EVOLUTION OF ELECTRICAL RESISTIVITY MEASUREMENTS DURING PROCESS OF WASTE BIODEGRADATION AT LAB SCALE

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Introduction

Electrical Resistivity Tomography (ERT) is applied in bioreactor landfill for many years to evaluate leachate distribution in waste body. Influence of moisture content and temperature is recognised to be significant on resistivity, nevertheless, impact of waste biodegradation should not be forgotten. Notably, biodegradation fractions could induce modifications of mechanical and chemical characteristics of porous media. Laboratory tests are in hand to follow waste resistivity variations according to biodegradation of waste sample for experimental conditions under control.

Waste composition and experimental conditions

Waste samples were composed according to the MODECOM model (ADEME, 2007) which is a characterisation of the different fractions of municipal solid waste made in France in 2007. This choice was made to get reproducible samples of waste and to focus on biodegradation of fresh waste. Each fraction was previously shredded to 10 mm maximum and moistened with digested treatment plant sludge to increase biodegradation kinetic. Waste sample was poured in test cell to reach low wet density of 0.36 kg/kg to get optimal waste biodegradation as previous tests had shown (Gholamifard, 2009). Waste biodegradation in anaerobic conditions needs essentially water and temperature to be encouraged. Field capacity was preferred with saturation state to manage this test. Saturation is one of the most suitable conditions for waste biodegradation but leachate conductivity could induce a main influence on resistivity measurements and blind the impact of waste biodegradation. Moreover, field capacity is in accordance and relevant to hydraulic conditions observed in landfill bioreactor. To achieve this goal, saturation was made by gravity flow at atmospheric pressure during 4 hours with synthetic leachate or green waste composting plateform leachate before a drainage phase to reach field capacity (volumetric water content of 0.45 m^3/m^3). The test cells are located on isothermal chamber at 35°C to contribute to biodegradation process of waste mass.

Analyse of biodegradation evolution of waste samples

During the different steps of waste evolution awaited, the biodegradation is followed according to biogas production. The volume of biogas production is measured from gas sampling bags and composition is analysed using gas chromatograph. Four parallel chromatographic columns coupled with Thermal Conductivity Detectors (TCD) compose the equipment (Micro GC CP4900 QUAD, Varian). A paraplot Q column is used to obtain CO_2, N_2O and H_2S concentration. Two molecular-sieve columns are used: one for O_2, N_2 and CH_4 concentration and another one for H_2. NH_3 concentration is recorded by using a special column. The gas carrier is Helium for the different components, excepted for H_2, which is Argon. The leachate accumulated at the bottom of the test cell is drained off and water content is recalculated, samplings are collected to confirm or explain gas analyses if necessary.

Electrical resistivity device

Laboratory test is led in a cell of 2.92 dm^3 of volume, 150 mm of diameter and 165 mm height. Apparent resistivity measurements (ρ_{app}) are recorded for 124 quadrupoles created starting from the 16 electrodes available. The electrodes are located in 4 verticals lines and 4 levels (Figure 1). Before carrying out resistivity measurements, errors on electrodes position and cells size were studied to evaluate uncertainties on geometric factor (k). Assistance of numerical computations with

COMSOL Multiphysics and AC/DC module was used (Figure 1). From apparent resistivity recorded, distribution model of interpreted resistivity is proposed by inversion software (Guenther, 2011) to calculate average resistivity to follow waste evolution. COMSOL Multiphysics was also employed to calculate punctual position of resistivity data used for inversion process.

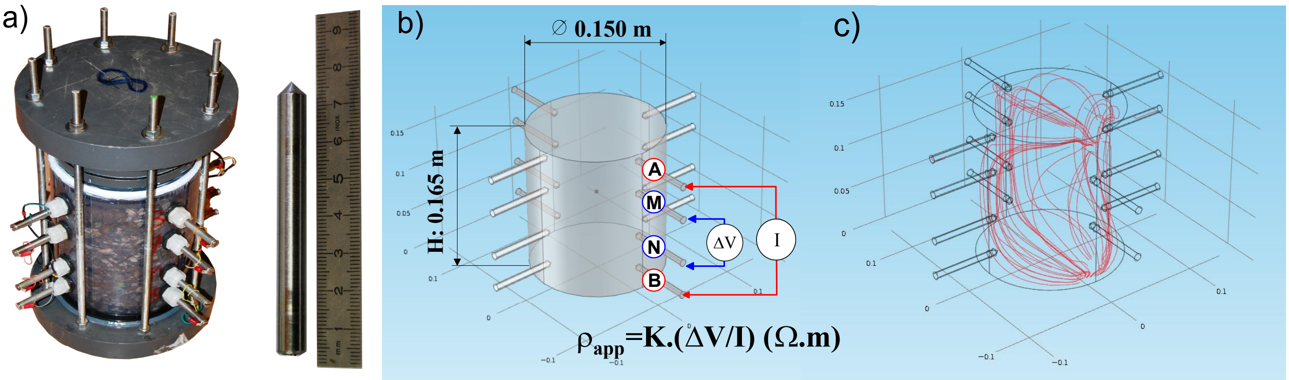

Figure 1: a) Test cell and electrodes; b) Electrical resistivity measurements (AB, current injection electrodes; MN electric potential electrodes); c) Current density

First Results and discussion

Surveys started in May 2011 for 4 test cells: 2 replicas of waste samples saturated with synthetic leachate (n°3 and 7) and 2 others saturated with leachate from green waste composting plateform (n°4 and 8). All gas analyses (composition and volume) are associated with resistivity measurements. First results are showed for test cell n°8 in Figure 2. Resistivity was recorded at the beginning, during saturation phase (6.7 Ω.m) and just after drainage phase (10.5 Ω.m) which is considered as the initial value to study the resistivity variations according to waste biodegradation. The pH of the liquid mixed to waste mass was equal to 7.6 and its resistivity was 1.7 Ω.m. Biogas production increases during 13 days (CO_2=46.8%, N_2=34.7%, O_2=10.5% and H_2=7.9%) and then stops; high concentration of VFA (Volatile Fatty Acid) was observed (Acid butyric=12.2g/l, pH=5.5, ρ=0.18Ω.m) and could explain this situation. Resistivity decreases during the first 20 days from 10.5 to 8.5 Ω.m and then increases to reach 12.9 Ω.m at 55 days. Biogas production or decrease of leachate resistivity can not explain the resistivity variations. The decrease of water content (3% of volumetric water content between days 20 and 55) is also too weak to describe resistivity variation from 8.5 to 12.9 Ω.m. The resistivity variations are the same for the 4 test cells with no biogas production observed after 20 days of experiment. Saturation and drainage were operated with leachate added to digested treatment plant sludge to boost the biodegradation of waste. Methane production is awaited to follow resistivity variations but field capacity seems to be limiting to induce a fast biodegradation of waste.

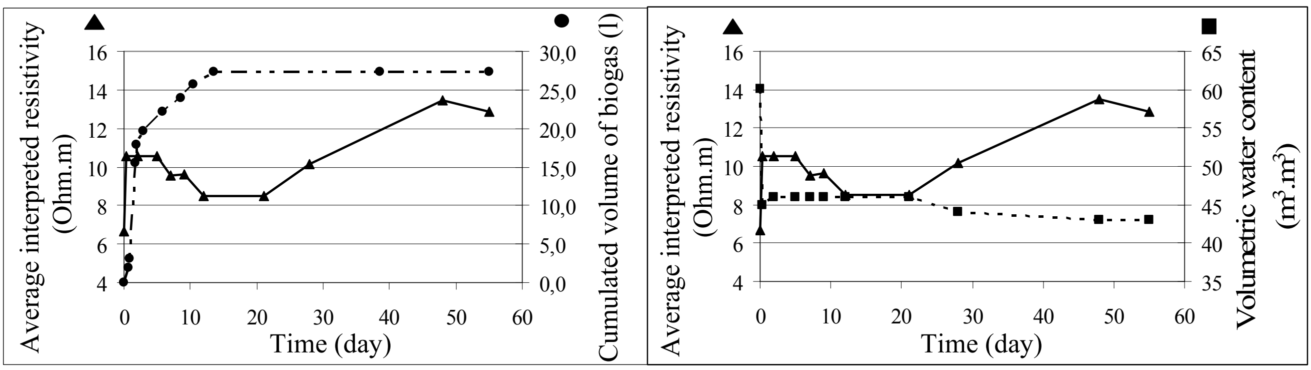

Figure 1: Average resistivity evolution according to biogas production and moisture variation