Unmasking carbon dioxide sources:

A data-driven approach for safer redevelopment

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Overview

- Context
- Carbon Dioxide gas risk and sources
- Differentiating between sources: Ternary Plots
- Case Study
- Conclusions and Recommendations

Context and Motivation

- As practitioners, we often encounter sites with CO2 levels exceeding 5%.
- BS 8485: this exceedance can trigger consideration to reclassify the site from CS1 to CS2.
- However, not all cases of elevated CO2 represent a significant risk.
- Misinterpreting data can lead to unnecessary design and remediation costs.

Modified Wilson and Card classification

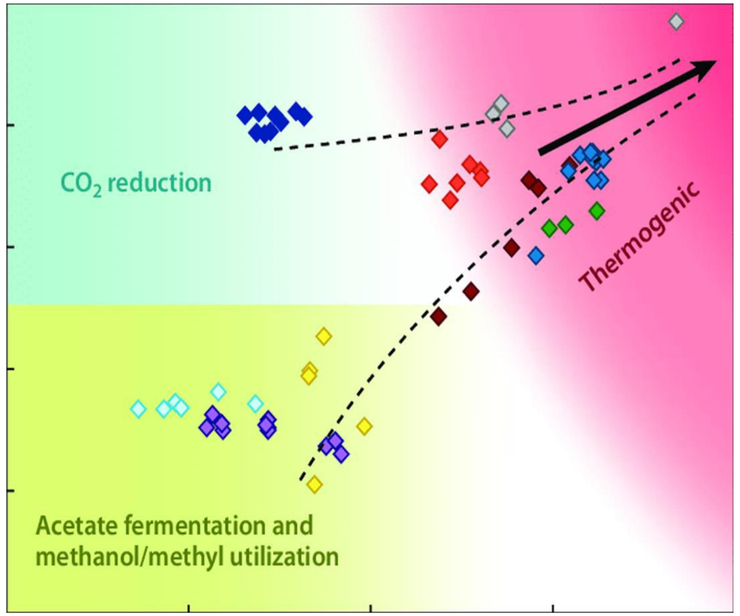
	Characteristic situation (CIRIA R149)	Comparable classification in DETR *et al* (1999)	Risk classification	Gas screening value (GSV) (CH_4 or CO_2) (l/hr)[1] Threshold	Additional factors	Typical source of generation
	1	A	Very low risk	<0.07	Typically methane £1 % and/or carbon dioxide £5 %. Otherwise consider increase to Situation 2	Natural soils with low organic content "Typical" made ground
	2	B	Low risk	<0.7	Borehole air flow rate not to exceed 70l/hr. Otherwise consider increase to characteristic Situation 3	Natural soil, high peat/organic content. "Typical" made ground
	3	C	Moderate risk	<3.5		Old landfill, inert waste, mineworking flooded
	4	D	Moderate to high risk	<15	Quantitative risk assessment required to evaluate scope of protective measures.	Mineworking – susceptible to flooding, completed landfill (WMP 26B criteria)
	5	E	High risk	<70		Mineworking unflooded inactive with shallow workings near surface
	6	F	Very high risk	>70		Recent landfill site

Wilson *et al* 2007

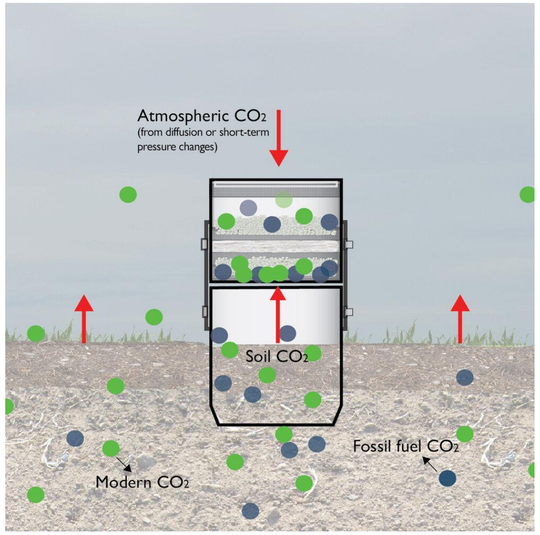
Carbon Dioxide Sources:

Source	Origin	Methane	Carbon dioxide	Other gases
		Typical concentration range (v/v)		
Soil	Physical, chemical and biological weathering	<2 ppm	350 ppm	–
Soil	Oxidation of organic matter		0–10%	–
Swamps and wetlands, waterlogged soils	Anaerobic microbial decay of organic material	10–90%	0–5%	Phosphine (PH_3)
Coal measures strata	Coal seam gas	<1–90%	0–6%	–
Organic shales	Tightly held gas originating from both biogenic and thermogenic processes	60-90%	0-5%	Ethane, H_2S
Carbonate strata, including shelly sands	Dissolution of carbonates by acidic groundwater (e.g. due to oxidation of acid sulfate soils)		1–20%	–
Natural gas traps	Leakage	90–95%	2–8%	–
Granite	Radioactive decay of uranium	N/A	N/A	Radon typically <200 Bq/m³

NSW EPA 2020



Core, 2024



EFLUX

- Radioisotope analysis
- Isotopic Fractionation
- Methane to Carbon dioxide and oxygen to balance ratios
- Background data set

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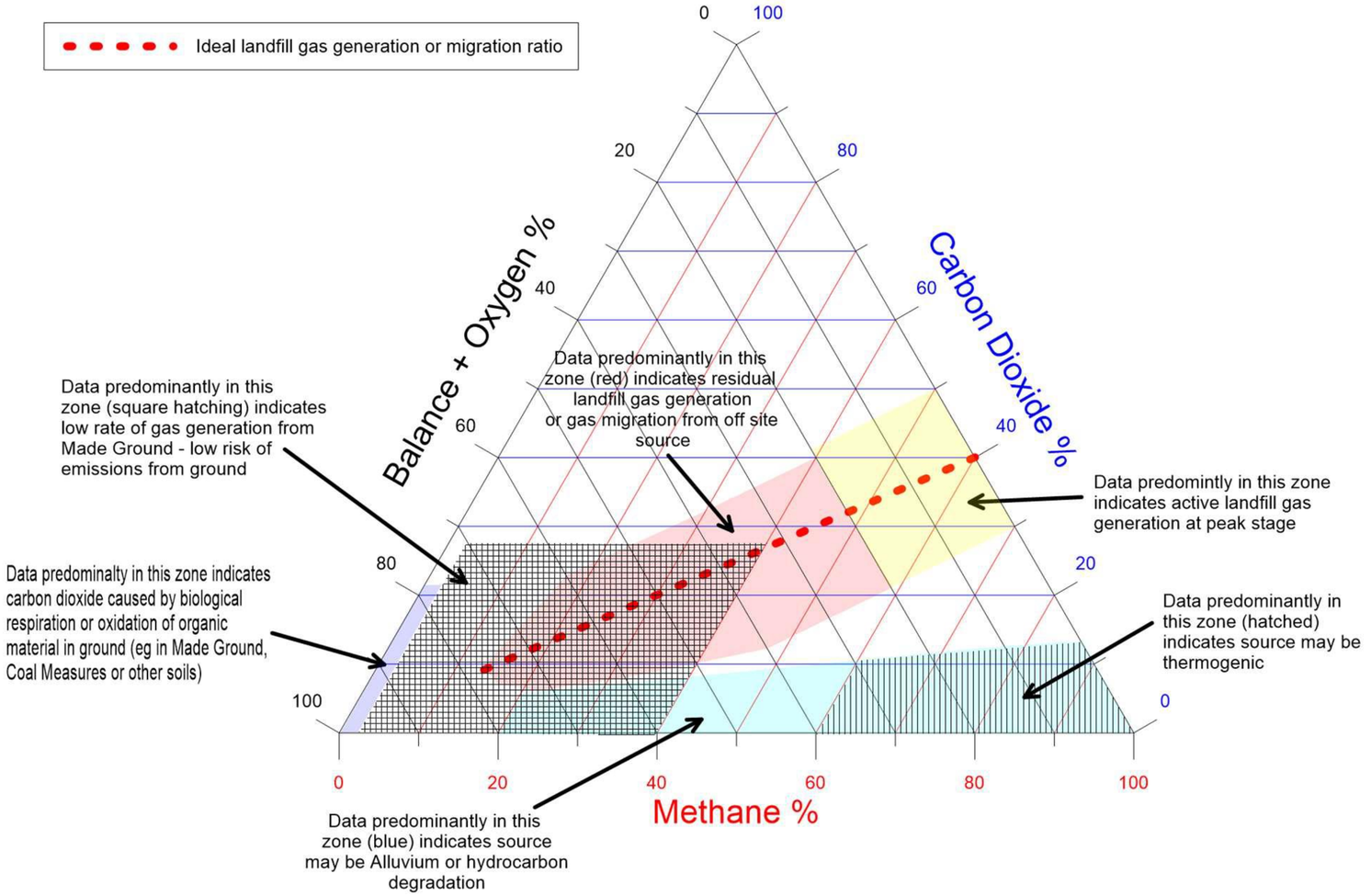
Ternary Plots



Society of Brownfield Risk Assessment 2023

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Ternary Plots – Case Study

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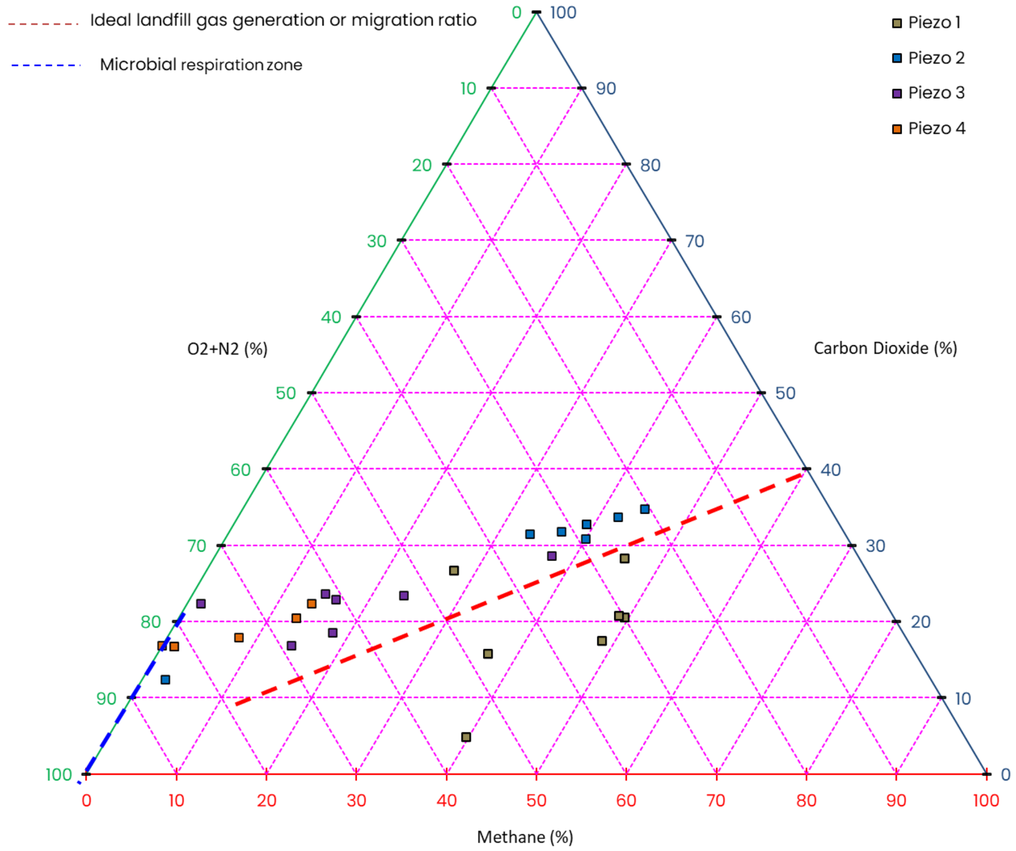
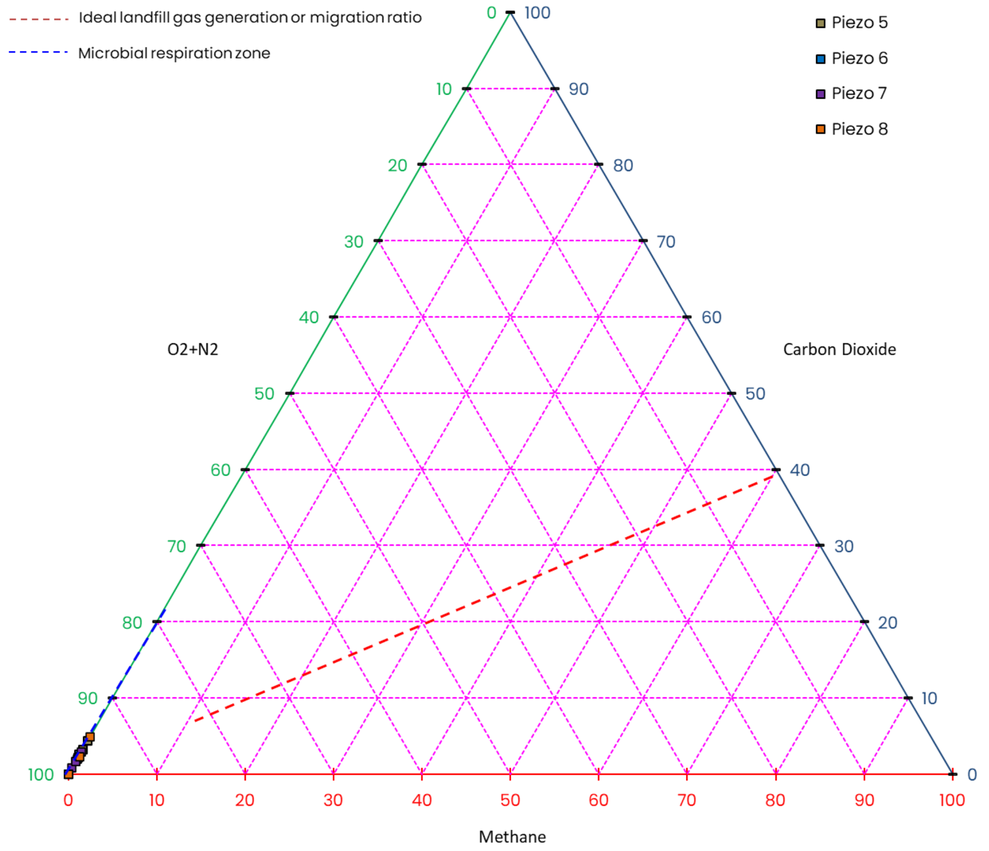
Ternary Plots – Case Study



Landfill boundary



Development Area

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Ternary Plots – Case Study

- Boundary of landfill:
  - Monitoring results showing consistently potential migration of gases from the closed landfill may be occurring.
  - The observed steady methane and carbon dioxide levels display a 1:1 ratio, characteristic of landfill gas emissions.
- Development area:
  - The monitoring readings showed low levels of steady carbon dioxide concentrations.
  - Oxygen depletion was occasionally observed, but methane levels remained negligible, and low gas flow rates were recorded.
  - Findings suggest that gases may originate from natural geological weathering or microbial degradation of organic material in the underlying soil.
  - As organic material decomposes in the presence of oxygen, oxygen levels decrease, while carbon dioxide levels increase proportionately.

Conclusions and Recommendations

- Ternary plots should only support a robust conceptual site model (CSM), not replace it.
- Careful with use of ternary plots (CSM consistency, check for flow rates, distribution of elevated concentrations, trends, etc.)
- Ternary plots help assess gas sources, distinguishing cases where carbon dioxide concentrations above 5% result from low-risk microbial respiration rather than contamination concerns,
- Upgrading characterization from CS1 to CS2 solely due to high gas concentrations is optional, not a requirement.

Thanks

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