



The Use of the TEM Method in the Sanitary Landfill of Gramacho, Duque de Caxias, State of Rio de Janeiro

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Abstract

There has been an on-growing concern with environmental protection and water supply both in surface and subsurface. The disposal of Municipal waste residues requires a special attention, due to the fact that it may be a major source of water contamination.

The Municipal Landfill of Gramacho located in the town of Duque de Caxias in Rio de Janeiro State, Brazil receives a daily average of 10.000 t of waste and it covers an area of approximately 120 Ha. It is situated in a mangroove area developed over recent fine fluvial marine sediments. The main purpose of this study is the use of a geophysical electromagnetic methodology to characterize this landfill.

Sixty single –loop transient electromagnetic – TEM soundings were carried out using 50 m sided loops, covering the entire area of the landfill site and reaching maximum depths of about 80 m. The resistivity varied from 0.5 ohm.m to 30 ohm.m. It was possible to characterize the leachate flow direction, the depth it concentrates most, and the depth where the leachate no longer occurred.

A geoelectrical model based on the uni-dimensional inversion results (Occam, Ridge-regression) was obtained. The resistivity values varied from 0.5 to ohm.m – 30 ohm.m and the maximum depth probed was 80 m. Our geoelectrical model allowed us to characterize the leachate flow direction, the spatial distribution of the contaminant plume at the subsurfaces, besides

confirming evidence for saline intrusion present in the leachate.

Introduction

The Brazilian society has suffered a severe change in the last 50 years. It has changed mainly from rural to urban. With the great urban agglomerates, a great number of complex and varied problems has become topical, including the environmental pollution. The urban soil has gradually been taken by solid residues, such as waste. The proliferation of waste deposits, due to inappropriate disposal of industrial and domestic residues on soil is one of the major environmental concerns nowadays.

Geophysics is already playing an important role in this scenario by providing fast and efficient techniques to assess environmental pollution. The geophysical survey through a geoelectric characterization of the geological materials in the subsurface, is usually able to determine the preferable direction for the underground water flow, underground water depth, and delineate the contaminated plume at low operational costs. A number of recent successful geoelectrical studies of landfill sites can be found in the literature (Cavalcanti et al., 1999; Nascimento et al., 1999; Ellis and Zuquette, 1997; Tezkan et al., 2000).

The purpose of this study is to understand the behavior of the contaminated plume in subsurface in the sanitary landfill of Gramacho, in Duque de Caxias Municipality of Rio de Janeiro State.

Sixty single –loop transient electromagnetic (TEM) soundings were carried out employing 50 m sided loops, covering the entire area of the landfill site. The Sirotem MK3 equipment was used in this study.

Information provided by the Municipal Landfill Company Comlurb was used, including a landfill map for the

location of the TEM soundings and geotechnical sounding profiles.

Location

The studied area comprehends the sanitary landfill of Gramacho, located in the Town of Duque de Caxias, State of Rio de Janeiro, being inserted in the topographic map of Rio de Janeiro (SF23-Z- B) in the scale 1: 250.000 published by I.B.G.E. (Figure 1).

Geological Setting

The regional geology is characterized by the presence of the São Fidélis - Pão de Açúcar Complex, and it has a very irregular lithologic distribution, varying from augen-gnaisses, to biotite-gnaisses. Locally there is some fluvial sediment and marine fluvial characterized by unconsolidated silt and sand. Only the quaternary features are relevant for this study. The bay is surrounded by gnaisses, granite and migmatite, which composes the basement of the pre-Cambrian. (Meis and Amador, 1972 and 1977, Amador, 1980).

The Transient Electromagnetic Method (TEM)

In the TEM method a transmission coil is turned on with an alternated current, which creates a primary magnetic field on the terrain. When the current is rapidly cut off, the primary field is extinct and the induced electromotive force in the terrain causes an eddy current to flow in the ground and in the nearby conductors in the sub surface. This eddy current generates a secondary magnetic field decaying with time. The decaying curve has a shape which is related to conductive bodies present in the earth's subsurface.

Results

The combined result for all 1D models are shown in Figure 2 for different depth slices using Occam inversion as implemented by Meju (1992). One is able to observe the contaminated plume, characterized by very low

resistivity values (up to 1 ohm.m) which starts at about 10 m depth and reaches a maximum depth of approximately 45 m. The contaminated plume has its maximum area at about 20 m depth, where it covers most of the landfill site. The resistivity values associated to the plume are very low and not observed in other landfill sites (Ellis, 1998), suggesting a saline intrusion. This latter is reinforced by the chemical analysis of the Gramacho leachate which showed very high concentrations of chlorides and sulfides (Barbosa, 1994). A preferable leachate flow direction could be noticed directed towards southeast, being bound by the Guanabara Bay and the Sarapuí Channel. This is directly reflected on the format of the plume at different depth slices. In Figure 3, it is possible to see a sketch of the landfill with the locations of both the 60 TEM soundings and the geotechnical profiles done by Comlurb in 2002. These geotechnical studies was used to associate the resistivity variation of the TEM soundings with the described lithology. An example can be seen in Figure 4.

Conclusions

The sanitary landfill of Gramacho, Duque de Caxias, Rio de Janeiro State was studied using the transient electromagnetic - TEM technique.

Based on one-dimensional inversion results of TEM data using Occam and ridge regression techniques, it is possible to point out some special marks, such as:

- The observed values for the electric resistivity on the landfill area are indeed extremely low and without similar in any other landfill site reported in the literature. Saline intrusion may be responsible for the anomalously conductive leachate, as confirmed by the presence of chlorides in chemical analysis.
- A very good correlation between the TEM results and the geotechnical soundings was noticed, showing the existence of three upper layers associated with waste in the first upper layer, followed by a second layer consisting of soft clay and a third layer of a clayey sand.
- 3D subsurface visualization of the landfill area, having the contamination as a distinct feature. On

the controlled points where geotechnical soundings were undertaken, it was possible to verify that the contaminated plume is associated with the clayey sand.

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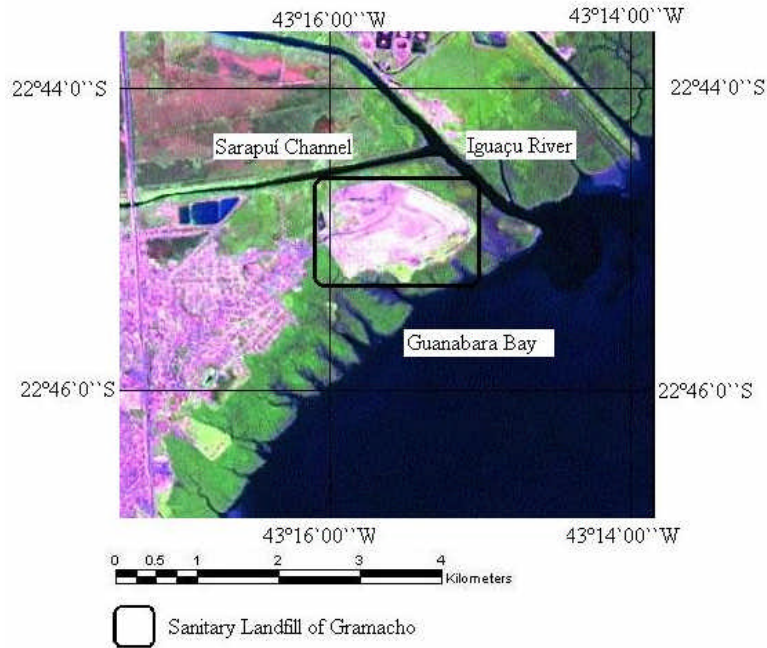


Figure 1: Satellite image from the referred area of the landfill of Gramacho

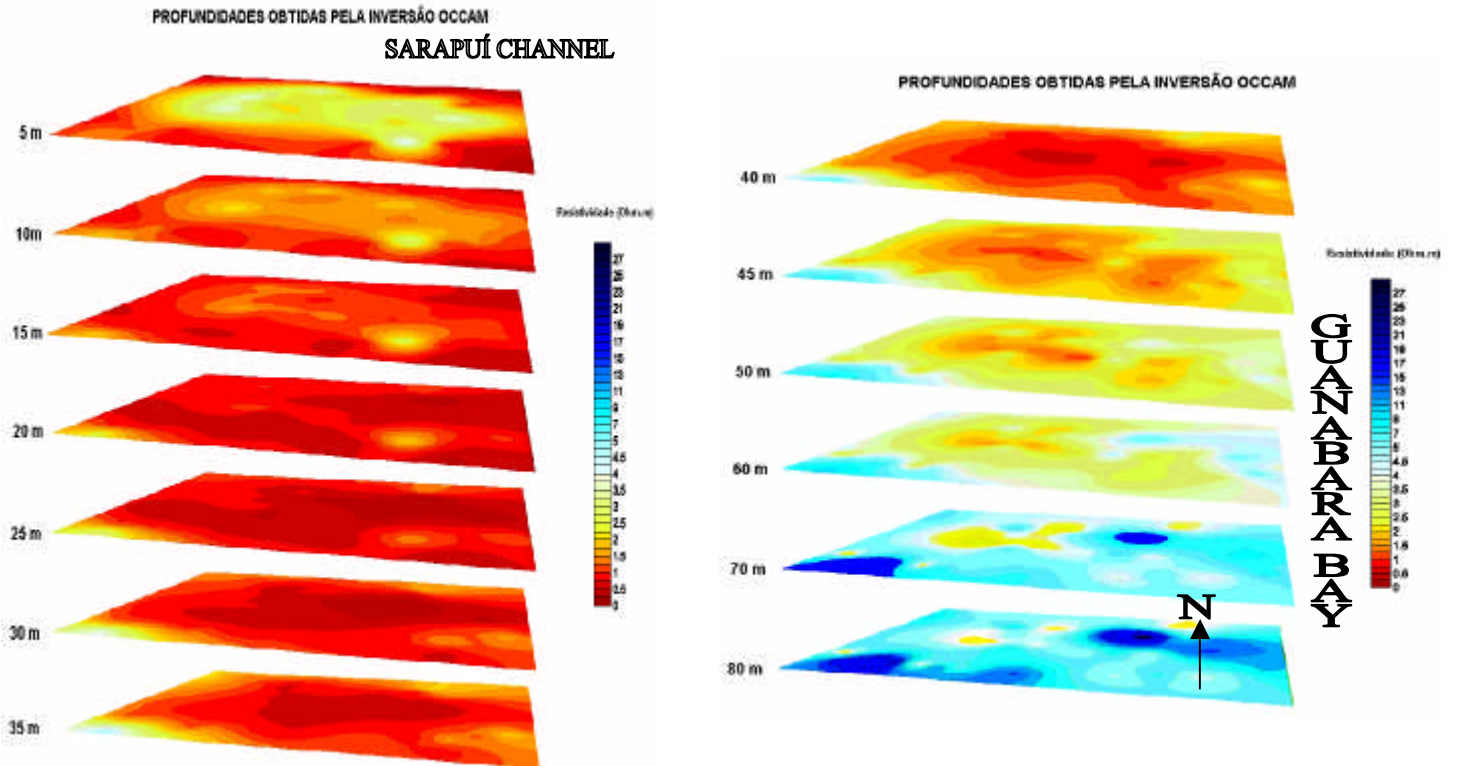


Figure 2: Depth slices obtained with the entire set of TEM sounding based on Occam Inversion

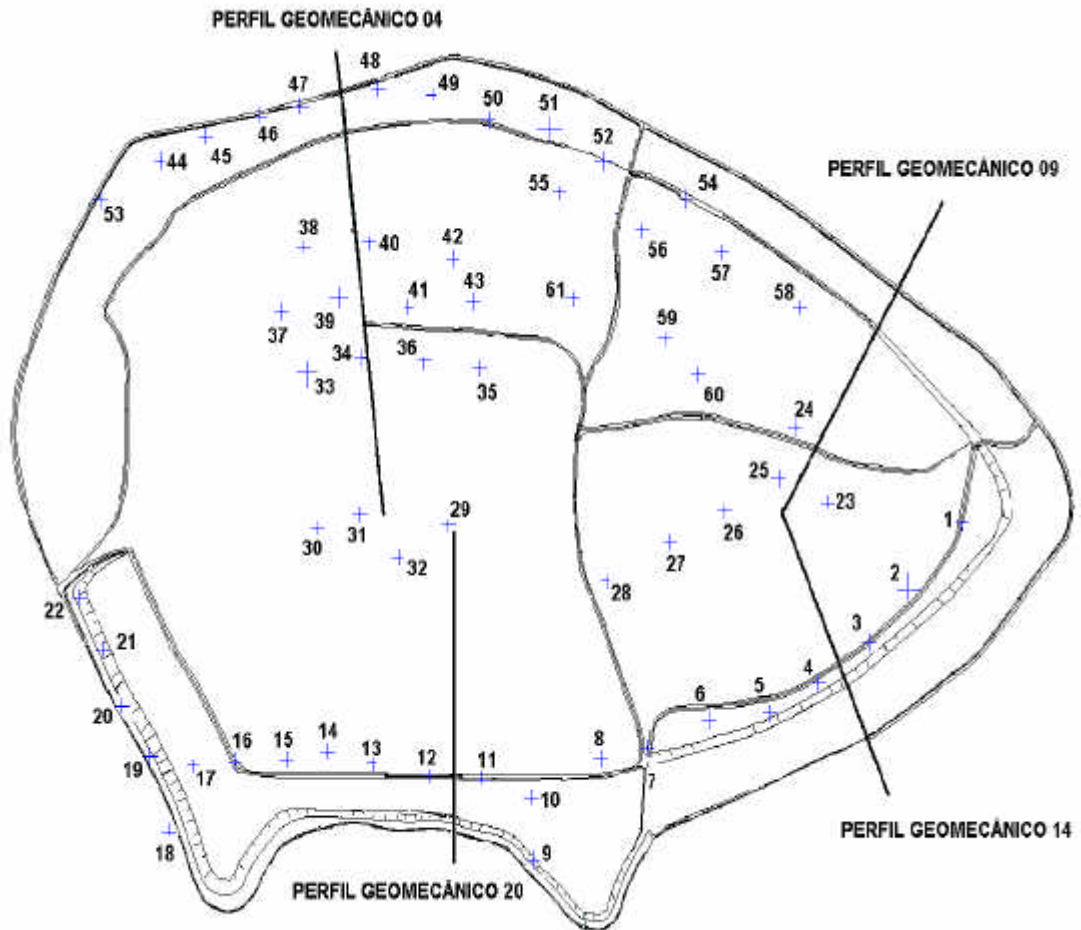


Figure 3: Map of the Sanitary Landfill of Gramacho, with the TEM Sounding Locations and the Geomechanical Profiles
Scale: 1:2500

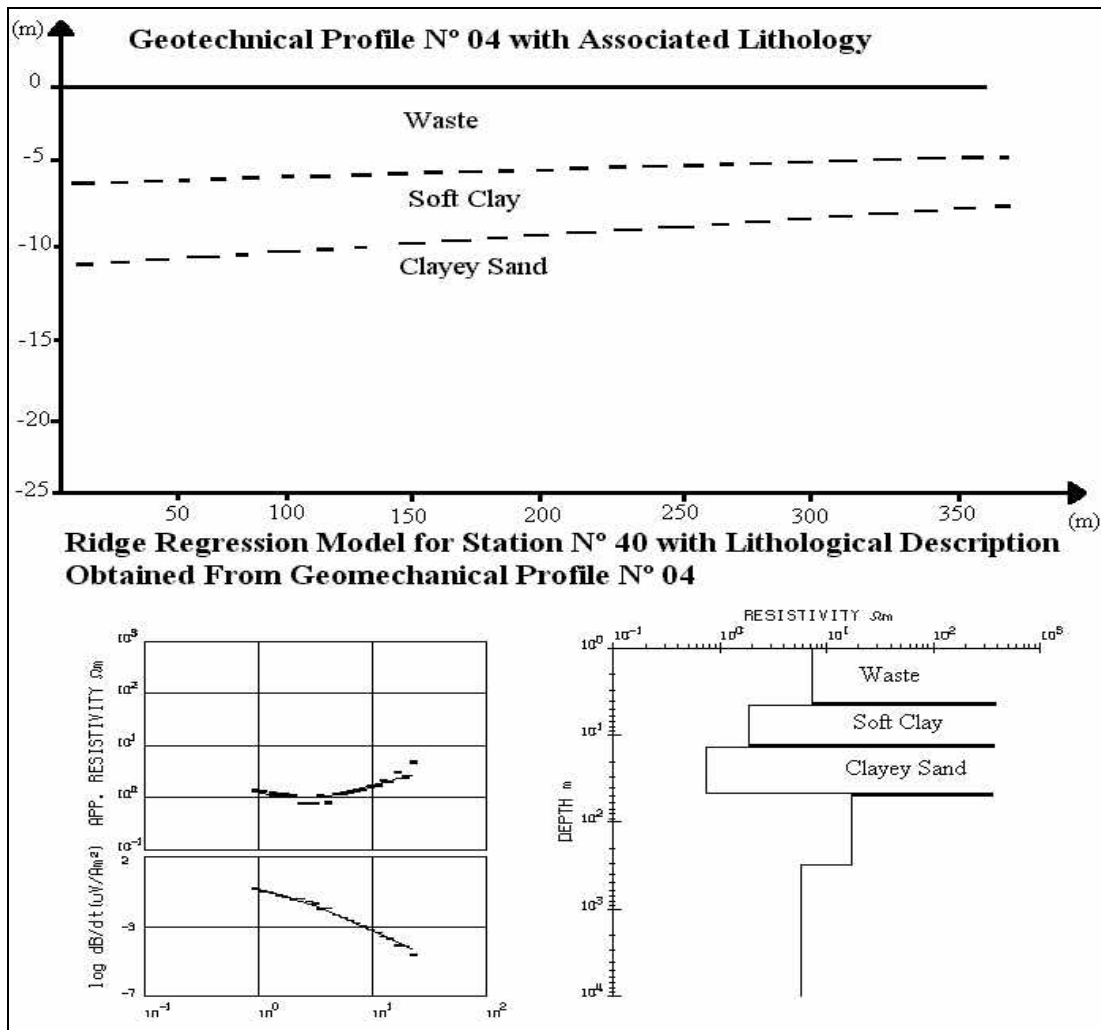


Figure 4: Associated resistivity variation of the TEM soundings with the described lithology