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Applications of Ground Penetrating Radar(GPR) and Resistivuty Surveys in the Detection of Organic Contaminants in the Subsoil

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ABSTRACT

This work presents the results obtained by two geophysical methods – Resistivity na Ground Penetrating Radar applied to a site inrio de Janeiro where the soil and ground water were contaminated by the pesticide called HCH (hexachlorcyclehexane). These two methods were used in order to detect anomalies related to the contaminat, and for stratigraphic purposos. Vertical Electrical Soudings and Transverse profilings were carried out inside and outside the focus area, in order to have a background measurement of the sediments present. Reflection Profiles were carried out with the GPR, using 100 and 50 MHz antenas. From the results of both methods.

INTRODUCTION

IN A GEO-ENVIRONMENT INVESTIGATION PROGRAM, THE FOLLOWING PARAMETERS MUST BE ASSESSED (RUDOLPH & CHERRY, 1996):

- 3-D understanding of ground water flow field
- accurate estimation of physical parameters
- delineation of extent and nature of groundwater contamination at extremely low concentrations
- mapping of various contaminant phases, including gas, dissolved and pure/imiscible phase

The purpose of a geo-environment investigation is rto characterize soil and grondwater polloution problems in sufficient detail to facilitate the design of a cost-effective corrective action program. For this purpose, the site investigation entails actual measurement of physical processes that control subsurface contaminant transport at a given site. Geologic, hydrologic and chemical data must be acquired and integrated to define the nature and extent of soil and groundwater contamination, as well as the potential migration of these contaminants within the natural groundwater flow system.

Such investigations can be carried out with drilling techniques, geophysical methods and direct push technology, and in recent years there has been a change in these techniques to accommodate these environmental issues related to contaminants. Surfce geophysical methods can aid in such investigations by providing continuous information about physical and chemical properties inthe earth in both areal and depth extent, noninvasively, remotely, safely and inexpensively.

This work presents a case study in which two geophysical methods – Resistivity and Ground Penetrating Radar (GPR) were used in a geo-environment investigation at a site where the soil and groundwater were contaminated by the organochloride pesticide HCH (Hexachlorcyclehexane).

Resistivity techniques are used extensively in the search for suitable groundwater sources and also to monitor types of groundwater pollution, since many contaminants show a strong contrast inresistivity/conductivity compared to the natural groundwater (Grazinoli, 1997)..Examples of such applications are present in Denson et al. (1983), Greenhouse & Harris (1983), Abu-Zeid (1994) and Grazinoli et al. (1997).

Of the available geophysical methods, GPR produces the highest resolution subsurface information. These method produces information about the subsurface by emitting na electromagnetic pulse and recording changes in the travel time, amplitude, and shape of the scattered pulse. The pulse is scattered by changes in the electrical properties of ground where the distance over which the change inproperties occur is comparable to the wavelength of the propagating electromagnetic pulse in the direction of propagation (Olhoeft, 1984). Such scattering occurs mainly by reflections and less commonly by diffraction. In Nickel et al. (1983), Annan & Davis (1976), Topp et al. (1980), Fisher et al. (1989), Olhoeft et al. (1991) and Grazinoli et al. (1997), application of GPR in geo-environment investigations are shown.

SITE CHARACTERIZATION

In 1950, in na site called Cidade dos Meninos, in the Municipality of Duque de Caxias, Rio de Janeiro, the soil and groundwater were contaminated by HCH. A great quantity of the pesticide remained at the site directly above the soil, without any protection. In 1995, through action of the Health Ministry, lime (CaO) was mixed with the surface material. Starting at the same year a comprehensive research project financed by the PADCT FINEP program started, having amongst other interests an investigation of the prsent state of soil and water contamination at the site.

The area at Cidade dos Meninos belongs to the lowlands of the Baixada Fluminense located between the sea and the Serra do Mar Range of mountains.-

In the area predominate river sediments deposited in irregular layers in form and thickness, sometimes lenticular with abrupt changes in its grain size distribution A comprehensive insitu hydrogeologic investigation was carried at the site

(Barreto,1998) which amongst other findings established that the aquifer is unconfined containing continuous layers of permeable sediments and a ground water level at 1.5-2.5m from the surface. The more permeable sediments are underlain by precambrian fractured rocks.The hydrogeologic studies concluded also that the unconfined aquifer feeds the rivers of the regions and the surface recharge is given mainly by rain water infiltration at the Serra do Mar range and at the site.

METHODOLOGY

Vertical Electrical Soudings, with Schlumberger configuration with maximum current electrodes spacings of 160 m, and Transverse Profilings were carried out inside and outside the focus area, in order to have a background measurement of the sediments present in the site. The profilings were presented inthe ofrm of pseudo apparent resistivity sections and isoline maps.
In relation to GPR, four reflection profiles were carried out in the focus area with 50 and 100 MHz antennas, as well as a CMP (commo-mid point) profile to estimate the average velocity.

RESULTS

Both techniques carried out with resistivity suggest a conductive character of the contaminants generated after the mixture with lime, which shows low values of resistivity, compared with the values measured in the adjacent area.
In contrast, a VES carried out in the local where there is the presence of pure HCH show high values of resistivity, in agreement with the response of most organic compounds, which exhibit higy values of resistivity.
Figure 1 show a reflection profile carried out in the focus area, showing a strong reflectivity where the HCH is inits pure form. The profiles carried out in the area of the mixture, show the attenuation of the electromagnetic signal due to the presence of conductive material.

CONCLUSIONS

The results show a conductive anomaly related to the contamination process after the addition of lime , since this mixture generates dissolved salts in the groundwater. However, the occurrence of pure HCH in the subsurface gives rise to a strong reflectivity, suggesting a resistive anomaly.
Although a sufficiently complex hydrogeologic environment could mask the results obtained by any geophysical method, most chemical-waste sites are mixtures of many chemical, and at least one of which should be visible to one or more geophysical methods.Besides, all the geophysical methods can be performed non invasively from the surface, which greatly decreases the risk of accidental spreading of the waste by drilling.
The results of this work illustrate the power and sensitivity of geophysical methods in the detection and monitoring of near-surface contaminants. Further investigations of the response of near-surface contaminats is required to the success of the use of geophysical methods in geo-environment investigations.

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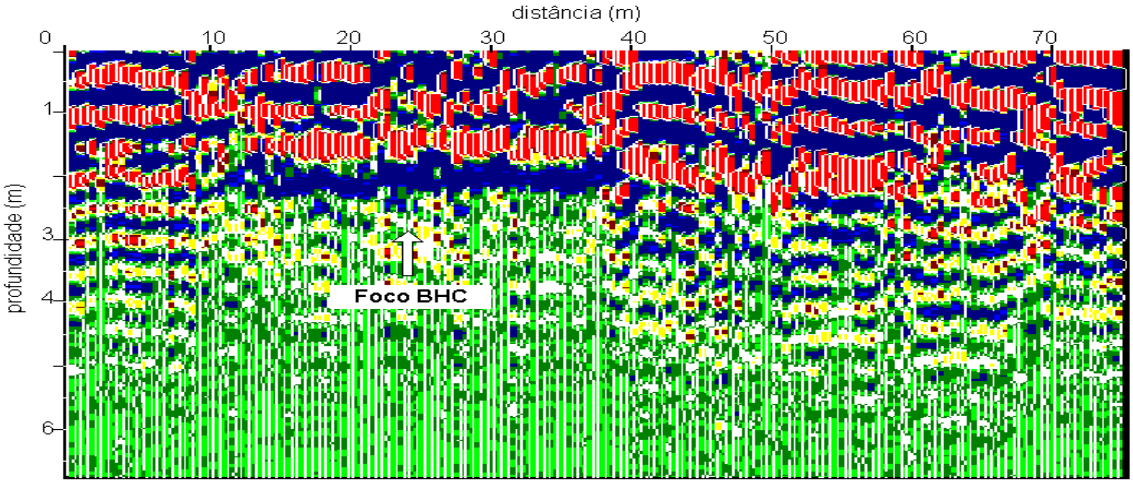

Figura 1 – Reflection Profile with GPR showing the reflector related to the presence of HCH in the focus area.