Monitoring Resistivity in Non-Hazardous Waste Landfill Using Time Domain Electromagnetism (Drôme, France)

Grenoble, France

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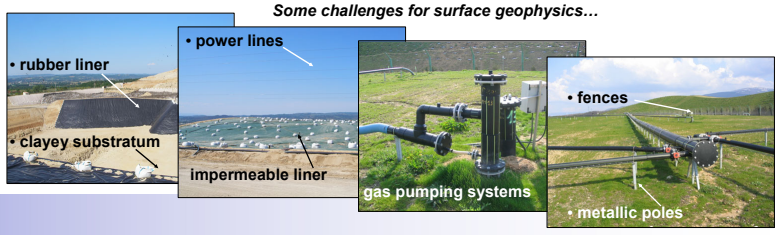
Objectives

- Project: evaluate non-destructive geophysical methods for optimizing bio-degradation of non-hazardous municipal solid waste.
- In-situ long-term monitoring of resistivity variations for thick (15-30m) waste deposits. Focus on TDEM method.
- Understand resistivity variations using monitoring of leachate conductivity, water content, density and temperature

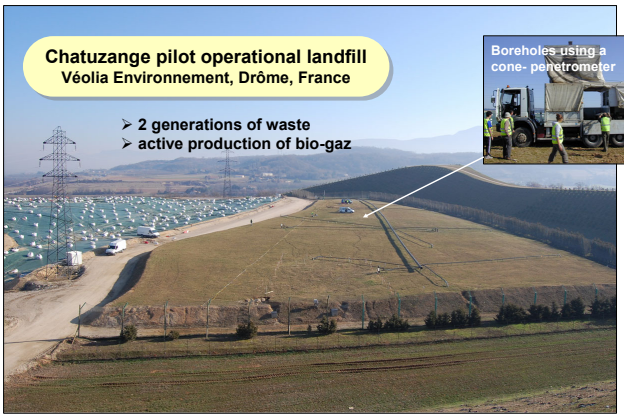
• Up-to-date non-hazardous municipal landfills are designed to optimize bio-degradation of waste (bioreactor process) and protect environment.
• The bio-degradation is controlled by water content, difficult to measure.
• Typical industrial sites show complicated geometry with various constrains.

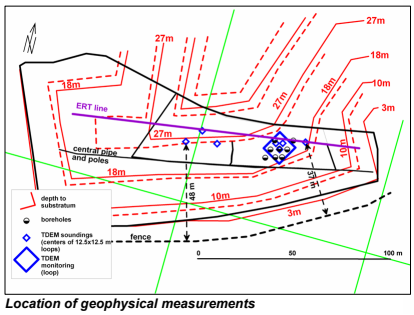
➢ impermeable (and isolating) liners, geosynthetic clayey liner
➢ 50 Hz power lines, pumping systems,
➢ pipes and metallic poles,
➢ fences
➢ limited survey area

Some challenges for surface geophysics…

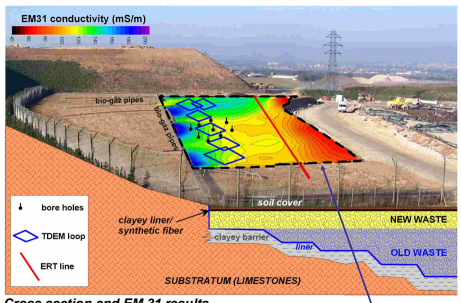


Site description and methods





Location of geophysical measurements



Cross section and EM 31 results

➢ Resistivity well suited for monitoring bio-degradation process

➢ Time Domain Electromagnetism (TDEM) sounding for deep investigation without large extension at the surface.
• advantages: non-destructive, very sensitive to low electrical resistivity, easy to layout, deep investigation, focused sounding thanks to small Tx/Rx loop
• limits: poor for shallow layer, 1D assumption

➢ Boreholes for in-situ monitoring of temperature, resistivity, water content, density

➢ One year monitoring period

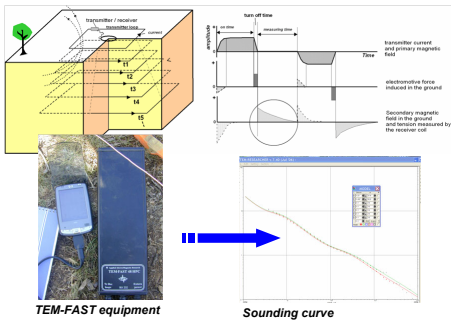
➢ Complementary surveys using DC resistivity / frequency EM

Frequency EM

EM 31 survey

➢ EM 31 (Geonics Ltd)
➢ fences and poles effect

Time Domain EM soundings time-lapse monitoring



TEM-FAST equipment

Sounding curve

➢ TEM-FAST 48HPC (AEMR Technology, the Netherlands, www.aemr.net)
➢ 48 channels, calibration coil
➢1 to 3.5 A, 50 Hz notch filter, light TX/RX units)
➢ Coincident loop (12.5 m x 12.5 m)
➢ Measurements every 2 months
➢ 1D interpretation

Soil moisture / density monitoring (neutron and gamma probe)

➢ CPN probes
➢ boreholes from 2.5 m to 7 m

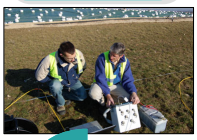
➢ sampling every 10 cm

Gaz and leachate conductivity monitoring

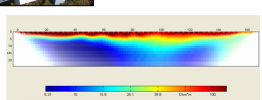
Resistivity and temperature logging monitoring

➢ borehole 2 m (7 m drilled, but technical problems to obtain deeper data)

DC resistivity (ERT)

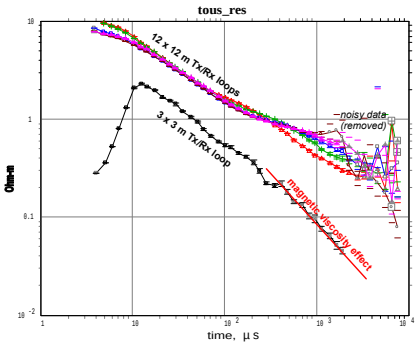


➢ Syscal Pro (Iris Instruments, France)
➢ limited array length (120 m)
➢ inversion using Dc2DInRes software (T. Günthe r, GGA Institute Hanover, Germany)
➢1D assumption valid for TDEM between 0 and 15 m
➢ electrical isolation of poles compulsory

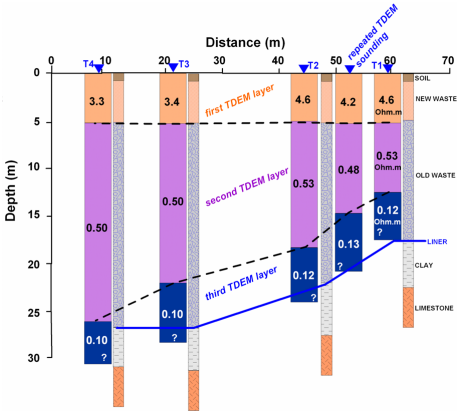


Results

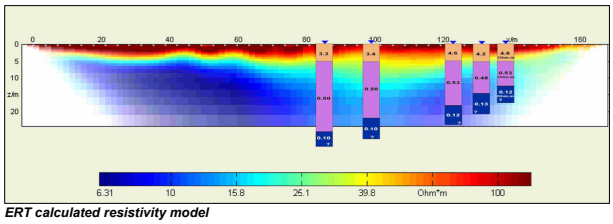
TDEM soundings



TEM-FAST sounding curves



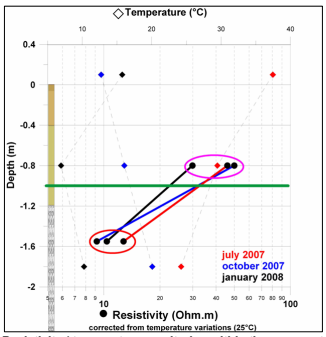
Comparison with ERT



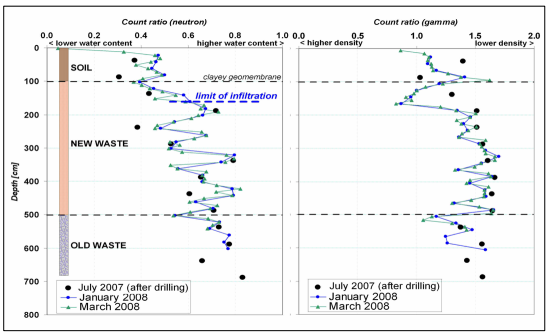
ERT calculated resistivity model

- TDEM response free from inductive effect (metallic conductors) thanks to high conductive response from waste.
- TDEM response contaminated by low magnetic viscosity effect, negligible with loops > 12 m.
- 2 layers of waste clearly identified.
- Leachate resistivity: 0.23 ohm.m at 7m.
- Depth to last layer (0.1 ohm.m): doesn't fit with known substratum.
- 3D effect or lower leachate conductivity?
- 1D assumption acceptable for first 10m
- Discrepancy with ERT resistivity, but accordance with FEM conductivity.

Loggings



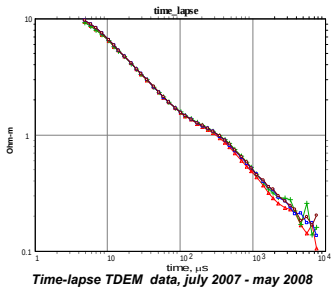
Resistivity / temperature monitoring within the new waste



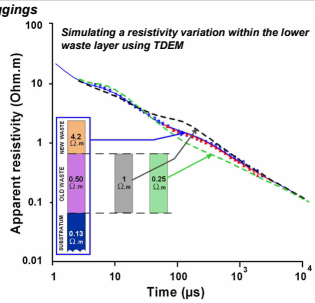
Neutron and gamma-densimetry loggings

- Negligible DC resistivity variations within the upper waste layer, once corrected from temperature variations.
- Very limited infiltration from the surface.
- No water content nor density changes with time down to 7m.
- Gaz production remained unchanged during 1 year.

Time-lapse TDEM



Time-lapse TDEM data, july 2007 - may 2008



- Calculated resistivity varies from 4.9 to 4.35 ohm.m for upper waste layer, and from 0.49 to 0.53 ohm.m for lower waste layer.
- Constant temperature and leachate conductivity are highly probable.
- Any significant resistivity change in the waste would have been recorded using TDEM that integrates a large volume.

Conclusion and perspectives

- TDEM is efficient to determinate resistivity of waste from the surface. Care should be taken regarding external effects and limitations due to 1D assumption.
- Time-lapse TDEM doesn't show any resistivity variation over 1 year within the waste. This observation is confirmed with additional destructive measurements down to 7 m (leachate conductivity, water content, density), and partly down to 2 m (temperature, DC resistivity).
- TDEM synthetic modelling indicates that significant resistivity variation (+/- 100%) could be recorded using TDEM.
- Leachate injection experiment is planned to evaluate TDEM for monitoring leachate recycling in bio-reactive landfill.

Acknowledgements

- *This study has been funded thanks to French research grant ANR "Bioréacteur" and technical help from Véolia Environnement*
- *P. Barsukov from AEMR technology (Tem-Fast manufacturer) provided useful help on TDEM interpretation*
- *Johan Parra made EM survey and bore hole design.*