Geoelectrical monitoring during waste biodegradation process

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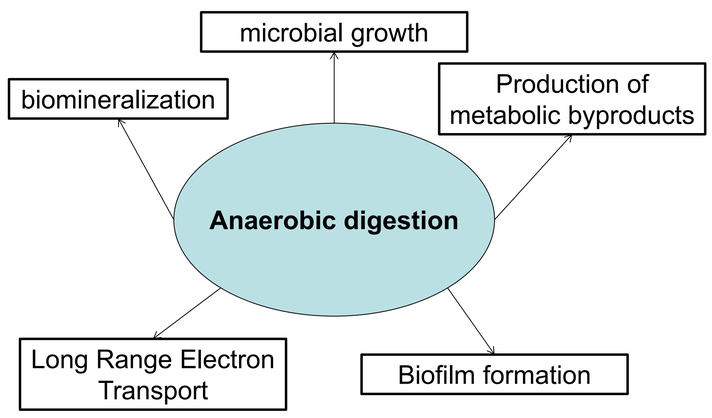
Introduction

Context : landfills are complex structures whose objective is to enhance energetically the biogas produced and reduce environmental impact. To reduce this impact the industrialist of the waste sector are obliged to conduct a long-term post operating 30 years monitoring related in particular to the waste biodegradation state in landfills. From a regulatory perspective, in France a ministerial order under review only propose biogas and leachate effluents analyzes (overall indicator) to monitor the state, evolution and impact of the landfill on the natural environment. For this reason industrialists are now looking for a new tool that would provide information on the waste biodegradation state for an entire landfill.

Objective : Assess the potential and limitations of certain geophysical methods to characterize the waste biodegradation state in laboratory scale.

Figure 1: Picture of a municipal solid waste landfill

Waste biodegradation

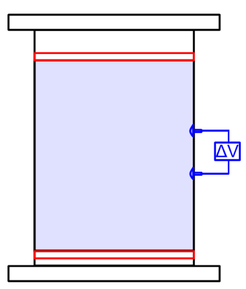


Electrical method allow to record all the physical end chemical changes due to the microbial activity. For this reason four geoelectrical methods were selected

Geophysical methods selected

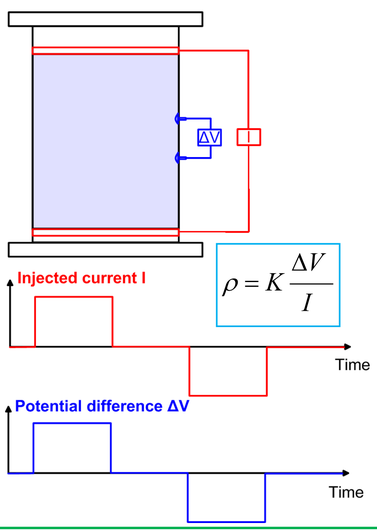
Self-potential :

self potential is the measure of the electric potential which occurs spontaneously in a medium.



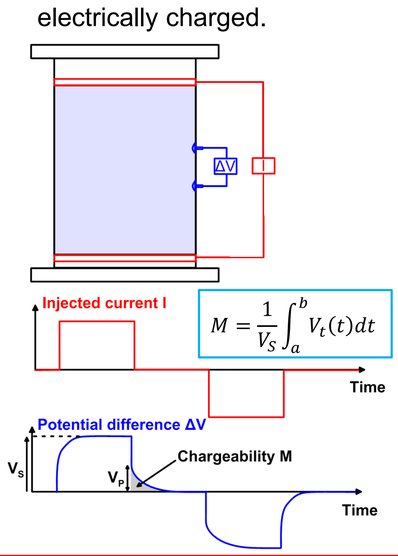
Electrical resistivity:

The electrical resistivity is the ability of a porous medium to be oppose to a current flow.



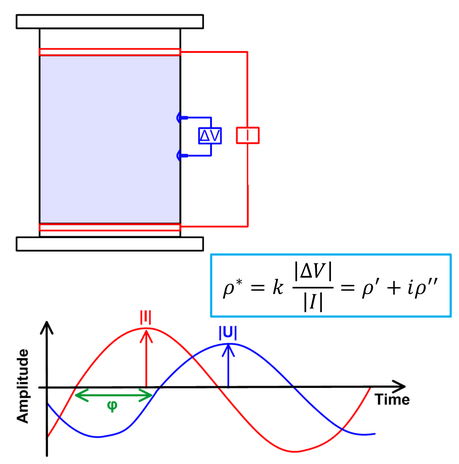
Induced polarization :

the induced polarization defines the ability of a medium to become electrically charged.



Spectral induced polarization :

Spectral Induced Polarization consists in measuring the complex electrical resistivity (obtained from AC current) as a function of frequency.



Influence of the biodegradation on measurement	Modification of redox potential by bacterial growth (Naudet et Revil, 2005; Singh, 2014)	Increase with acid production (Cassidy et al, 2001; Slater et al., 2009) Long-term convergence to a plateau value (Moreau et al., 2005; Beaven et al.,2007)	Related to the presence of biodegradable organic matter (Carlson and Mayerle, 2009; Leroux et al., 2010)	Modification of phase shift associated with biofilm formation (Albrecht et al., 2011; Ntarlagiannis et al., 2005)

Establishment of a laboratory pilot

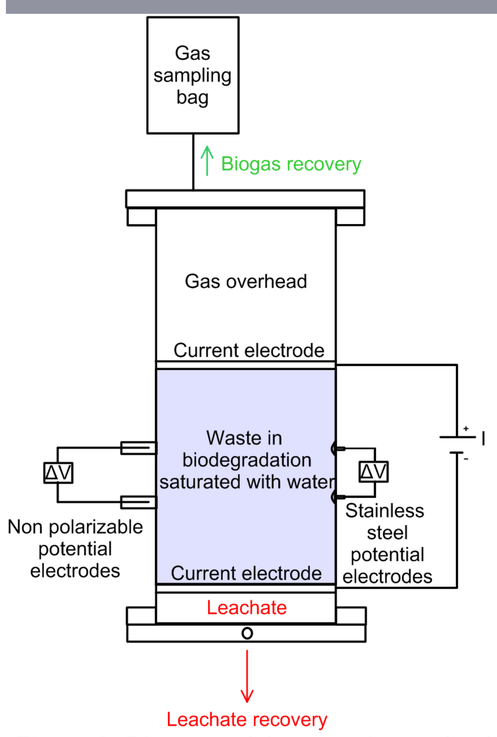


Figure 2: Diagram of the experimental column

Installation of the column:

- shredded waste and poured in the column
- Moisten with a biowaste digestate
- Saturated it with water and placed at 35 ° C
- Add two stainless steel plates for the current injection
- Add two stainless steel potential electrodes
- Add two non polarizable potential electrodes

Chemical measurements:

Effluents analysis:
Leachates: VFA, pH
Biogas: composition, production

Geophysical measurements:

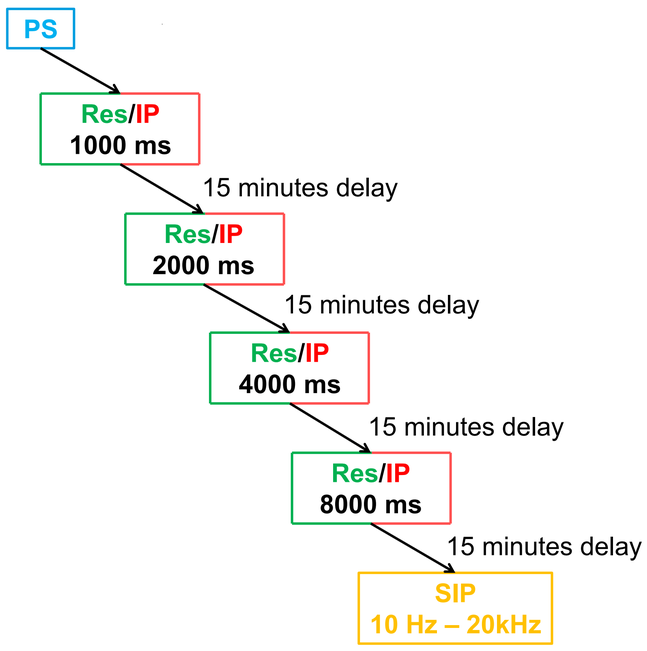


Figure 3: laboratory test column

Outlook and early returns

Monitoring of the four geophysical methods as well as the cell gas production and composition is carried out since early September. The injection of current into the medium, because the column is saturated with water, causes electrolysis of water and production of hydrogen. The problem is that too high concentrations of hydrogen is an inhibitor of anaerobic digestion and especially for methanogenic microorganisms. Because of this production of hydrogen the anaerobic digestion process was stopped until mid-November. The resistivity, chargeability and complex resistivity measurements were therefore likewise stopped.

In order to allow the restarting of biodegradation process, the column was desaturated and resaturated with water containing nutrient to place the microorganisms in the most favorable conditions for their proliferation. Since then the biodegradation process has restarted and the column produces biogas again. We plan to use a single injection time and to limit the measures so as not to produce in the column too high concentration of hydrogen.

These columns are a first draft which we will determine where is the difficulties of setting up such a device. We plan to conduct a second laboratory experiment with this time five identical columns but with contrasting biodegradation kinetics. This experiment will allow us to obtain geophysical measurements associated with different waste biodegradation states and to judge the ability of geophysical methods to be used as an indicator of biodegradation.

Parteners

Supports