Beyond Tier 1 estimations: the urgent need for direct GHG measurements in WWTPs a case study in Mexico for the global south

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A brief introduction

1996-2005

Kyoto Protocol

- The UN Framework Convention on Climate Change (UNFCCC) was created.
- The signatory countries have to adopt mitigation policies and report greenhouse gas (GHG) emissions regularly.

2016

Paris Agreement

- The goal is to limit global warming to well below 2 °C, preferably to 1.5 °C.
- Nationally Determined Contributions (NDCs).
- Global Stocktake

2021-2023

COP26-COP28

- Securing ambitious emission reduction commitments.
- Historic agreement to provide funding for vulnerable countries.
- Transition away from fossil fuels.

2024

COP-29 Baku

- Scheduled to address funding for adaptation and the loss and damage fund.
- **Methane emissions** from the waste sector must be reduced by 30-35%

The Mexican context regarding greenhouse gas (GHG) emissions

- Mexico emitted a total of 714.04 $MMtCO_2eq$ (million metric tons of CO_2 equivalent), which represents 1.28% of total global emissions, placing **Mexico in 15th place** among the world's main GHG emitters.

- Regarding to the waste sector, the last inventory accounts for 63.8 $MMtCO_2eq$, of which the wastewater treatment is responsible for ~ 50%.

- For the first time since reporting began on sanitation coverage and infrastructure, CONAGUA reports a **decline.** 98 wastewater treatment plants (WWTPs) were out of operation, which represents a decrease of 2% in the treated flow in the country.

Building of the estimations

This study constructed Tier 2-type estimations, assessing methane (CH_4) emissions from Mexican WWTPs(Eq.1,2). These estimations were based on operational data (COD, flow rate, treatment technology, and regulatory compliance) and emission factors (EF) from IPCC guidelines (2006 and 2019)

$$CH_{4\,emission} = \left[\sum_{i,j}\left(U_i \cdot T_{i,j} \cdot EF_j\right)\right](TOW - S) - R \qquad \text{Eq. 1}$$

$$EF_j = B_o \cdot MCF_j \qquad \text{Eq. 2}$$

Estimates using the 2019 Refinement were constructed using Eq. 3,4

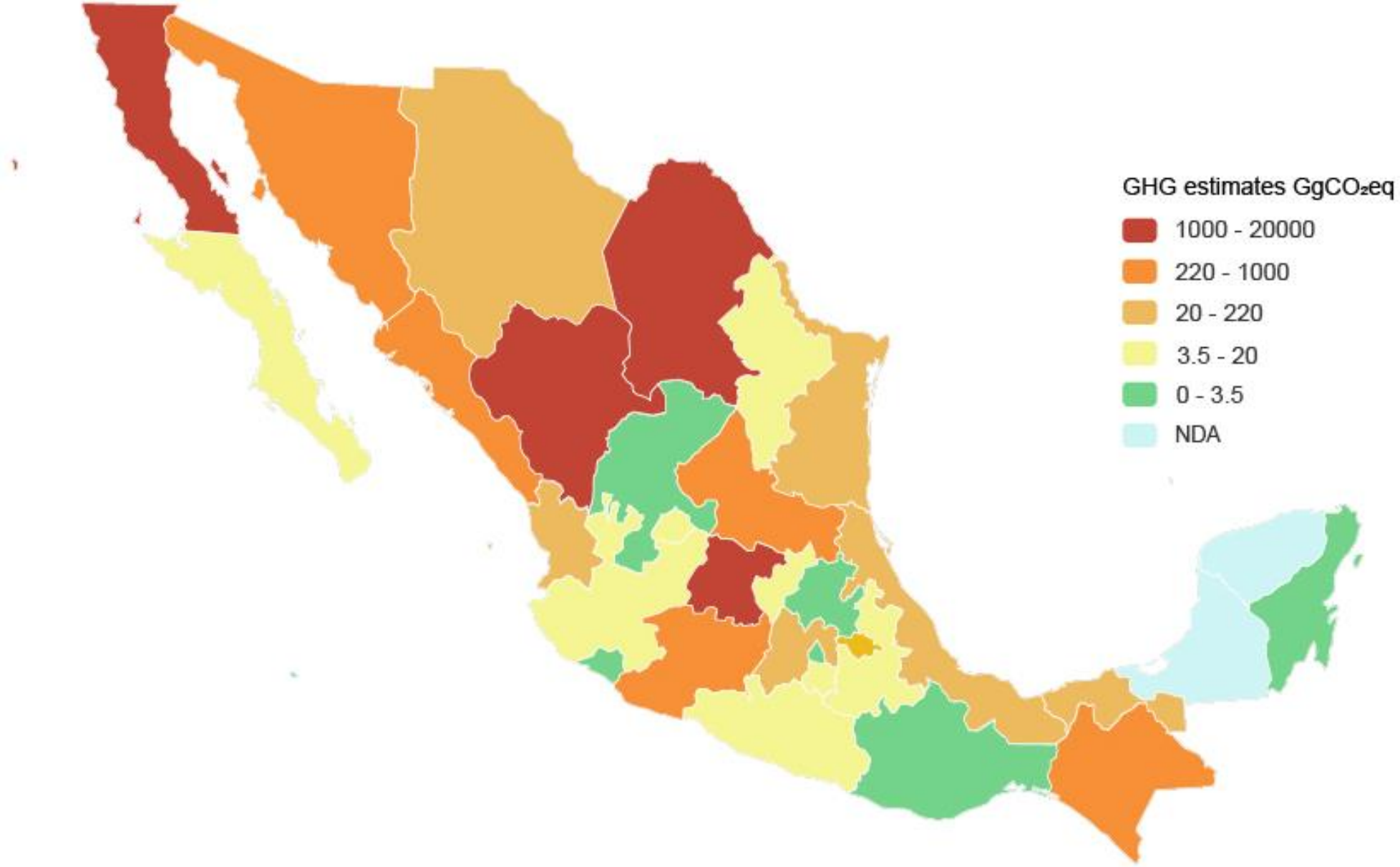
$$CH_{4\,emission,j} = \left[\left(TOW_j - S_j\right)\right] \cdot EF_j - R_j \qquad \text{Eq. 3}$$

$$TOW_j = \sum_i \left[TOW \cdot\ U_i \cdot T_{ij} \cdot I_j\right] \qquad \text{Eq. 4}$$

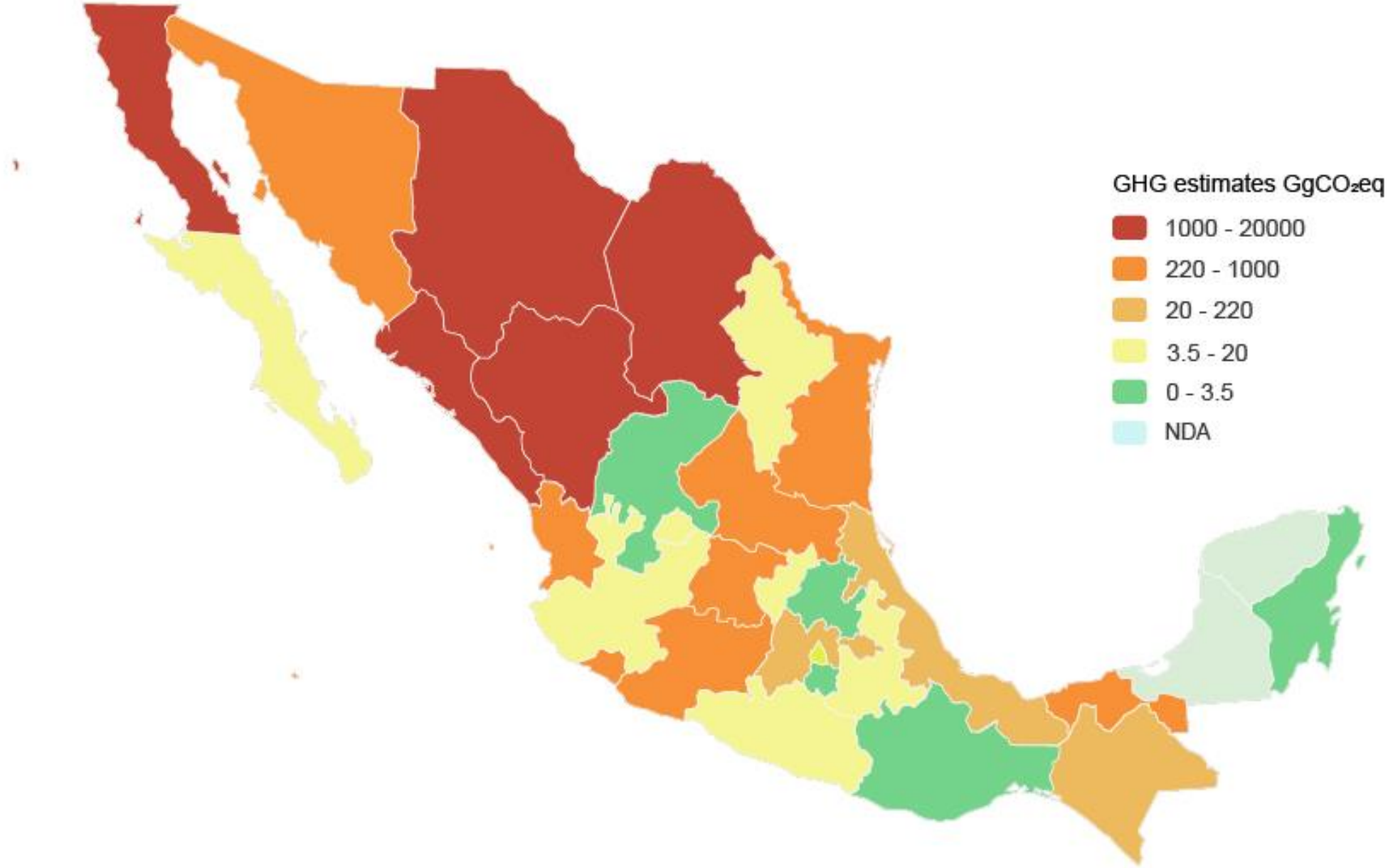
For WWTPs with an aerobic process, Eq. 4 (which calculates the organic component removed as sludge) is applied; otherwise, S_j is assumed to be 0.

$$S_{aerobic} = (S_{mass} \cdot K_{rem}) \qquad \text{Eq. 5}$$

IPCC 2006 Tier 2-type estimations using operational data



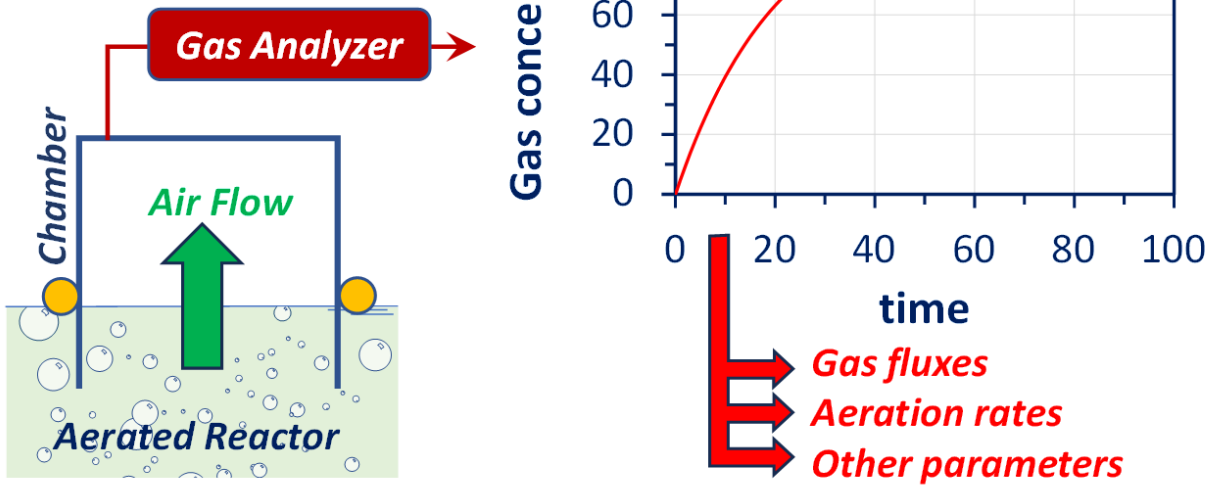
IPCC 2019 Tier 2-type estimations using operational data



Direct greenhouse gas measurement with a process-unit approach

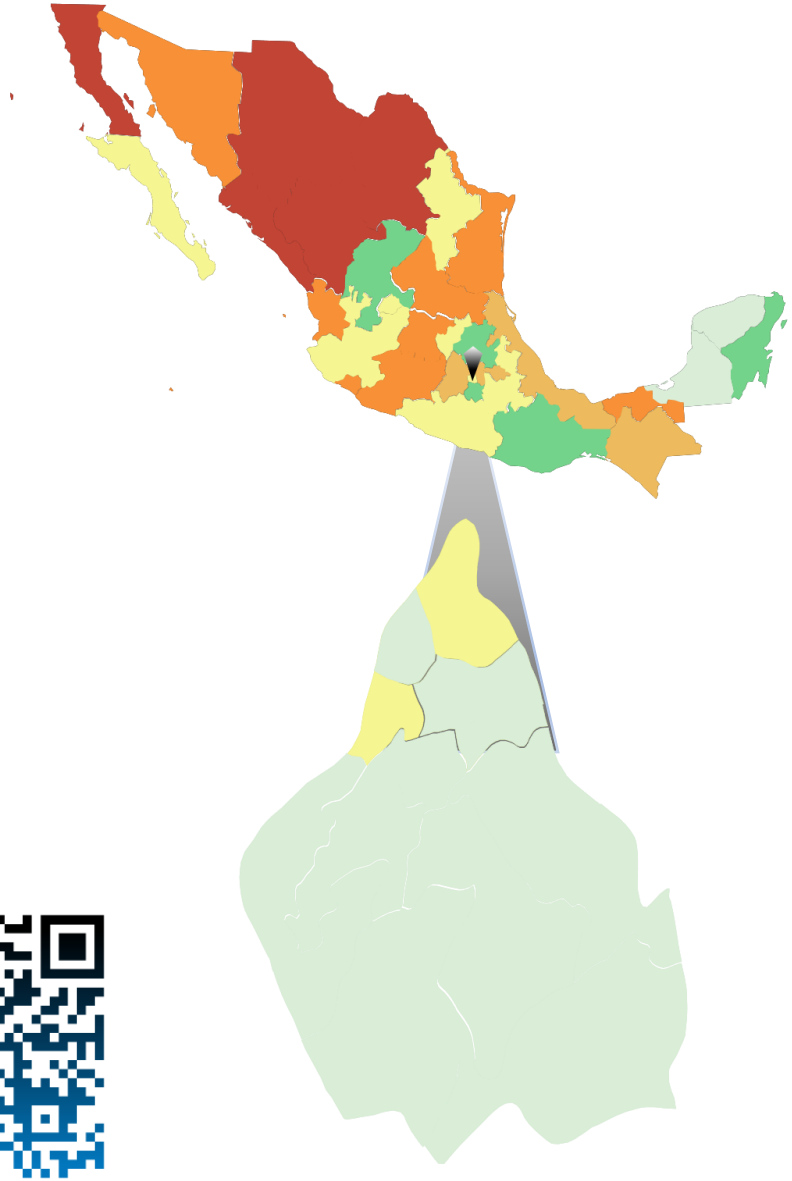
Research approach

We developed a simplified method for quantifying CH4 emissions from aerated reactors of WWTPs, based on the Open Flux Chamber (OFC) principle.

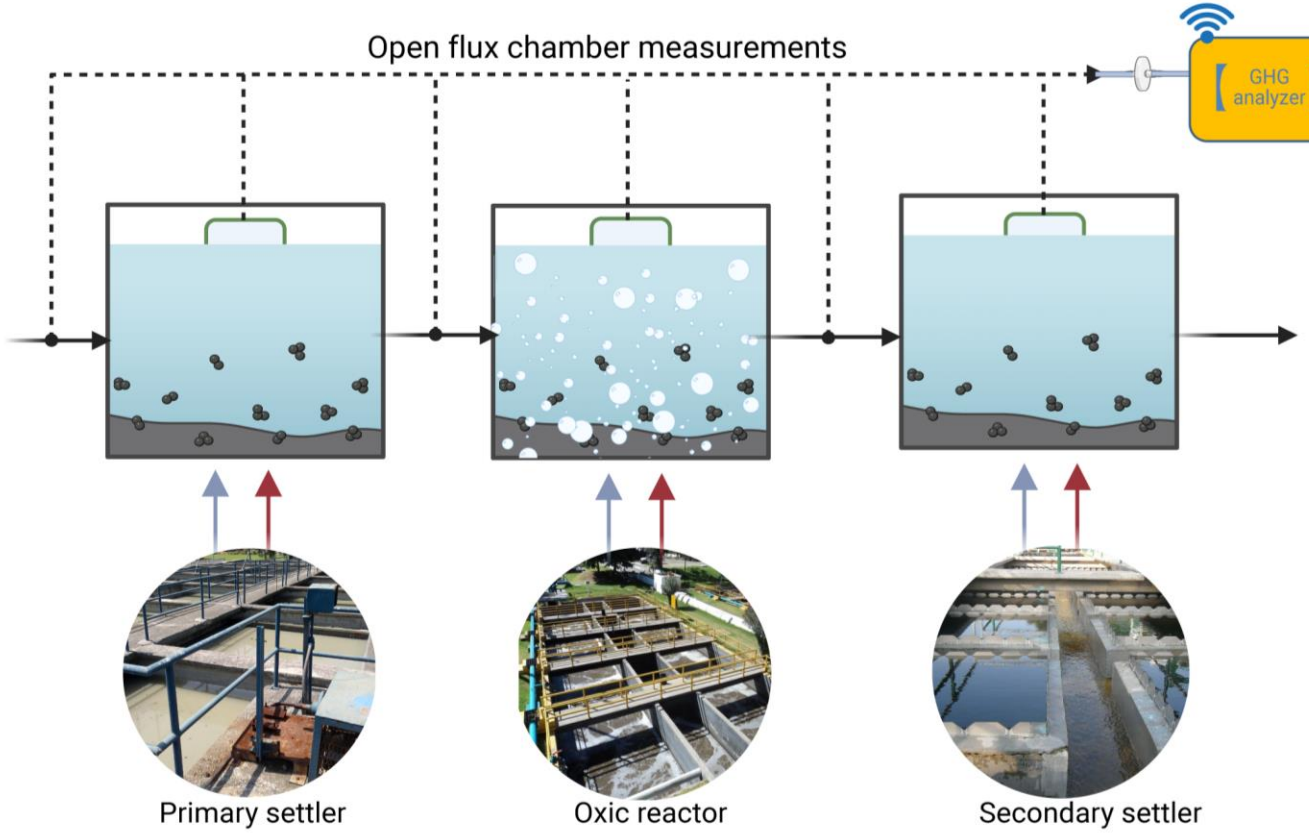


OFC prototypes

Mexico City as a case study

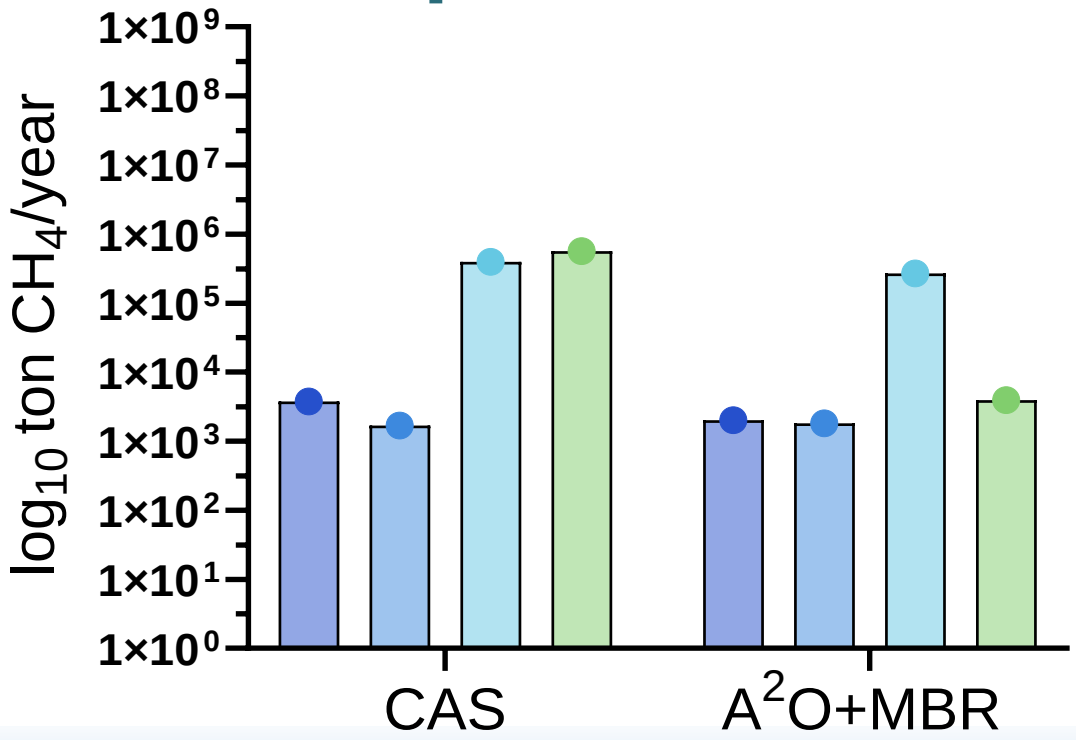


Direct GHG emissions from a conventional activated sludge (CAS) WWTP



	Primary settler	Oxic reactor	Secondary settler
Average Emisssion factor CH_4 :	0.304 g m^{-3} (72.3%)	0.091 g m^{-3} (27.7%)	0.003 g m^{-3} (0.02%)
Methanogenesis:	+++	-	-
Methanotrophy:	-	+++	-
Average Emission factor CO_2 :	0.47 g m^{-3} (0.5%)	96.8 g m^{-3} (99.4%)	-0.11 g m^{-3} (0.1%)
Production	+	++	uptake
Emissions	-	+++	-

A real underestimation problem?



- IPCC,2006
- IPCC,2019
- this work
- Noyola,2018[a]

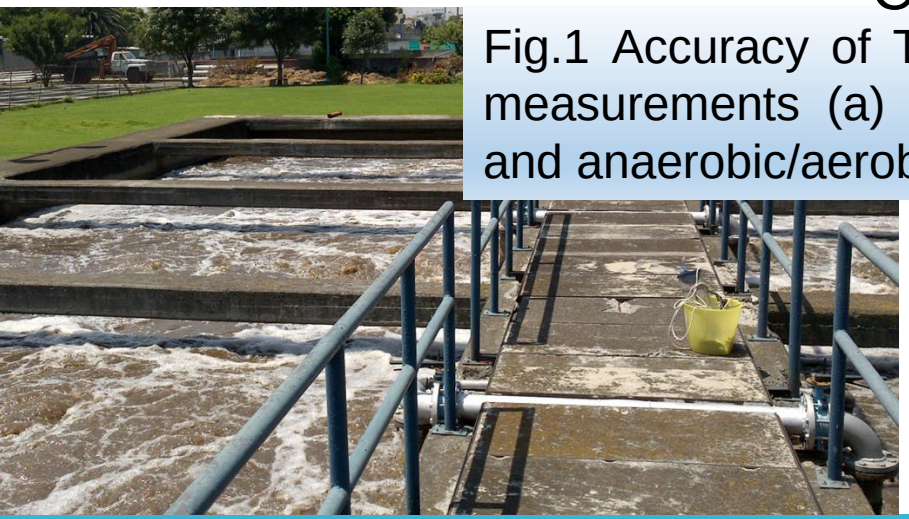
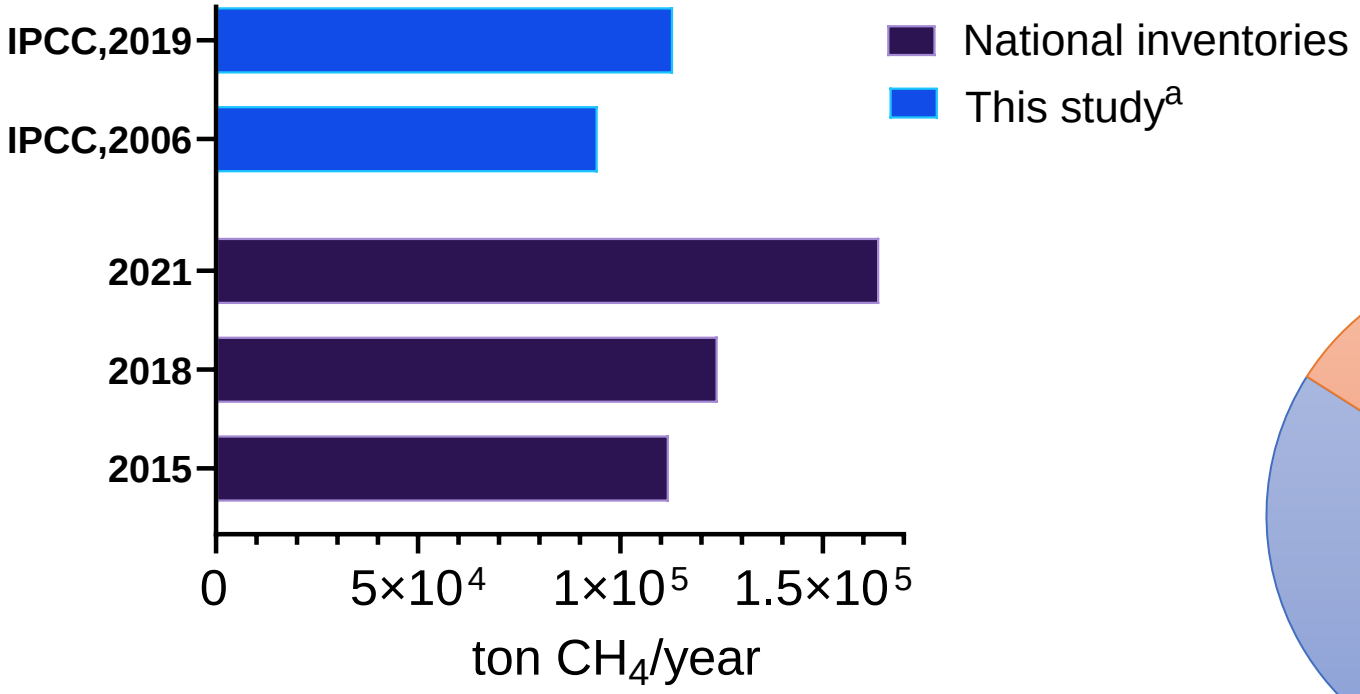


Fig.1 Accuracy of Tier 1 estimations vs. Direct and indirect emission measurements (a) between a Conventional Activated Sludge (CAS) and anaerobic/aerobic/oxic + membrane bioreactor system (A_2O+MBR)

Discrepancies between Reality and Mexico's National GHG inventories

Fig.2 Comparison of national inventories vs. our estimations



[a] Accounting for only 262 WWTPs, based on their flow rate, these plants treat ~ 70% of the wastewater generated.

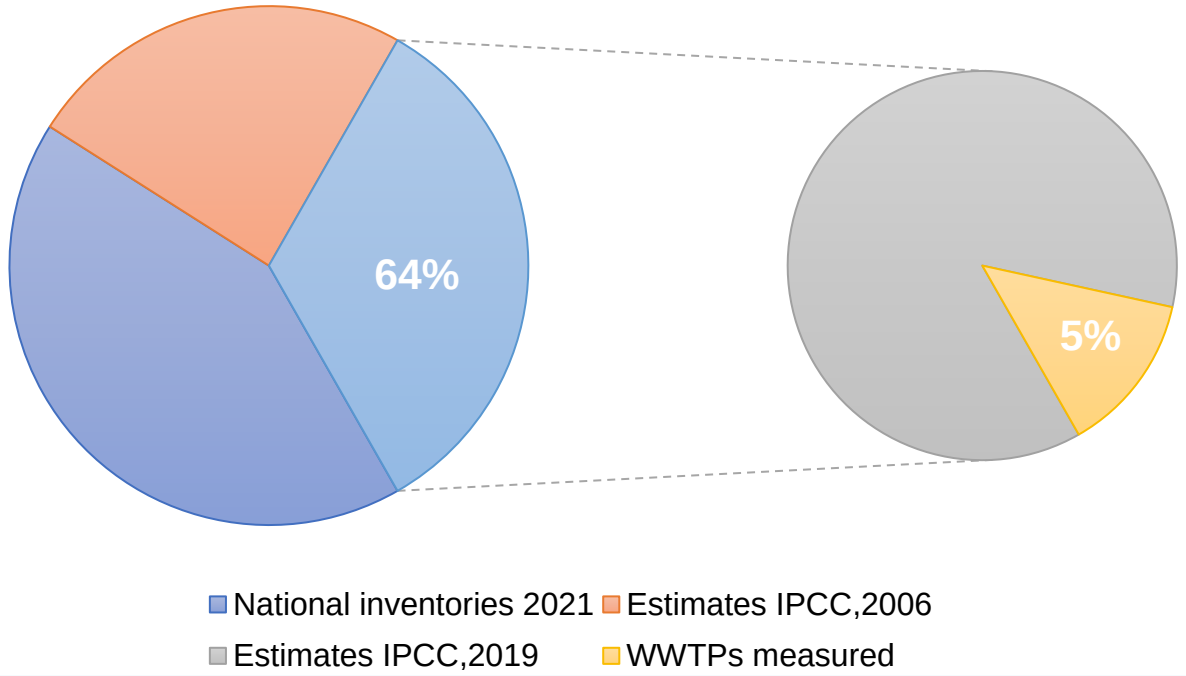


Fig.3 CH_4 Emissions from wastewater treatment: a comparison of data sources

Final remarks

- The results reveal that estimated GHG emissions, even when only accounting for CH_4, are significantly underestimated compared to direct measurements.
- Comparative analysis between the two WWTPs showed that the A_2O+MBR plant, representing a newer and more advanced technology, emitted 60% more GHGs than the CAS plant.
- The study highlights the critical role of methane correction factors (MCFs) Incorporating locally determined MCFs resulted in a twofold increase in estimated emissions, even when these MCFs were determined indirectly.
- By providing a detailed analysis of GHG emissions from two contrasting WWTPs in Mexico, this study offers valuable insights and data to inform mitigation strategies in Mexico and other global south nations.

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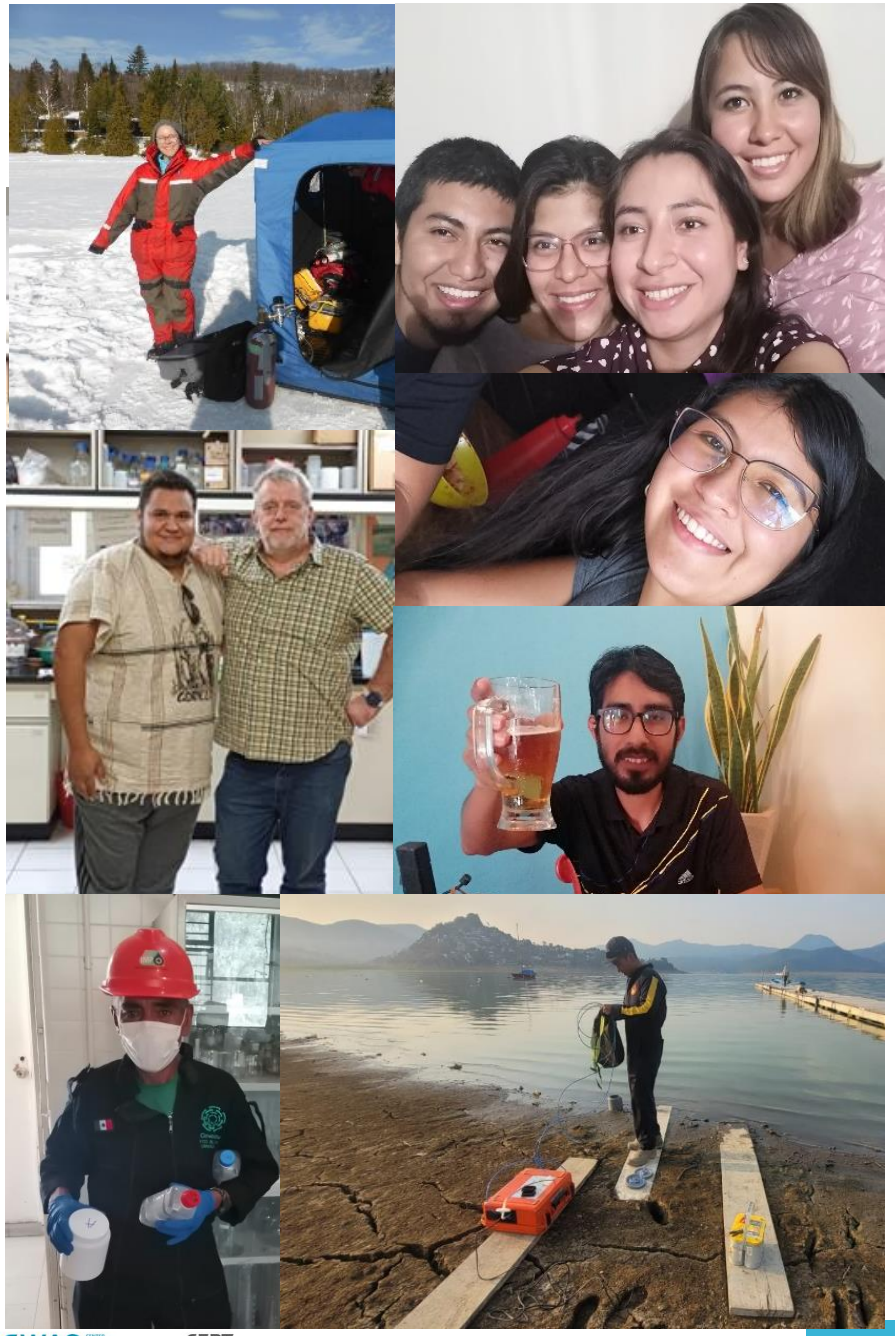

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Thank You

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