Animal bodies and grave detection in soil using electrical resistivity imaging

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This paper was prepared for presentation during the 12th International Congress of the Brazilian Geophysical Society held in Rio de Janeiro, Brazil, August 15-18, 2011.

Abstract

Environmental impacts related to the deployment and operation of animal and human cemeteries have been shown by many surveys and academic papers.

In those studies, researchers and professionals have been using various methodologies, especially the indirect methods of investigation due to quickness and quality of results.

These major indirect methods used in evaluation and control of contamination caused by cemeteries has been the electrical and electromagnetic. More recently Ground Penetrating Radar has been mentioned in literature and mainly used in forensic studies.

In the present study the authors installed in an area without anterior uses a grave with animal bodies with similarities to human burials and compared the result using electrical imaging before and after this deposition.

The results show that the method produces good results concerning the delimitation of the grave and the soil modification with the bodies deposited.

Introduction

After death, the bodies decompose, passing through phases of tissue destruction by the action of bacteria and enzymes, resulting in its transformation into gases, liquids and salts.

According to Pacheco (2000) in the first phase of body decomposition, after three to four weeks, the gas developed inside the body (H2S, CH4, CO2, NH3 and H2) are spread throughout the body, causing the rupture of organs and tissues.

The second phase, most important for environmental researches, is called coliquative, when occurs the dissolution of the soft parts of dead bodies by the joint action of the scavenger fauna, with an average duration of three years. The liquid formed in this phase is called necroleachate, for its similarity to the leachate formed in waste landfills. Finally, after the dissolution of the tissues has been the stage of skeletonization.

On the other hand, in environmental studies and especially when trying to assess in detail a possible soil contamination, geophysical techniques have been of great importance, becoming an indispensable tool (Dobecki & Romig, 1985 ; Greenhouse, 1991, Steeples, 1991; Carvalho Jr & Costa e Silva, 1997). More recent studies have shown also the importance of the geophysical application to cemeteries and its associated contamination.

A few studies on environmental assessment of cemeteries with the use of geophysics have been published, for example, Bastianon et al. (2000), Silva & Malagutti Filho (2010) in Brazil and Senos Matias et al. (2004) in Portugal. More common are the texts focused on forensic research (Bevan, 1991; Nobes, 1999).

The application of geophysical methods to evaluate the geological and environmental suitability of an area planning to the establishment of cemeteries may been seen in Gallas & Birelli (1993) and Peluso et al. (2006).

Saraiva (2010) demonstrated that the application of electrical resistivity imaging in the same conditions of this study presents better results than other common geophysical methods usually applied in environmental researches, as electromagnetic and ground penetrating radar.

According to this, the research involved the use of electrical imaging to analyze an area before and after the installation of a grave with 6 metric tons of animal bodies in an interval of one month between the two field campaigns.

Method

The study area was defined among several possibilities that are presented initially, evaluated in public places and private areas without any apparent environmental problem, even within the various campuses of USP.

The area, situated in Pirassununga campus of the Universidade de São Paulo (São Paulo State University) is covered with sand sediments of Pirassununga Formation (Ferreira, 2005) with a high permeability coefficient, providing a rapid movement in subsurface of the formed necroleachate.

Before the grave installation three vertical electrical soundings (VES) were conducted which indicated the water table depth and helped the results interpretation of the electrical imaging. The location of the VES are shown on Figure 1.

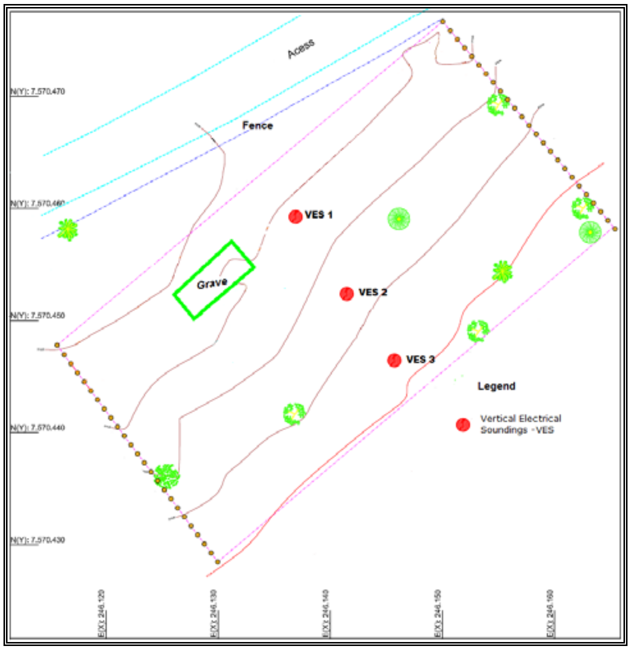

Figure 1 - Location of the three VES and the grave.

Electrical imaging profiles were performed with 25SW-NE lines, 45m long, using dipole-dipole array and electrode spacing of 1m, 2m and 4m. This arrangement allowed to investigate10 levels resulting in 915 data for each section.

Two field campaigns were made during August and September 2008, 15 days before and one month after implantation of the grave.

For this research it was used a IRIS equipment (Syscal Pro Switch) with 48 electrodes switching configuration and a cable with 5 meters take-out spacing.

After each survey data were transferred from the device to a notebook via an IRIS software, ProSys II. After a brief editing, the data was exported in DAT format for use in the inversion software Res2dinv from GEOTOMO (Loke & Barker, 1995).

The inversion technique is based on the least square and the smoothness-constrained methods (Gandolfo, 2007).. Thus, the inversion can be performed without requiring an initial geological model and produces a resistivity model of the subsurface free of distortions observed in the pseudo-sections of apparent resistivity, caused by the geometry of the electrode array (Loke & Barker, 1995).

Results

The results of the three VES indicated that the local water table is about 4,2m deep, a meter below the grave base (Figure 2), confirmed with excavations in the VES points.

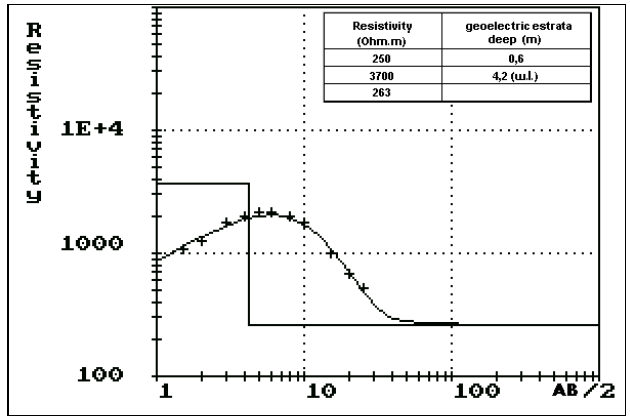

Figure 2 -Result of VES 1, at the same height of the grave.

The results obtained from the electrical resistivity imaging proved to be adequate in terms of both electrode spacing and number of investigation levels.

Analyzing a section (Figure 5) after the bodies installation, a clearly change of the resistivity pattern can be noticed at the grave area. Resistivity decreased from nearly 3000 ohms x meter to 140ohm x meter.

In this figure is also possible to visualize the vertical flow of liquid into the depths of the grave, represented by low resistivity values under 4.0 meter deep.

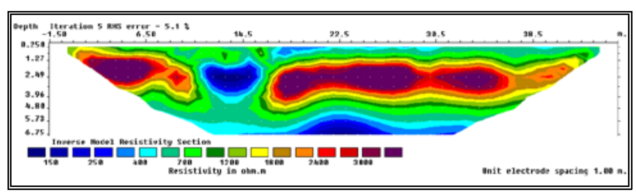

Figure 3 – Resistivity section showing the location of the grave.

In shallower depths, despite the clear determination of the location of the grave, no results were obtained associated with the formation of necroleachate, what agrees with the depth of animal bodies and the water table.

Figure 4 shows a map of the area at 3.96m deep before placing the grave, with a standard high resistivity, reaching values around 2500 to 3000 ohms x meter including the place (red rectangle) where the animal bodies would be buried 15 days after this campaign.

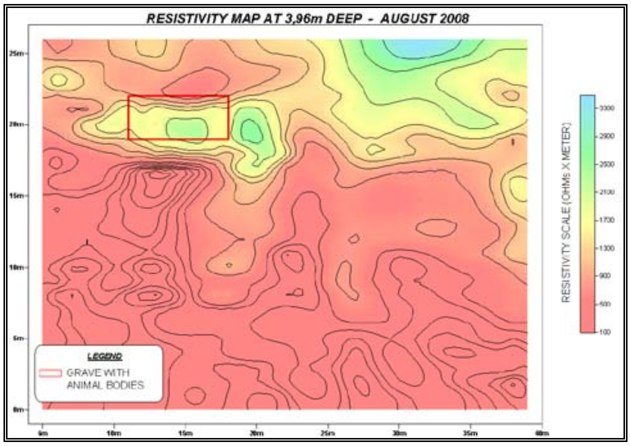

Figure 4 - Resistivity map of August of 2008, at 3.96 m deep.

The map of the same depth, after the placement of the bodies (Figure 5) shows a low resistivity in the area where approximately the grave is located, discordant of the rest of the neighborhood, with higher resistivity.

Also in Figure 5, at the right side of the grave, a portion with higher resistivity due to possibly less porous soil (represented by green to yellow), impeding horizontal migration of the necroleachate formed.

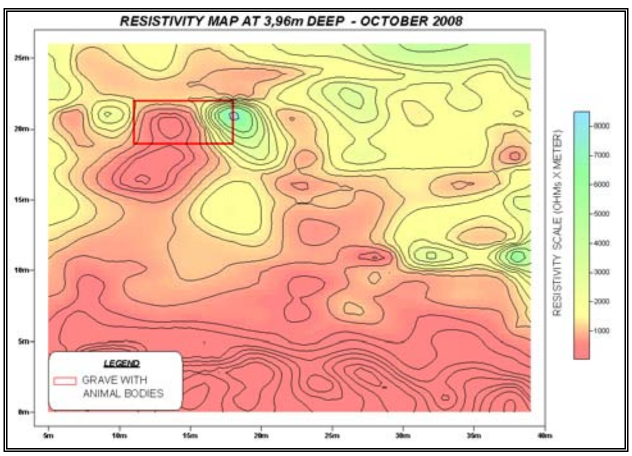

Figure 5 - Resistivity map of October of 2008, at 3.96 m deep. The red rectangle indicates the grave area

Conclusions

Animal bodies were implanted in a grave into an area, without any previous history of contamination, to evaluate the results of geophysical surveys through the use of electrical imaging.

The result of the survey after de grave and bodies installation shows a clearly change when compared to the same area before the experiment.

The result shows a great resistivity decrease, related to the soil mobilization and to the animal bodies that were in the first stages of decomposition, as expected according to the literature.

The continuity of field campaigns might show new variations, including further increase in resistivity after the total bodies decomposition.

Acknowledgments

To FAPESP (process 2006/06755-0) for financial support of the major research.

To CEPAS - Groundwater Research Center of Geosciences Institute, São Paulo State University, for allowing the research and the use of equipments and technicians.

To the managers of the Faculty of Veterinary Medicine from São Paulo State University, campus Pirassununga, for the area use and support in field activities.

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