EJGE

# Assessment of Leachate Flow at Gampong Jawa Dumpsite Area, Banda Acheh (Indonesia)

**Dr. Muhammad Syukri**
*Senior Lecturer, Geophysics Section, Department of Physics, Faculty of Sciences, Syiah Kuala University, Banda Aceh, Indonesia.*
*e-mail:* m.syukri@unsyiah.net

**Dr. Rosli Saad**
*Senior Lecturer, Geophysics Section, School of Physics, Universiti Sains Malaysia, Penang, Malaysia.*
*e-mail:* rosli@usm.my

**Marwan**
*Lecturer (MS.), Geophysics Section, Department of Physics, Faculty of Sciences, Syiah Kuala University, Banda Aceh, Indonesia.*
*e-mail:* marwan.fisika@gmail.com

## ABSTRACT

The leachate flow study conducted at dumpsite area, Gampong Jawa, Banda Acheh (Indonesia) using 2-DERT. Eleven (11) survey lines were designed in such a way to see the leachate flow. Line L1-L7 was situated in the dumpsite compound and L8-L11 was outside the dumpsite area, across the drainage system and river. The 2-DERT results show the leachate detected around the dumping area only and not exceeding the drainage system and river. The leachate flows from the dumpsite was identified diverted to the drainage system and river.

KEYWORDS: Leachate, 2-DERT, dumpsite, Banda Acheh

## INTRODUCTION

The operation of solid waste landfills has gained significant attention of the environmental professionals. Solid waste is a growing menace in present times since the population increased. The waste materials (leachates) which formed by a decaying processes of the waste with time may percolate to ground water which polluted the ground water and ultimately affects the health of local inhabitants. The leachates may run off in the nearby natural water resources such as ponds, lakes and rivers and percolate to ground water causing water pollution (Arneth et al., 1989). The non-invasive geophysical methods which measure the electrical resistivity, specifically electrical resistivity tomography (ERT), could overcome these problems. The method depends on water content; measured electrical resistivity values allow determination of spatial distribution of waste moisture. Recently, the ERT method has been proved to be efficient to monitor moisture distribution during leachate recirculation in bioreactor landfills in France (Moreau et al., 2003; Rosqvist et al., 2003; Guerin et al., 2004). Grellier et al., (2005) showed that ERT is a suitable method to monitor the leachate recirculation in MSW, and it can provide an estimation of the variations of the moisture content during leachate recirculation events. To date, the ERT method has been used to monitor moisture distribution and evaluate the efficiency of leachate recirculation.

## STUDY AREA

The leachate flow study was conducted at Gampong Jawa, Banda Acheh (Indonesia) using 2-D electrical resistivity tomography (2-DERT). The study conducted at dumpsite area with latitude of 5°34'46.77"N and longitude of 95°18'52.08"E (Figure 1).


**Figure 1:** Gampong Jawa, Acheh study area (Google earth, 2013).

## 2-D ELECTRICAL RESISTIVITY TOMOGRAPHY (2-DERT)

The 2-DERT has been used to study the leachate flows (Dahlin, 2001). The method essentially consist of injecting an electrical current (I) through two metallic electrodes and measuring the potential difference (ΔV) between two other electrodes. The apparent resistivity ($\rho_a$) is given by Equation 1.

$$\rho_a = k\frac{\Delta V}{I} \quad (1)$$

The K is a geometrical factor which only depends on electrode position. $\rho_a$ is the ratio of the potential obtained insitu with a specific array and a specific injected current for a homogeneous and isotropic. The measurements provide information about resistivity for a medium whose volume is proportional to the electrode spacing. The data point corresponding to the investigated volume is conventionally represented on a section at a depth equals to the electrode spacing (Figure 2). The apparent resistivity measurements do not allow interpreting the distribution of resistivity inside the medium. Indeed, the apparent resistivity is conventional: it consists of a pseudosection with x in abscissa and z in ordinate. The z is not a real depth. Software such as Res2DInv (Loke and Barker 1996) used to interpret the data, to propose a model of resistivity of the medium according to the real depth.

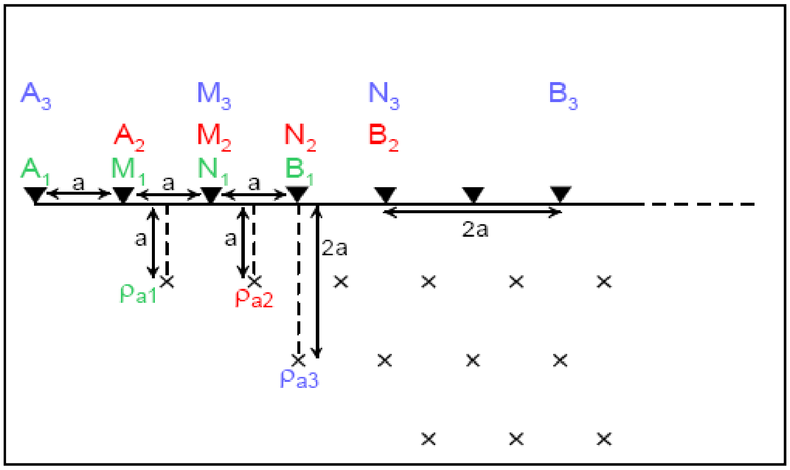


**Figure 2:** Conventional representation of the measured apparent resistivity $\rho_a$ according the electrode spacing (a) between the electrodes (A, B, M and N).

Electrical resistivity depends on several parameters: water content, temperature, ionic content, particle size, resistivity of the solid phase, permeability, porosity, tortuosity, pressure and clay content. Except for the moisture content and temperature, the influence of the parameters on resistivity in waste mass is unknown (Grellier et al., 2005). The changes in electrical resistivity can be correlated directly with the changes in moisture contents. The ERT method has been well studied and it has shown that electrical current can flow through the waste mass (Carpenter et al., 1991; Haker et al., 1997; Berstone et al., 2000). Table 1 and 2 shows the resistivity value of some of the typical rocks, soil materials and water (Keller and Frischknecht 1996). Igneous and metamorphic rocks typically have high resistivity values. The resistivity of these rocks is mainly dependent on the degree of fracturing. The water table is generally shallow, the fractures are commonly filled with ground water. The greater the fracturing, the lower is the resistivity value of the rock. Soils above the water table is drier and has a higher resistivity value of several hundred to several thousand ohm-m, while soils below the water table generally have resistivity values of less than 100 ohm-m.

**Table 1:** Resistivity values of common rocks and soil materials in survey area (Keller and Frischknecht, 1996; Telford and Sheriff, 1990).

| Material | Resistivity (ohm-m) |
|---|---|
| Alluvium | 10 to 800 |
| Sand | 60 to1000 |
| Clay | 1 to 100 |
| Groundwater (fresh) | 10 to 100 |
| Sandstone | 8 - 4 x $10^3$ |
| Shale | 20 - 2 x $10^3$ |
| Limestone | 50 – 4 x $10^3$ |
| Granite | 5000 to 1,000,000 |

**Table 2:** Resistivity values of some types of waters (Keller and Frischknecht, 1996; Telford and Sheriff, 1990).

| Type of water | Resistivity (ohm-m) |
|---|---|
| Precipitation | 30 - 1000 |
| Surface water, in areas of igneous rock | 30 – 500 |
| Surface water, in areas of sedimentary rock | 10 - 100 |
| Groundwater , in areas of igneous rock | 30 - 150 |
| Groundwater , in areas of sedimentary rock | > 1 |
| Sea water | ≈ 0.2 |
| Drinking water (max. salt content 0.25%) | > 1.8 |
| Water for irrigation and stock watering (max. salt content 0.25%) | > 0.65 |

# METHODOLOGY

The study applied geophysical method, 2-DERT to identify the leachate flow. A total of eleven (11) survey lines were designed in such a way to study the leachate flow around the study area. Line L1-L7 was design in the dumpsite compound and L8-L11 was design outside the dumpsite area, across the drainage system (Figure 3). The 2-DERT survey was conducted using ABEM SAS4000 resistivity meter system with Pole-dipole and Schlumberger array which is applicable. The field data was processed using RES2Dinv software (Loke and Barker, 1996) for inversion and interpretation. Data was interpreted in terms of attribution to lateral variations between the materials surrounding the dump site.


**Figure 3:** The 2-DERT survey lines (L1-L11) of Gampong Jawa, Acheh dumpsite area.

## RESULTS AND DISCUSSION

Figure 4-10 show the 2-DERT inversion models of line L1-L7 conducted in the dumpsite compound. Generally the whole area covered by reclaim layer with thickness of <20 m and resistivity value of >6 Ohm.m. The marine alluvium with resistivity value of 3-30 Ohm.m was underlay by the reclaim layer. The resistivity value of <1 Ohm.m was detected at all the survey lines, L1-L7 and it was identified as leachate.

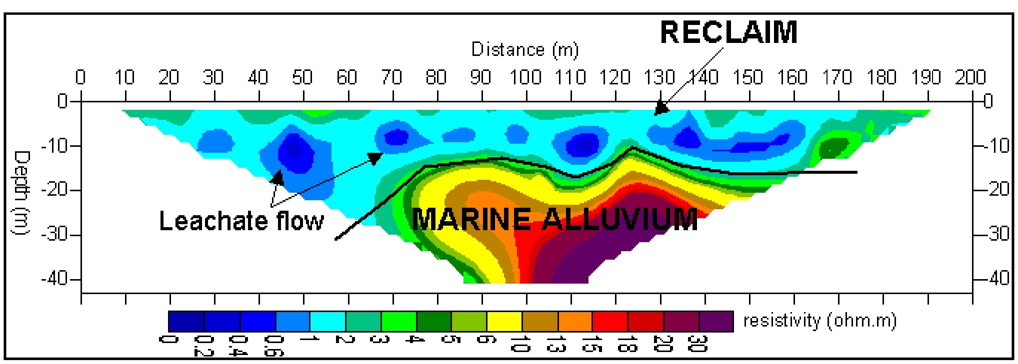


**Figure 4:** The 2-D resistivity inversion model of line L1

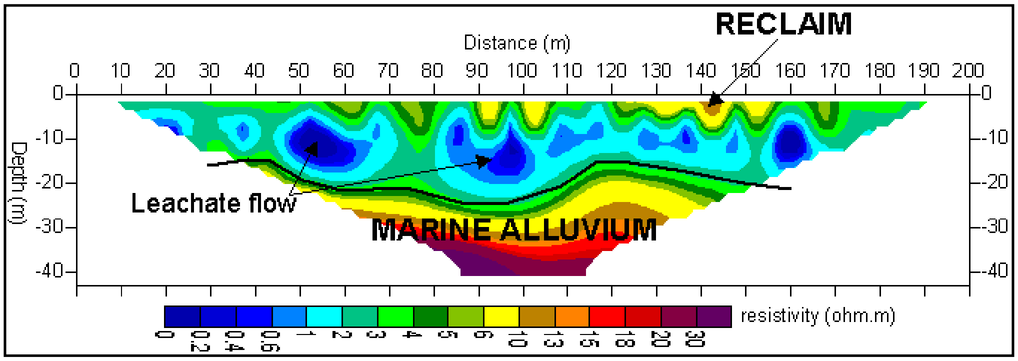


**Figure 5:** The 2-D resistivity inversion model of line L2

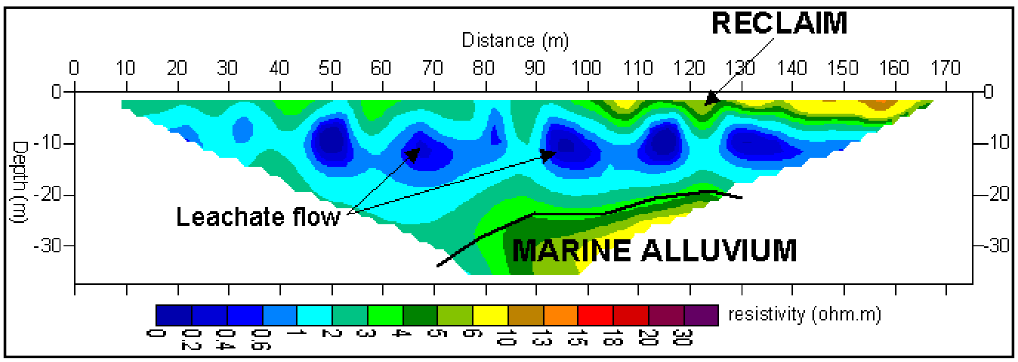


**Figure 6:** The 2-D resistivity inversion model of line L3

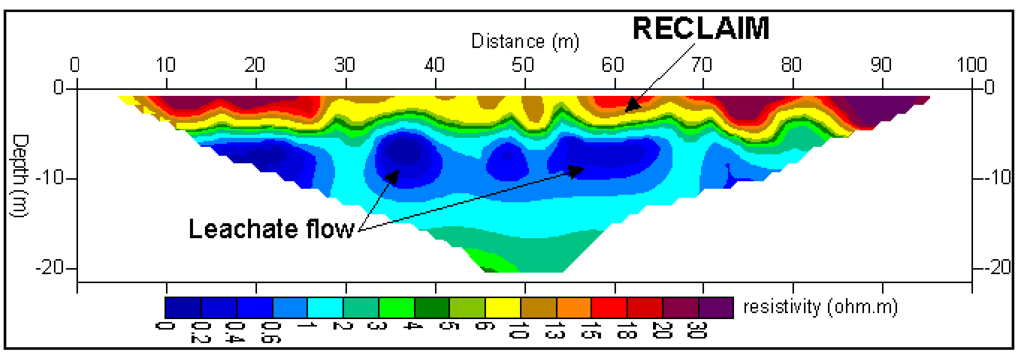


**Figure 7:** The 2-D resistivity inversion model of line L4

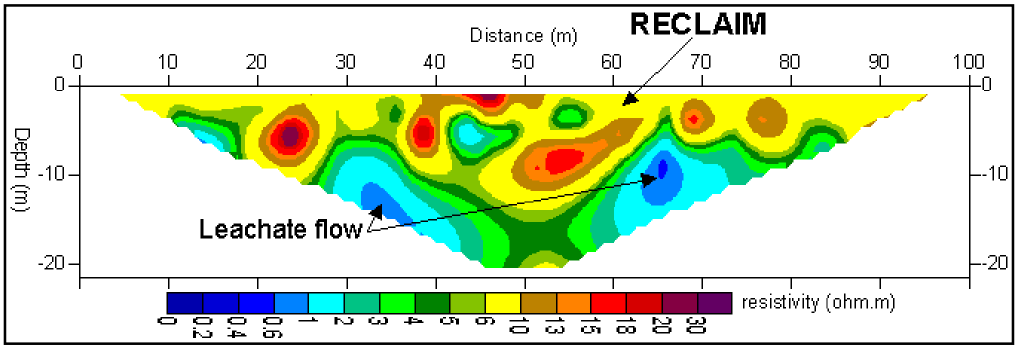


**Figure 8:** The 2-D resistivity inversion model of line L5

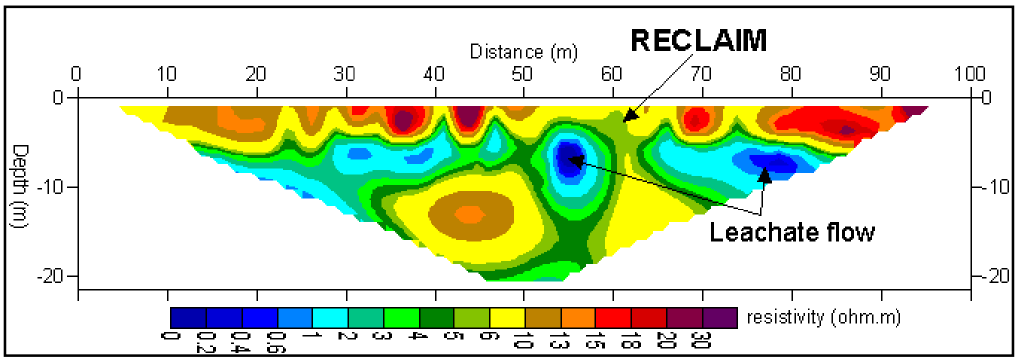


**Figure 9:** The 2-D resistivity inversion model of line L6

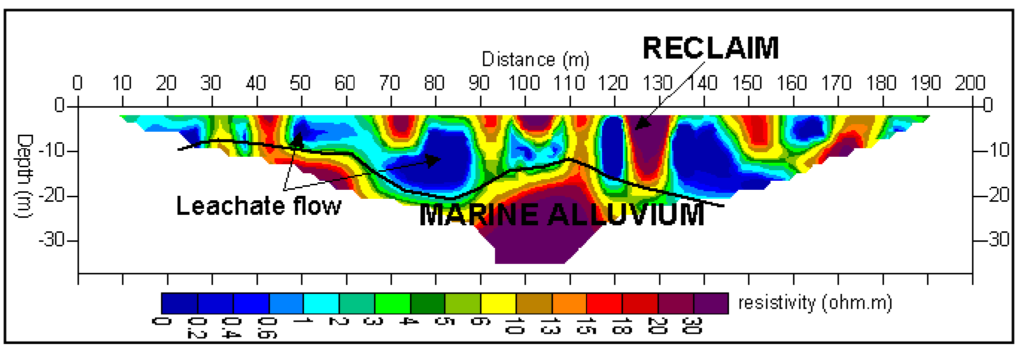


**Figure 10:** The 2-D resistivity inversion model of line L7

Figure 11-14 show the 2-DERT inversion models of line L8-L11. Generally the whole area covered by reclaim layer with thickness of <20 m and resistivity value of >6 Ohm.m. The marine alluvium with resistivity value of 3-30 Ohm.m was underlay by the reclaim layer. The resistivity value of <2 Ohm.m was detected and interpreted as salt water intrusion or brackish water.

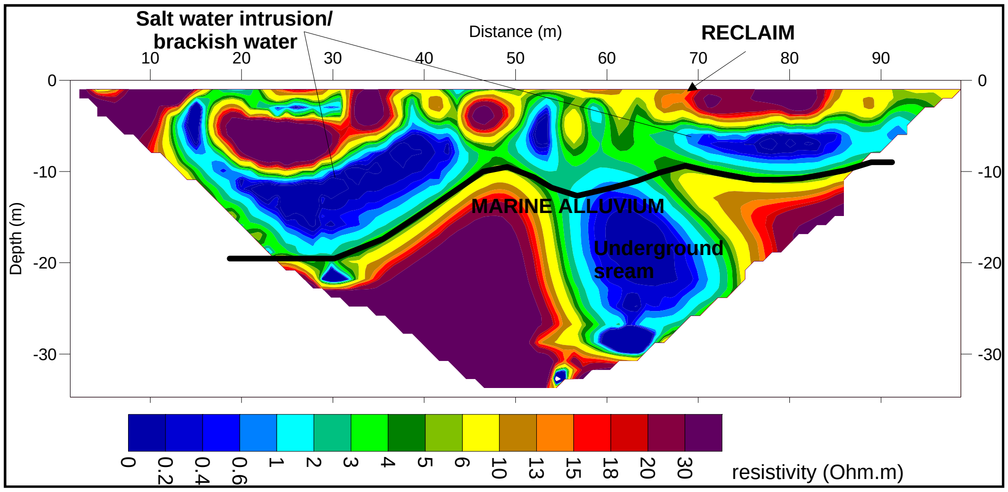


**Figure 11:** The 2-D resistivity inversion model of line L8.

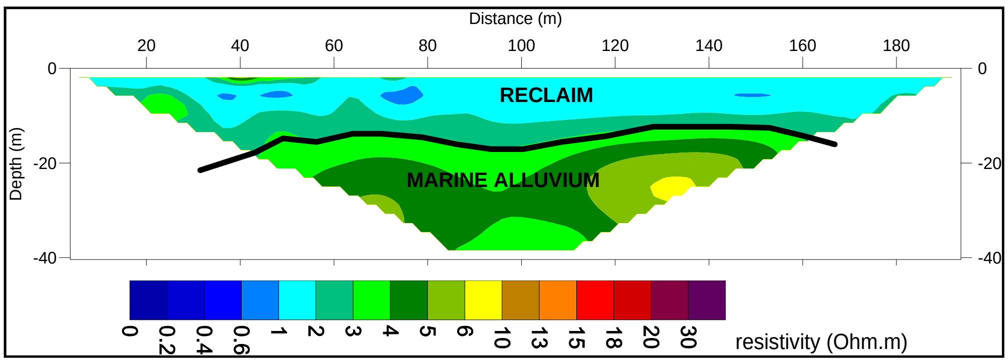


**Figure 12:** The 2-D resistivity inversion model of line L9.

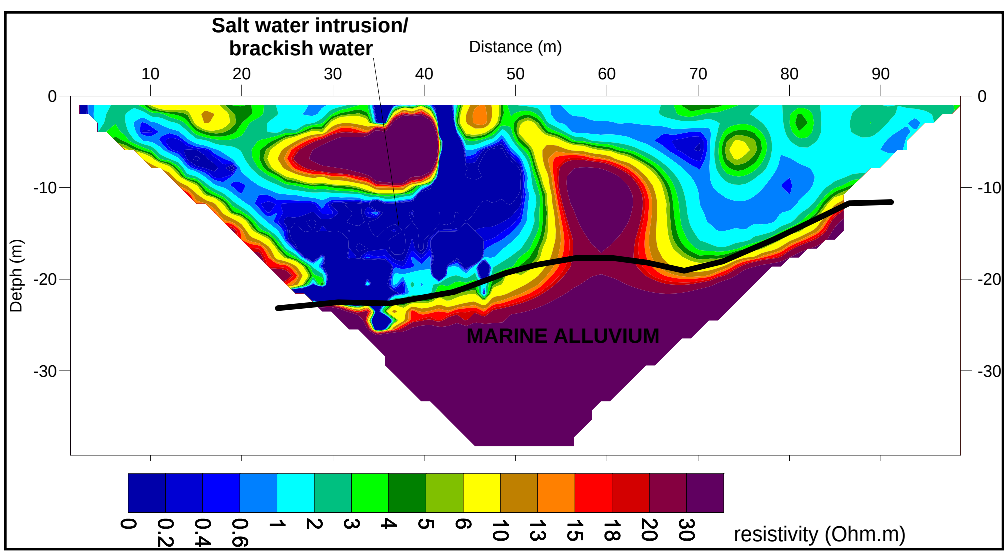


**Figure 13:** The 2-D resistivity inversion model of line L10.

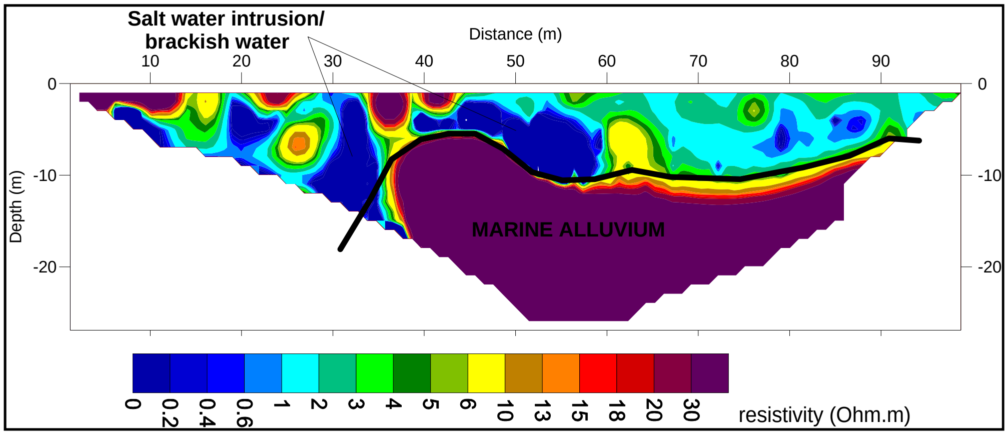


**Figure 14:** The 2-D resistivity inversion model of line L11.

## CONCLUSION

The 2-DERT results show the leachate detected around the dumping area only and not exceeding the drainage system and river. The leachate flows from the dumpsite was identified diverted to the drainage system and river.

## ACKNOWLEDGEMENTS

The authors wish to express their gratitude to the Ministry of Education and Culture, Indonesia in the scheme of Decentralized Research Competitive Grants Program 2014 for financial support. The authors thank the technical staffs of the geophysics laboratory and geophysics postgraduate students, School of Physics, Universiti Sains Malaysia and geophysics students, Faculty of Sciences, Syiah Kuala University for their assistance during the data acquisition.

## REFERENCES

1. Arneth, J.D., Midle, G., Kerndoff, H. and Schleger, R., "Waste in deposits influence on ground water quality as a tool for waste type and site selection for final storage quality". Landfill reactions and final Storage quality. Baccini, P. (ed) Springer Verlag Berlin pp.339 (1989).
2. Bernstone, C., Dahlin, T., Ohlsson, T., and Hogland, W., 2000, "DC-resistivity mapping of internal landfill structures: two pre-excavation surveys", *Environmental Geology*, 39 (3-4), 360-371.
3. Carpenter, P.J., Calkin, S.F., and Kaufmann, R.S., 1991, "Assessing a fractured landfill cover using electrical resistivity and seismic refraction techniques", *Geophysics*, 56, 11, 1896-1904.
4. Dahlin, T. (2001). "The development of DC resistivity imaging techniques." *Computers & Geosciences*, 27 (9), 1019-1029.
5. Guérin, R., Munoz, M.L., Aran, C., Laperrelle, C., Hidra, M., Drouart, E., and Grellier, S, 2004, "Leachate recirculation: moisture content assessment by means of a geophysical technique". Waste Management, 24 (8), 785-794

6. Grellier, S., Bouyé, J.M., Guérin, R., Robain, H., and Skhiri, N., 2005, "Electrical Resistivity Tomography (ERT) applied to moisture measurements in bioreactor: principles, in situ measurements and results", International Workshop "Hydro-Physico-Mechanics of Landfills", Grenoble (France), 21-22 March.

7. Grellier, S., Bouyé, J.M., Guérin, R., Robain, H., and Skhiri, N., 2005, "Electrical Resistivity Tomography (ERT) applied to moisture measurements in bioreactor: principles, in situ measurements and results", *International Workshop "Hydro-Physico-Mechanics of Landfills"*, Grenoble (France), 21-22 March.

8. Haker, C.D., Rix, G.J., and Lai, C.G., 1997, "Dynamic properties of municipal solid waste landfills from surface wave tests", *Proc SAGEEP'97 (Symposium on the Application of Geophysics to Engineering and Environmental Problems)*, Environmental and Engineering Geophysical Society, Wheat Ridge (USA), 301-310.

9. Keller G.V. and Frischknecht F.C. (1996) "Electrical methods in geophysical prospecting". *Pergamon Press Inc*., Oxford.

10. Loke, M.H., and Barker, R.D., 1996, "Rapid least-square inversion of apparent resistivity pseudosections by a quasi-Newton method", *Geophysical Prospecting*, 44 (2), 131-152.

11. Moreau, S., Bouyé, J.M., Barina, G., and Oberti, O., 2003, "Electrical resistivity survey to investigate the influence of leachate recirculation in a MSW landfill", Proceedings of the 9th International Waste Management and Landfill Symposium, Session C02, CISA publ.

12. Rosqvist, H., Dahlin, T., Fourie, A., Röhrs, L., Bengtsson, A., and Larsson, M., 2003, "Mapping of leachate plumes at two landfill sites in South Africa using geoelectrical imaging techniques", Proceedings of the 9th International Waste Management and Landfill Symposium, Session C02, CISA publ.

13. Telford, L. Geldart and R. Sheriff, (1990) "Applied Geophysics" 2nd Edition, *Cambridge Univ. Press*, Cambridge, UK