

The FLUX-METER: implementation of a portable integrated instrumentation for the measurement of CO₂ and CH₄ diffuse flux from landfill soil cover.

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SUMMARY

- **INTRODUCTION**

the problem of landfill gas (LFG) emission in Municipal Solid Waste Landfills

- **THE FLUX-METER** (the accumulation chamber)

- ✓ An integrated instrument

- ✓ Advantages

- **DATA PROCESSING**

a tool to estimate the total amount of LFG discharged into the atmosphere

- **CONCLUSION**

INTRODUCTION

- MUNICIPAL SOLID WASTE LANDFILLS (MSW): important sources of atmospheric contamination due to diffusive emissions of landfill gas (LFG) from the cover.
- COMPOSITION OF LFG
 - ✓ CH₄ and CO₂ (greenhouse gases)
 - ✓ compounds present in trace with toxic and malodorous characteristics.
- LEGISLATION: D.Lgs. 152/2006 and EU Directive 96/61/CE

→ EVALUATION OF LANDFILL EMISSIONS

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INTRODUCTION

The numerous techniques to **quantify the flux released** from soil (landfill) can be divided in three main categories:

- Measurements of the gas concentration gradient
- Micro-meteorological techniques (e.g. eddy correlation)
- Enclosure based techniques (static and dynamic accumulation)

→ THE ACCUMULATION CHAMBER

THE FLUX-METER

Flux-Meter: Integrated instrument, based on accumulation chamber, for the measurement of the diffuse degassing phenomena

Why a static non-stationary technique?

- It is the least affected by environmental and meteorological parameters (Trègourès et al., 1999)
- It allows soil gas flux measurements without any information about soils characteristics and flux conditions or ranges
- These methods are much faster in respect to other techniques

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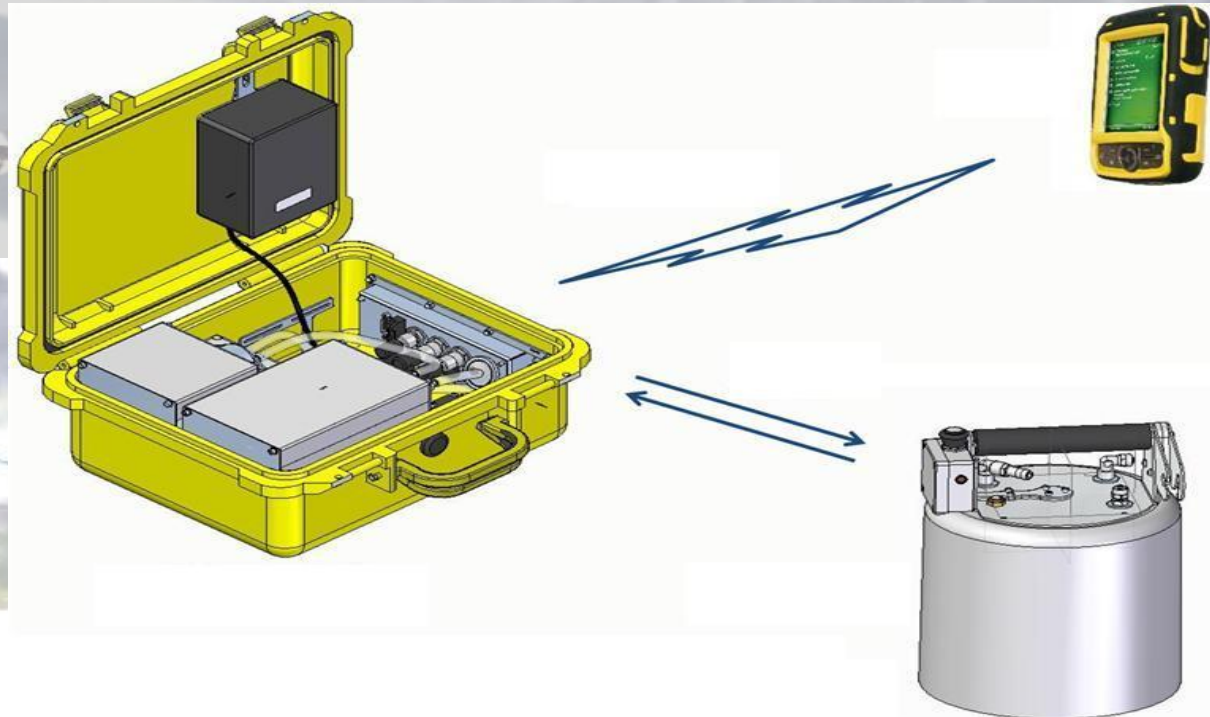
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THE FLUX-METER

The integrated instrument realized by West Systems:

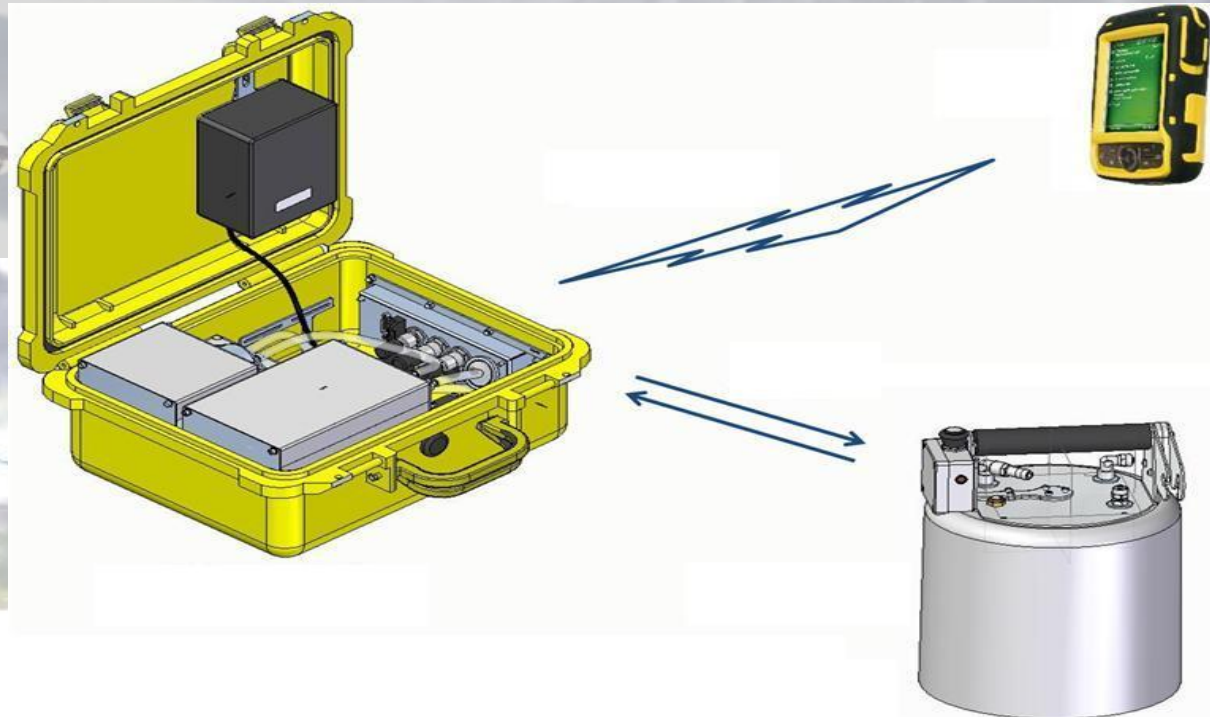
- Accumulation chamber
- Palmtop computer (PDA) with integrated GPS
- A backpack with
 - ✓ gas analyzers
 - ✓ Electronics
 - ✓ battery



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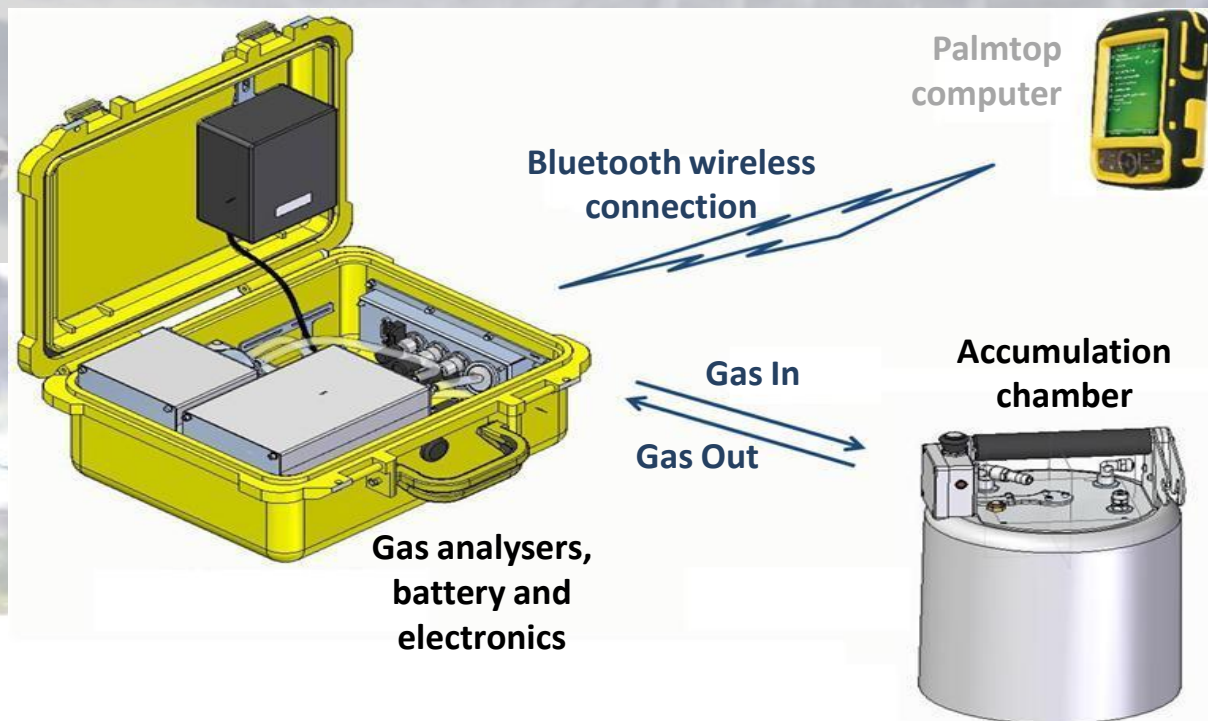
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 - ✓ Non-Dispersive Infrared (NDIR) spectrometer for CO₂ measurement
 - ✓ a tunable laser spectrometer combined (TDLAS) with a Herriot multi-pass cell for the measure of CH₄
 - ✓ an electrochemical detector for H₂S measurement
 - ✓ a photoionization detector for VOC measurement
 - ✓ pneumatic system
 - ✓ battery

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THE FLUX-METER

Detectors specifications:

Detector	Measurement Range	Resolution	Accuracy
NDIR for CO ₂	0-20,000 ppm	RMS Noise at 370 ppm with 1 sec signal filtering: <1 ppm	3% of reading
TDLAS for CH ₄	0-100,000 ppm	0.1 ppm	10% of reading
Electrochemical for H ₂ S	0-20 ppm	RMS noise (ppm equivalent): < 0.02 ppm	10% of reading
Photoionization for VOC	0-10 ppm	1 ppb	(Isobutylene) 10% of reading

THE FLUX-METER

Accuracy of measurements in function of the flux:

<i>Detector</i>	<i>Flux range</i>	<i>Accuracy</i>
Methane TDLAS	0.5 – 1,500 millimoles/m ² ·day	± 25%
	1.5 – 1,000 moles/ m ² ·day	± 10%
Carbon dioxide NDIR	1.0 – 1500 millimoles/m ² ·day	± 25%
	1.5 – 300 moles/ m ² ·day	± 10%

THE FLUX-METER

Main characteristics:

- PDA: to receives and exchanges information with the instrument via a Bluetooth wireless connection
- Specific software to acquire:
 - ✓ gas species (CO₂, CH₄, H₂S, VOC)
 - ✓ GPS data → automatic geo-referencing of the flux measure
 - ✓ other data (P and T of the measuring cells of the detectors and battery voltage of the of the system)
- The concentration data are represented in function of time, and the flux curves are visualized in real time to be checked and validated by the operator
- All the data acquired are saved into the PDA memory and on the on-board Micro-SD card to be available for further processing

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THE FLUX-METER

Field measurement:

- The chamber edge must be well attached to the ground to avoid the input of atmospheric air
- A fan ensures the mixing of the gases
- The gas is continuously extracted from the chamber, sent to the analysers, and then injected again inside the chamber
- The operator can visualize on the PDA the increase of gas concentration vs. time and the software computes the flux in real-time

Steps of a field measurement with the FLUX-meter



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MAIN ADVANTAGES:

- Integration of high performance detectors: able to measure very low CH₄, CO₂, H₂S and VOC concentrations
- Portable instrumentation: total weight, including accumulation chamber, is less than 10 Kg
- manageability of the device
- simple use
- Fast flux measurements: 2-3 minutes per measurement

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DATA PROCESSING

An example

- AIM: Quantify the total flux released from a MSW of about 140,000 square meter
- FIELD ACTIVITY: Flux measures in specific points inside the whole investigated area located in a regular grid (mesh size of 20x20 meters)
- METHODOLOGY: statistical and geostatistical approach to quantify a specific gas released from the investigated area and to recognize the presence of zones characterized by anomalous fluxes

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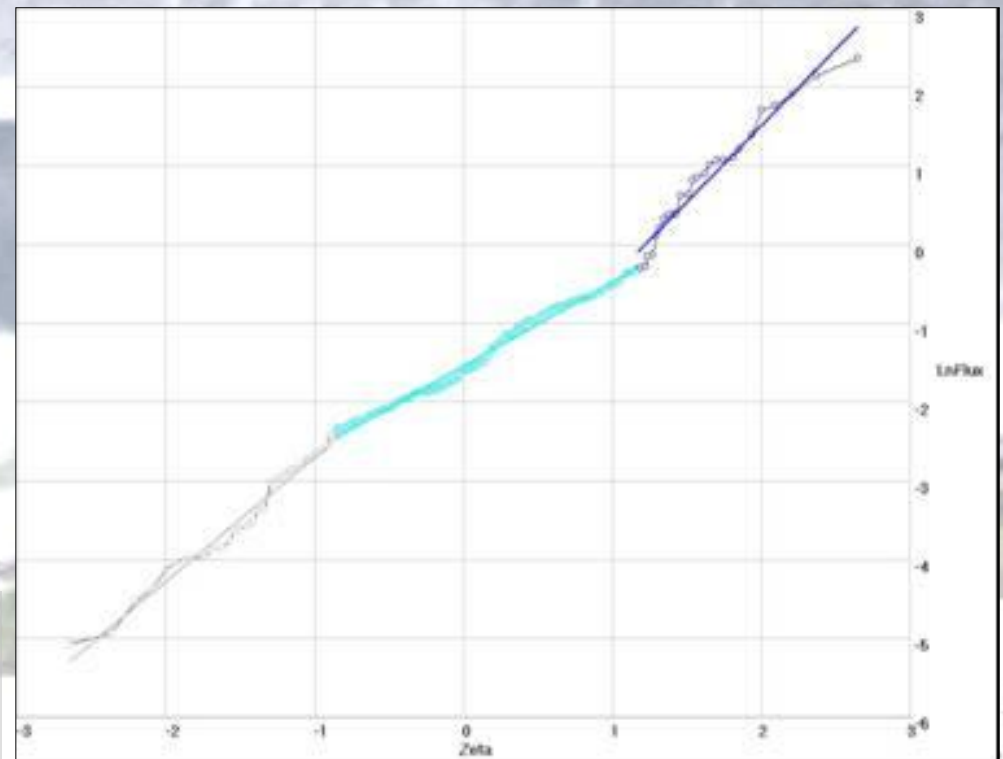
DATA PROCESSING

STATISTICAL ANALYSIS

Methodology based on partitioning the flux data by means of cumulative probability plots, formalized by Sinclair (Sinclair, 1970 and 1991).

It allows to recognize different populations from the whole of the data.

Cumulative
probability plots of
 CH_4 flux



DATA PROCESSING

STATISTICAL ANALYSIS

Methodology based on partitioning the flux data by means of cumulative probability plots, formalized by Sinclair (Sinclair, 1970 and 1991).

<i>Subset</i>	<i>N. measures</i>	<i>Mean</i>	<i>Variance</i>	<i>Sichel-V</i>	<i>Flux (Nm³/h)</i>	<i>95% confidence interval (Nm³/h)</i>	
1	12	2.19	0.846	1.506	95.4	217.2	61.3
2	131	-0.964	0.889	1.557	46.0	56.4	38.9
3	45	-3.303	0.342	1.185	1.2	1.4	1.0
Tot CH₄					142.5	275.0	101.3

An implementation for pc of the Sichel method has been developed by West Systems. It allows to calculate:

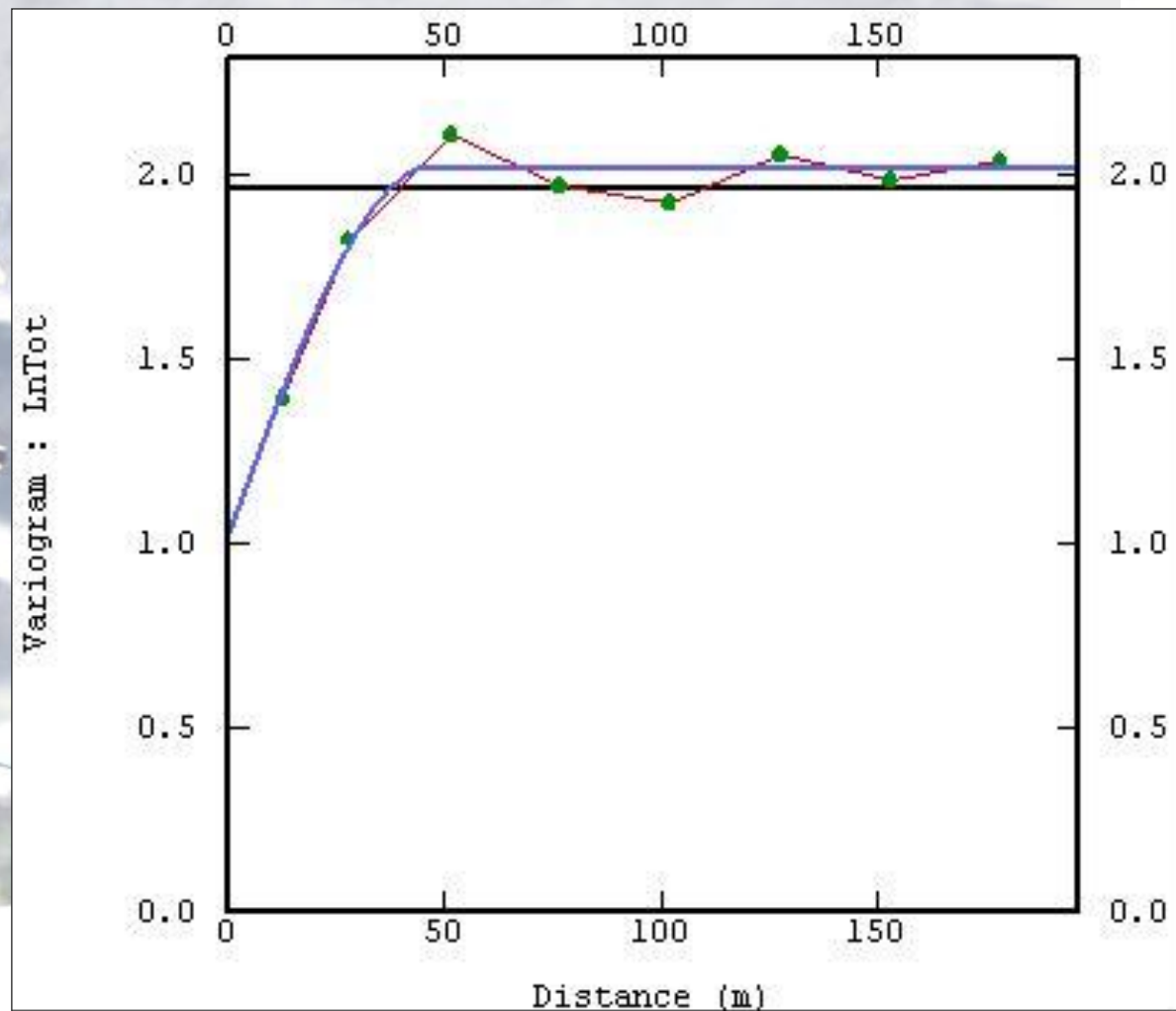
- the cumulative probability plot
- the total output of LFG knowing the extension of the investigated area (Raco *et al.*, 2010).

DATA PROCESSING

GEOSTATISTICAL ANALYSIS:

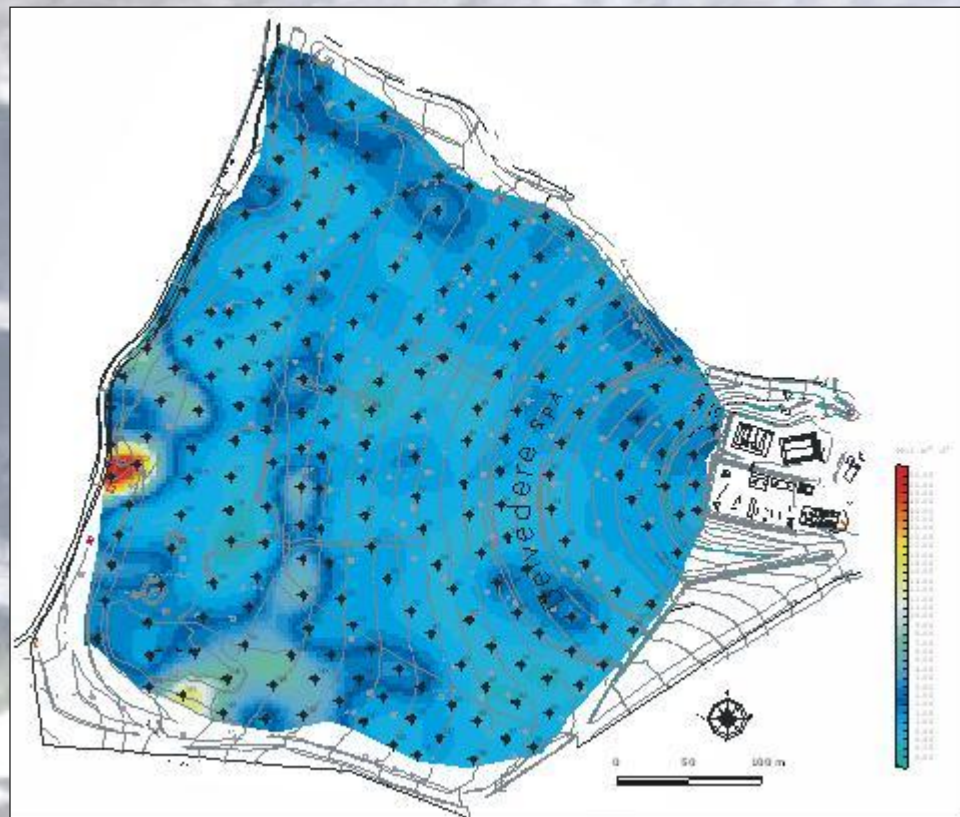
Kriging methodology

Experimental variogram
and variogram model



DATA PROCESSING

GEOSTATISTICAL ANALYSIS: Kriging methodology



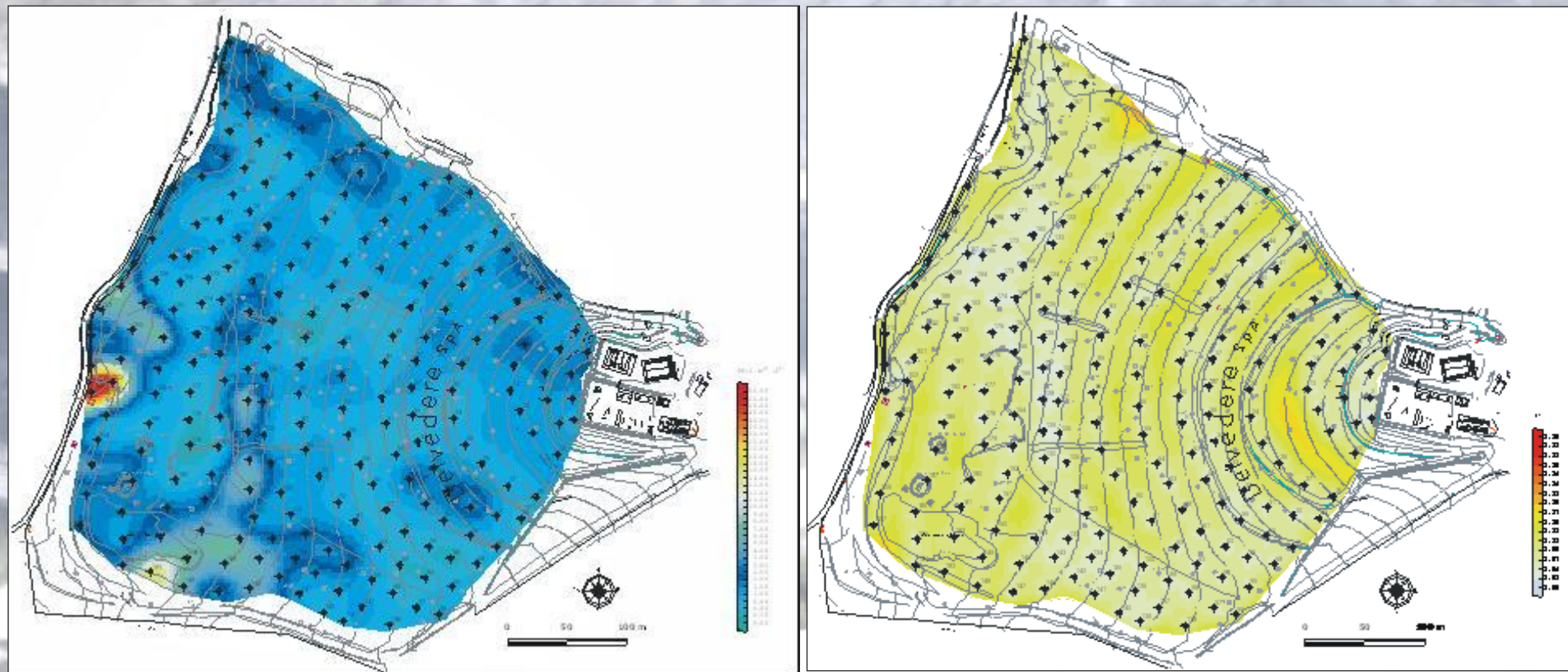
Isoflux map of LFG released from the cover of the MSW landfill

The black dots represent the locations of flux measurements performed with FLUX-meter

DATA PROCESSING

GEOSTATISTICAL ANALYSIS: Kriging methodology

Isoflux map associated with its standard deviation map



CONCLUSION

FLUX-METER, an integrated equipment

- allows the measurements of the real amount of CO₂, CH₄, H₂S, and VOC discharged into the atmosphere
- permits to carry out **quick** and **reliable punctual measurements**

All registered data by Flux-Meter can be processed:

- by an implementation of the Sichel method
 - quantify the total amount of LFG
 - estimation of LFG lost by the capture system
- by geostatistical method (elaboration of isoflux maps)
 - visualization of high fluxes zone

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