# MEASURING LANDFILLS $CH_4$ EMISSION WITH AIRCRAFT, EDDY COVARIANCE AND CHAMBERS TECHNIQUES

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**Summary**

We report on the combination of multiple techniques (aircraft, eddy covariance and chambers) to assess $CH_4$ emissions of several landfills in Italy. Chambers were able to characterize the spatial variability of the continuum of the landfill but not the presence of preferred localized fugitive emissions. The deploying of light aircraft and payloads in remote access areas to characterize large-scale emissions with the presence of multiple sources supported measures in areas not covered by the eddy covariance tower footprint. Landfills emissions where biogas extraction was present were on average an order smaller than landfill without any extraction, demonstrating the benefit of biogas extraction not only in terms of energy production but also of avoided GHGs emissions.

**Introduction**

Landfills are high emitting hot spots but their contribution to total GHGs budget in Europe is largely unknown (e.g. Bogner et al., 2008). Monitored landfills differ in terms of topography, presence of biogas extraction, age and type of waste, and maintenance, resulting their actual emission to the atmosphere basically not deliverable from inventorial methods. Here, we show the combination of multiple techniques to assess $CH_4$ emissions of several landfills in Italy.

**Methodology and Results**

From the one hand landfills emissions can respond on short time-scales driven by controls such as atmospheric pressure and temperature, on the other hand they exhibit high spatial variability that needs to be sampled. We developed an experimental framework capable of integrating measurements at different spatial and temporal scales: (1) cavity ring down spectroscopy (CRDS) coupled with soil chambers (monthly campaigns); (2) open-path $CH_4$ laser devices on eddy-covariance stations (in continuous); (3) open-path $CH_4$ laser devices on a SkyArrow ERA (Environmental Research Aircraft) platform to sample atmospheric transport coupled to $CH_4$ plumes (campaigns).

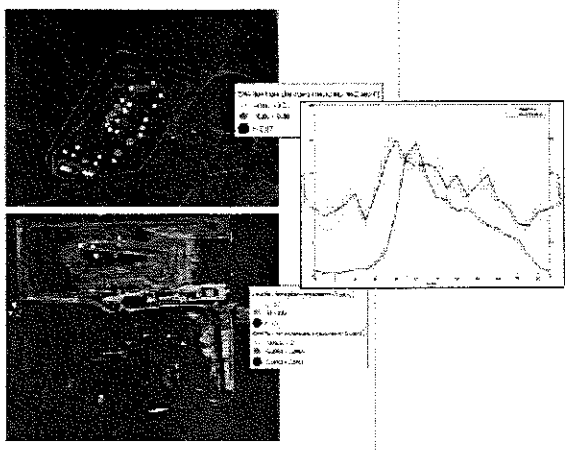

*Fig.1 $CH_4$ emissions detected with chambers and eddy covariance station.*

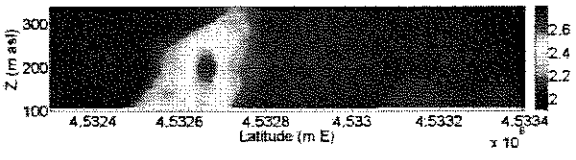


*Fig.2 $CH_4$ emissions detected with aircraft (x=424426.4 m E).*

$CH_4$ emission measured with eddy covariance were on average 0.49 and 6.34 μmol $m^{-2}$ $s^{-1}$, while measured with CRDS on the same landfill were on average ten times lower, suggesting that chambers were able to characterize the spatial variability of the continuum of the landfill but not the presence of preferred localized fugitive emissions. Landfills emissions where biogas extraction was present were on average an order smaller than landfill without any extraction, demonstrating the benefit of biogas extraction not only in terms of energy production but also of avoided GHGs emissions (Fig. 1).

Aircraft flights were designed to sample the plumes developing downwind individual landfills, arriving to quantify the emissions of a larger areas with five landfills in Giugliano at an average of 33 μmol $m^{-2}$ $s^{-1}$ (Fig. 2).

**Conclusions**

We showed the benefit of deploying light aircraft and payloads in remote access areas to characterize large-scale emissions with the presence of multiple sources, not covered by the eddy covariance tower footprint. The main limitation of aircraft measurements remains the capability to fly very close to ground not sampling part of the plume when flying very close the emission source; this limitation will be overcome with the integration of ground mobile measurements and UAV equipped with low weight sensors.

**References**

Bogner J., et al., 2008. Mitigation of global greenhouse gas emissions from waste: conclusions and strategies from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. Working Group III (Mitigation). Waste Management 26, 11-32