Towards a high-granularity methane emissions inventory for Colombia – First *in situ* measurements of solid waste landfills and wastewater treatment plants emissions

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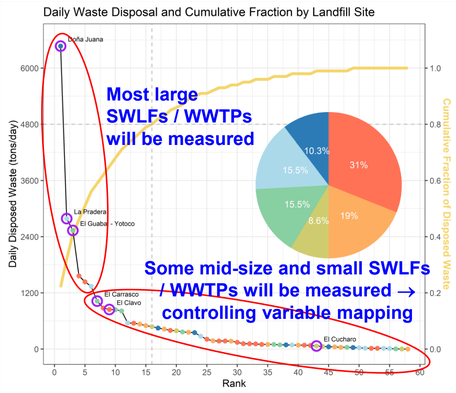
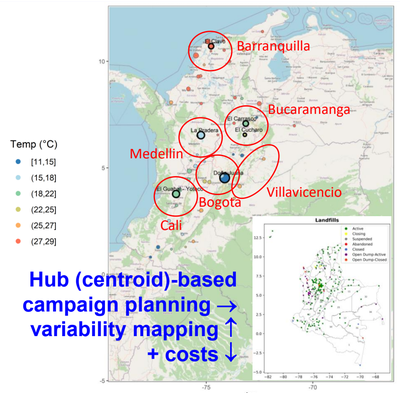
Global South CH_4 emission measurements scarce / unsystematic → SWLF + WWTP measurement campaign (MET-CO)

- CH_4 short lifetime + low mitigation costs → near-term climate action
- Mitigation accounting / climate science ← accurate emission inventories
- **Most EFs / model parameters derived from measurements in/at of developed countries conditions**
- **Global South CH_4 emission measurements scarce / unsystematic → large discrepancies among global databases and with national inventories** (-60% to +180% for Colombia)
- **Solid waste landfill (SWLF) CH_4 emissions fastest growing category in Colombia** ← disposal in SWLF 43% (2009) to 98% (2020)
- UNEP's International Methane Emissions Observatory (IMEO) coordination/support → multi-sector observation-based baseline inventory for Colombia
- **Conducted by Universidad Nacional de Colombia (UNAL, Bogota) and Carleton University (Ottawa, Canada) → MET-CO measurement campaign**

Observation-based inventory scale up / Measurement strategy / Hubs + facilities



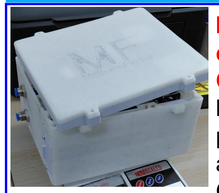


- **Facility by facility ("census-like") inventory → high granularity**
- **Mixed approach: large facilities directly measured + some mid- / small-size facilities → controlling variable mapping** + emissions from non-measured facilities ← estimated from measurement-derived, categorized parameters

Measurement strategy ← balance *generated biogas = channeled + diffuse* →

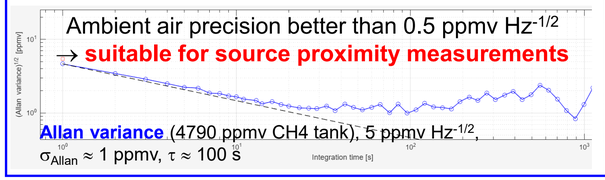
1) Drone **surface sniffing of active + closed SWLF cells + WWTP elevated units**
2) **Soil / floating flux chambers** / dissolved CH4
3) **Channeled biogas composition + flowrate**
4) **Drone mass balance measurements (Carleton University)**
5) Biogas model tuning → mixed approach parameters

Instrument / methodology development + performance assessment

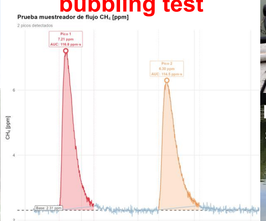


In-house integrated, drone-borne ready CH_4 instrument (< 2 kg; Internal battery powered; Based on an Axetris LGD Compact-A CH4)

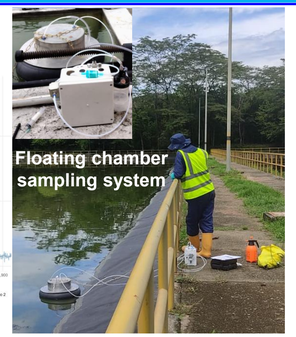
Performance in flight degraded very little once instrument was mech. locked



Floating chamber bubbling test

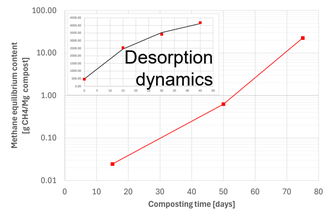


Direct (chamber) and indirect (sampling system) CH_4 conc. agreed within 2%

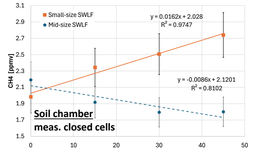


Compost methane content increased with age ← chamber desorption dynamics (t_{eq} < 30 min)

Compost fluxes difficult to measure using chambers

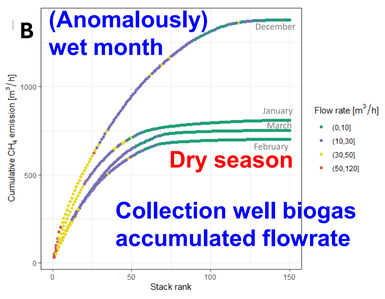


First *in situ* measurements

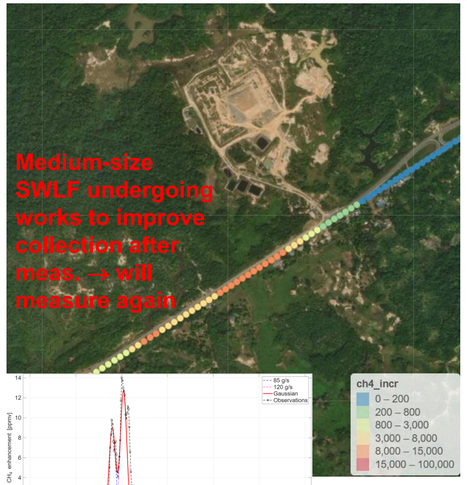


Small fluxes from cells closed ~10 yr ago (2.3; -1.3 mg CH4 m^{-2} day^{-1})

Large flux from recently closed cell (0.15 kg CH4 m^{-2} day^{-1}); Nearly zero from cell closed ~10 years ago
Enhancements near sources ~3-17 ppmv; **Abandoned extraction pipeline = 39%**



- Operator monitored collection well biogas composition / flowrate
- Channeled biogas partition ← cell design / construction / operation
- **Biogas burning effectiveness**
- Low CH_4, CO_2 + near-ambient O_2 levels associated with lowest flowrates → eventually extinguish combustion
- **Found twofold increase in biogas generation wet month**
- **Dry season → low flowrates** (~70% wells) (compared to <20% during wet month)



- Opportunity measurements
- Methane uncorrelated with CO_2
- U(2 m) ≈ 1.6 m/s + Pasquill C
- Active zone to road ≈ 650 m
- **Fitted CH4 emission = 738 kg/hr**
- **IPCC estimation = 580 kg/hr**

LARGE DIVERSITY IN WWTPs!

Poorly maintained lagoon system

Aerobic lagoon operating anaerobic → strong ebullition

Dissolved methane (headspace) ≈ 6200 ppmv
Enhancements near sources ≈ 0.3-17 ppmv

Better maintained / more complex WWTPs showed emission peaks near sewage entrance, digested sludge outlet and biofilter outlet