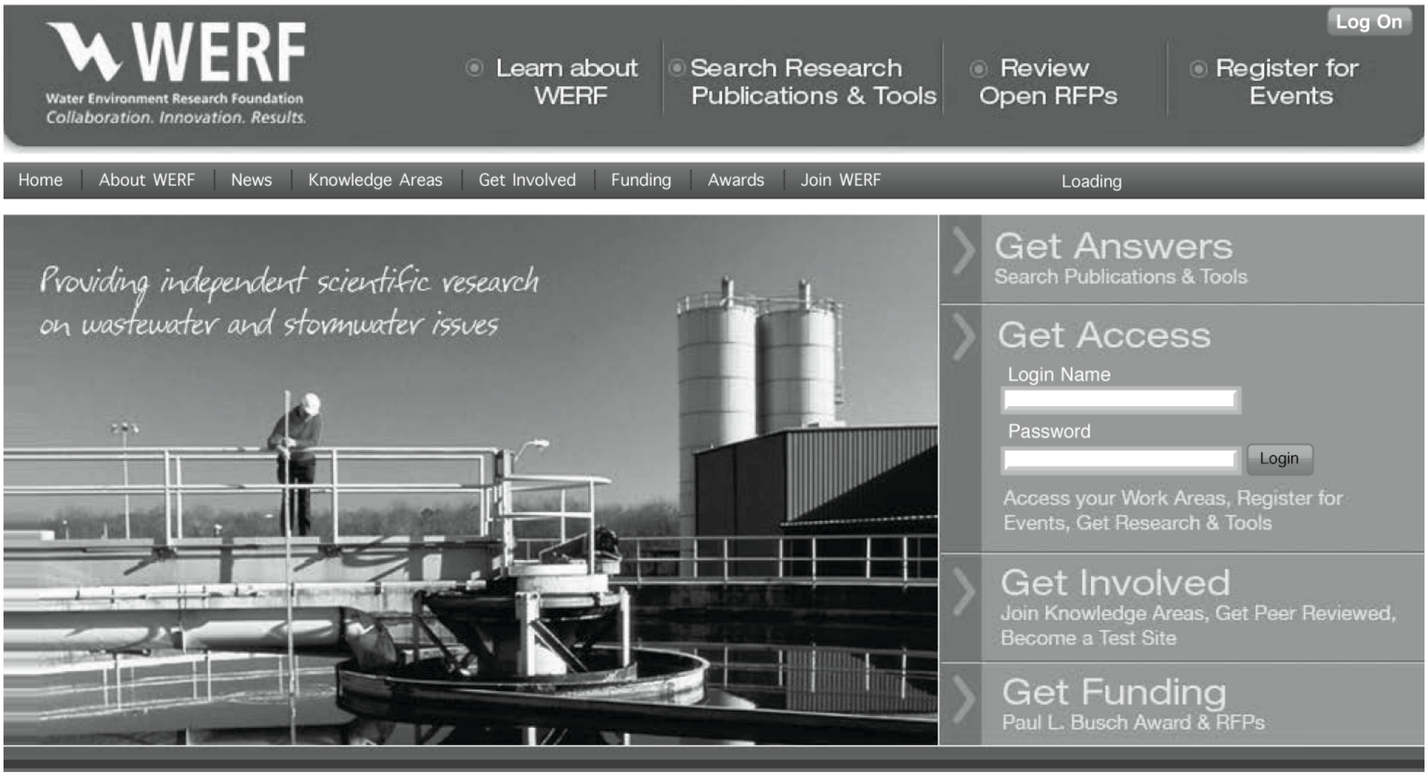

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