Antoine Babilotte *(Veolia Environment R&D)*

Direct measurement of GHG emissions:
The case of fugitive methane from landfills

Presentation to IPCC expert meeting
23-25 March 2010, Utrecht

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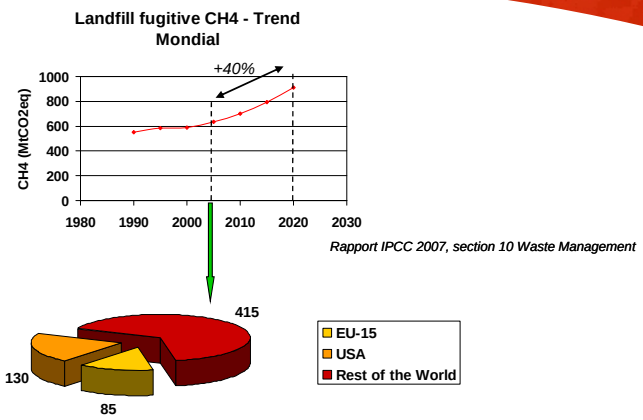
Landfills

Methane Emissions - Figures

Worldwide

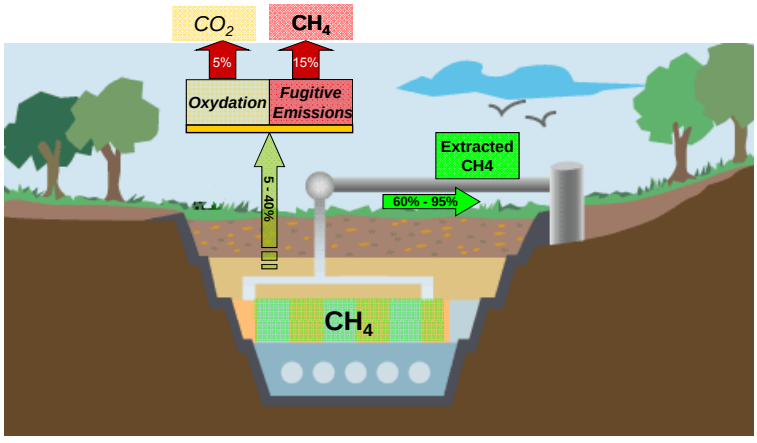


Rapport IPCC 2007, section 10 Waste Management

✓**Stabilized for EU-15 and USA**
Landfills : ~2% of GHG emissions of a country

✓**Rapid increase in Developing countries**

Landfills
Biogas & Fugitive Emissions



CH4 Mass Balance

Production = [Extracted] + [Non-Extracted]

Mesured

Non-Extracted = Emitted + Oxidized

Emitted (65-95%)

Oxidized (5-35%)

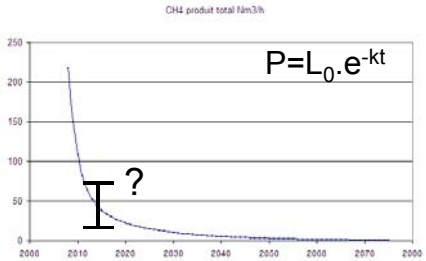
Biogenic CO2

Inventories

(Environmental Impact)

Estimates for inventories

- Modelling methane production



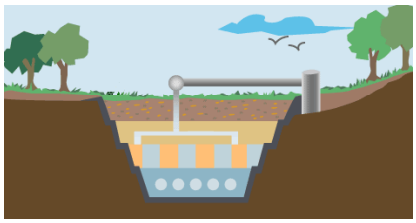
Possibilities to complexify the description
L_1, L_2, L_3, k_1, k_2, k_3 etc…

✓Parameters function of waste type
Vs
✓Waste intrinsic heterogeneity
Vs
✓Physical & chemical conditions (moisture, pH,…)

Estimates for inventories

- Extraction efficiency ?
  - ➔ Extraction system efficiency (wells type, wells density, extractors)
  - ➔ Top-cover type (material, thickness)
  - ➔ Cell design and operation (landfill dimensions, waste density)

- Oxidation potential ?
  - ➔ Climate
  - ➔ Top-cover
  - ➔ Methane fugitive flux



Synthesis

- Estimates based on a combination of assessment of 3 essential parameters, each subject to high hypothesis
- Use of generic default values
- No uncertainty assessment on final result
- Difficult (impossible…) validation/calibration
  - ➔ one measured parameter (collected gas) compared to the combination of 3

[Production] = [Extracted] + [Emited] + [Oxydized]

  - ➔ **Direct Measurement**
    - Access to the only one interesting parameter : Emission
    - Access to Uncertainties?

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Direct Measurement Available Methods

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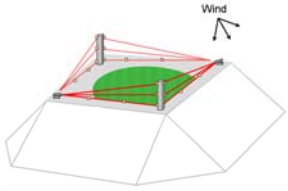
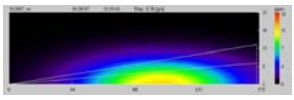
Radial Plume Mapping

Waste Management / Arcadis US / USEPA

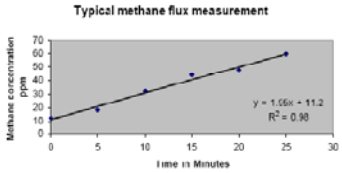




- Reconstruction of vertical concentration profile with 5 laser beams
- Combination of concentration and wind profiles
- Calculation of a surface emission factor on an upwind impact area (footprint)
- 4 corners configuration

Flux Chambers Methods

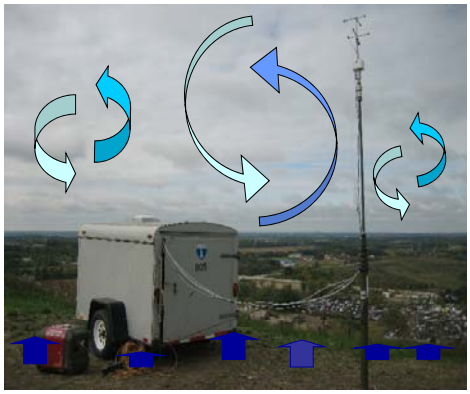
Waste Management / Landfills+ / University Florida



- Airtightness chamber
- Methane accumulation function of the time
- Use of 25m systematic grid
- Set up on the same areas as VRPM footprint
  - ➔ Used for comparison
  - ➔ Not for total site sampling

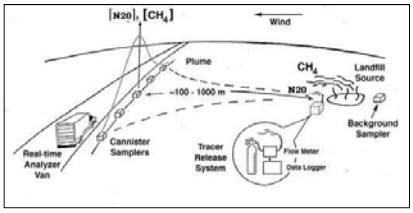
MicroMeteorological Eddy-Covariance flux measurements

Finnish Meteorological Institute



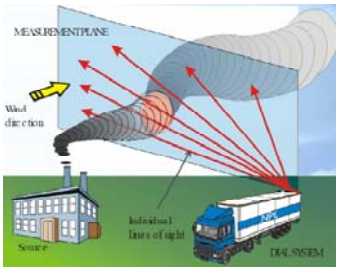
- Gas emitted from the surface has to pass through the turbulent lowest meters of the atmosphere.
- Concentration of a gas is higher close to the surface.
- Gas concentrations in the turbulent updrafts are higher than in the counter balancing downdrafts.
- High frequency analysis of vertical wind and concentration
- Coupled to an atmospheric dispersion model

Mobile Tracer Gas Method
FluxSense (Sweden)



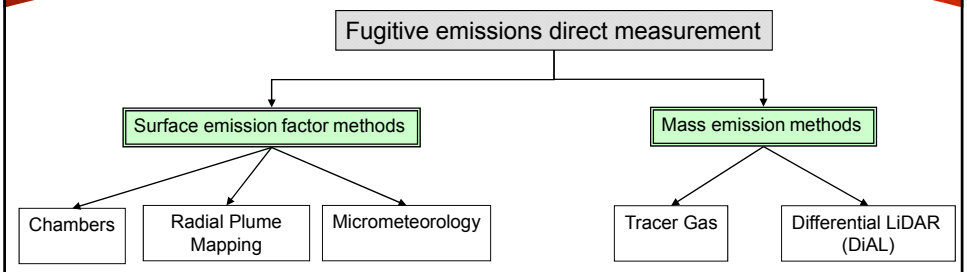
- Nitrous oxide tracing gas
- Search leak, inflow and outflow
- Selection of area to trace
- Mobile FTIR Downwind measurement of concentrations
- Calculation of CH4 fugitive flux based on concentration ratio

Differential Absorption Lidar (DiAL)
National Physical Laboratory (UK)



- Remote sensing (« gas radar »)
- Large scale range resolved concentration map
- Combination Concentration and Wind profiles
- Source measurement
- Spatial information

Global scheme



Surface emission methods

- Averaged emission on a limited area (between 0,1ha and 2ha)
- Result in gCH4/s/m²
- Surface Extrapolation for gCH4/s

Mass emission methods

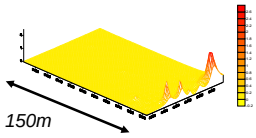
- Integrate a whole area emission
- Result in gCH4/s

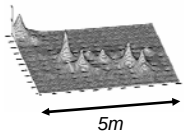
Conclusions of technical studies (2006-2009)

- Full description achieved
  - Technical/Time/Budget/Implementation/Limits
- Low availability of these methods (Not a routine control yet)
- From a technical point of view (landfill emission quantification):
  - Because of high spatial heterogeneity or/and difficulty to control the footprint issues, extrapolation of surface emission factors will create estimates rather than measurements
  - Mass flux methods appear more relevant to this field

Spatial Scale

- Observations from technical studies
  - ➔ Between cells : High disparities
  - ➔ Entire surface of a cell : High heterogeneity
  - ➔ No rules, No easy extrapolation allowed
- Measurement of large scale unknown heterogeneous sources
- Recommendations
  - ➔ Favor an entire site inspection
  - ➔ And so to integrate spatially as large as possible, in order not to miss fluxes.
  - ➔ Studies in progress





Temporal Scale

- Measuring a « living » process
- Integrate over time in order to get an annual inventory estimate
- Continuous measurement doesn't exist
  - ➔ Measurement frequency is the key parameter
  - ➔ To be adapted of the variation of phenomenon frequency
- Variations come from
  - ➔ External (meterological data)
  - ➔ Internal (landfill operation : closing/opening cells, technical breakdowns or maintenance)
- Studies in progress

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Uncertainties
Assessement and Reduction

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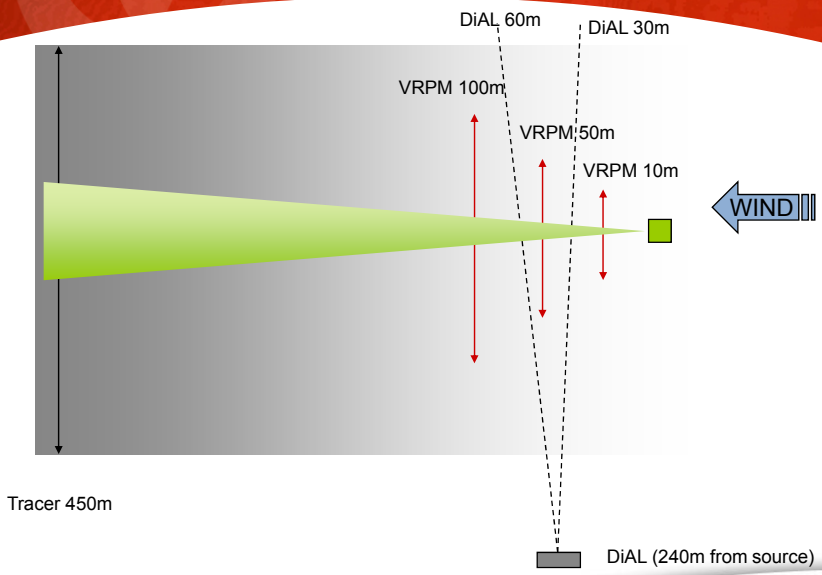
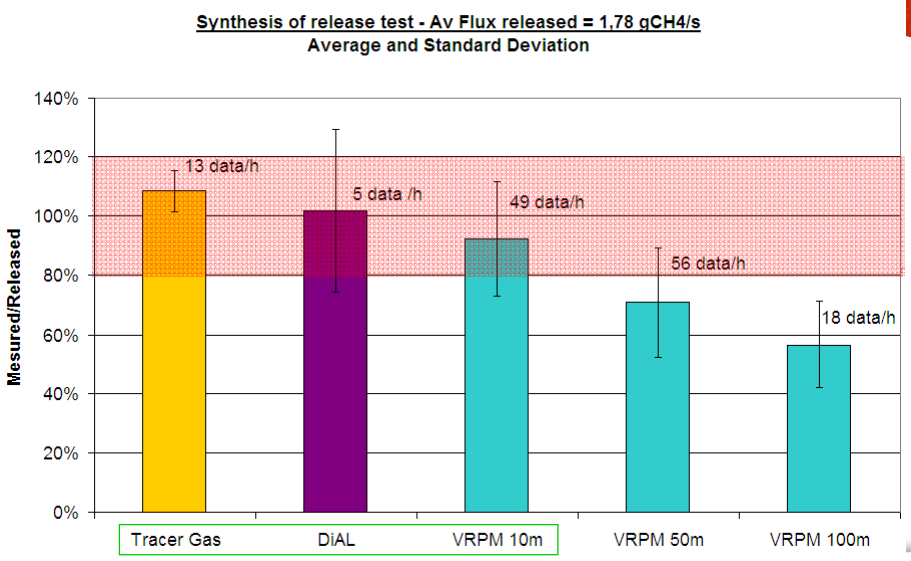
Release Calibration tests

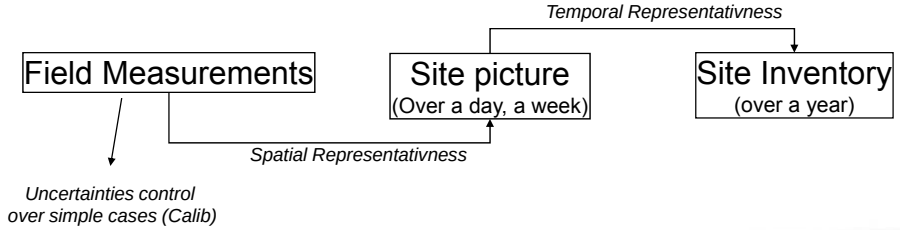


Test results

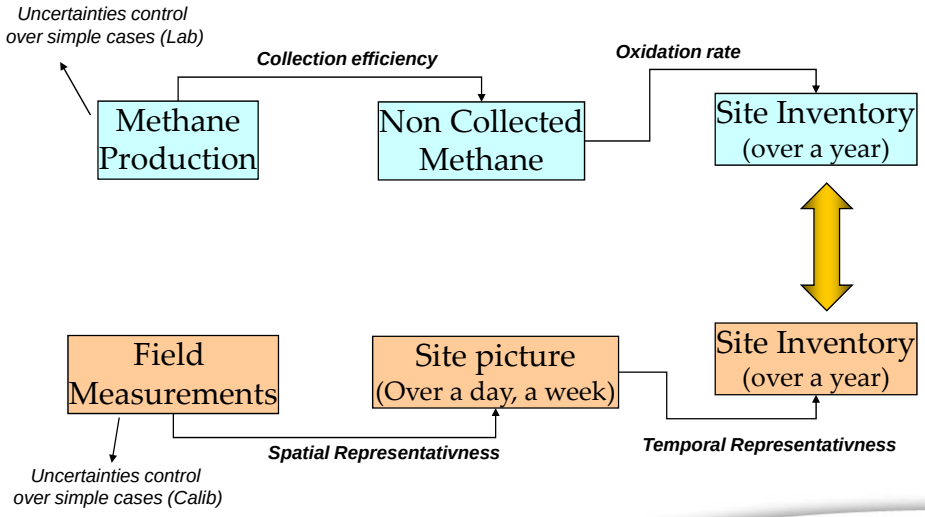


Uncertainties : Assessment & Reduction

- Calibration : really good results
- Landfill?
  - → Comparison to field scientific knowledge
  - → Comparison to empirical knowledge.
  - → Comparison between methods
    - Similar results on similar scales
    - High disparity on global landfill analysis
- Impact of the method strategy
  - → Over space : integrating methods
  - → Over time : to be defined.

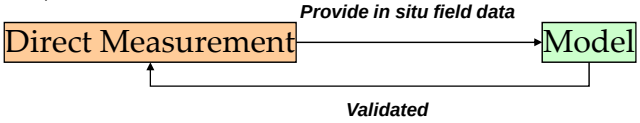


Synthesis



Synthesis

- A measurement method development can now be envisioned ONCE the needs are correctly defined
- Direct measurement utilization appears to be the unique way to access the scientific figures of uncertainties of emission data
- But
  - ➔ *Using Modelling approach only OR Using Measurement approach only will lead to important difficulties*.
- Recommendations:
  - ➔ Envision to formally couple both approaches for a maximum efficiency (an evolutive complementary approach)



  - ➔ Support the creation of normalization/standardization protocols (use of the measurement, place of the model) to harmonize practices and allow sound and relevent comparison of estimates

Ladies and Gentlemen,
Thank you for your attention

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