Apparent Resistivity Measurements in Complexo do Aurá Landfill, Ananindeua - Pará - Brazil

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ABSTRACT

Apparent electrical resistivity measurements were performed in Complexo do Aurá Municipal landfill in Ananindeua-Pará, Belém Metropolitan area. The measurements, done after 8 years of waste disposing, are compared to measurements done prior disposing. Results show flow and depth distribution of contamination leachate. The study is important because the landfill is close to lakes that supply water for Belém Metropolitan area.

INTRODUCTION

Domestic garbage from the Metropolitan area of Belém-Pará is disposed on a landfill located in Santana do Aurá, a small district of Ananindeua, north of Belém, close to lakes Água Preta e Bolonha that supply water for the city consumption (Figure 1). Since the leachate derived from the waste disposed on the landfill may contaminate ground water and drainage that goes to the lakes, resistivity measurements were done to study its flow distribution.
Measurements were performed after 8 years of disposing through vertical electrical soundings (VES) and compared to measurements performed prior disposing.

LOCAL GEOLOGY

Geological surface mapping (Bastos, 1991) show a sandy, clayed, and silty ground (Figure 2).
Low depth drilling (less than 25 m deep), showed a sequence, from top to bottom, of brown clay, ferrous concretion, dark clay, coarse sand and gravel, clayed silt, silt, fine sand, medium to coarse sand, clay concretion, clayed to silty sediments and, finally, clay (Bastos, 1991).
Since geological subsurface sequence show clayed to silty sediments close to ground surface laying over sands at medium depths, it is probable that vertical flow of leachate dominates close to the surface while lateral flow becomes dominant at medium depths.

GEOPHYSICAL WORK

Apparent electrical resistivity measurements were taken through 17 VES using Schlumberger electrode array. Current electrodes were set at maximum separation of 150 m, which gives a maximum empirical depth of investigation in the range of 15 to 45 m. The Location of the VES is showed in Figures 3 to 6.
VES data were not inverted to get geoelectrical models for the subsurface because the resistivity values were biased by the leachate. Instead, apparent resistivities were plotted and contour maps for different current electrode separations were drawn (Figures 3 to 6). For comparison, apparent resistivity values measured before waste be disposed are written on these maps at the locations where they were collected. The old apparent resistivity data came from 10 VES done by Bastos (1991) in a previous work (Figures 3 to 6 show the location of the old VES). Since depth of investigation is partially related to current electrode separation, a view of the movement of leachate in subsurface can be inferred by comparing new and old data for the different electrode separation.
The main feature that can be observed in comparing new and old data is the drastic reduction of resistivity in new data, obviously impaired by the leachate.
Since old and new VES were not taken at same locations (except for new VES 2 and old VES 4A), an apparent resistivity average for VES 17, 1, 2, 6, 7, 8, 3 and 12 (new VES) was calculated to compare to the average for the VES 1A, 2A, 3A, 4A e 9A (old VES); also an average for the apparent resistivity measured in VES 5, 16, 15 e 14 was calculated to compare to apparent resistivity measured in VES 10A. This comparison is represented in table I where empirical depth is also shown for several electrode separation.
The comparison in table I shows that for the area where VES 17 to 12 (third column of table) were located the greater reduction in resistivity occurs beetween the electrode separations AB/2=1 and AB/2=18, decreasing for larger separations, suggesting also that leachate is more concentrate at depths less of 3.5 m (using lower limit of empirical depth), but can reach depth as deep as 15 m (taking lower limit of empirical depth for separation AB/2=75).
The comparison also suggests that the leachate has moved to south of the landfill since the reduction in resistivity is not so large but it is still efective in the area where VES 5 to 14 were located (as shown by the fourth column of table). In this area the comparison shows that for the separation AB/2=75 there is no leachate influence.

The resistivity maps and three-dimensional plots (Figures 3 to 6), on the other hand, show that the leachate seems to flow mainly to south and west of the landfill up to an empirical depth around 8.5 m.

Table I – Apparent resistivity comparison.

SEPARATION AB/2 (m)	EMPIRICAL DEPTH (m)	VES 17,1,2,6,7,8,3,12 to VES 1A,2A,3A,4A	VES 5,16,15,14 to VES 10A	VES 2 to VES 4A
1	0.2 a 0.6	Reduction of 97 %	Reduction of 62 %	Reduction of 87 %
5.5	1.0 a 3.0	Reduction of 98 %	Reduction of 68 %	Reduction of 99 %
18	3.5 a 10.0	Reduction of 97 %	Reduction of 60 %	Reduction of 98 %
42	8.5 a 25.0	Reduction of 94 %	Reduction of 75 %	Reduction of 96 %
75	15.0 a 45.0	Reduction of 81 %	Increase of 34 %	Reduction of 91 %

CONCLUSIONS

Contamination by leachate is shown by a drastic reduction in resistivity.
Resistivity maps suggest that the main flow of leachate is to south and west of the landfill, going probably out of its limits.
The dispersion of the plume of leachate seems to be mainly vertical from surface to 1 m and lateral below this depth.
The major contamination seems to be concentrate between depths of 1 m and 8.5 m, but it can reach depths as deep as 15 m.
A study outside of the limits of the landfill (up to 500 m) is recomended.

REFERENCES

Bastos, R.G.P., 1991, Mapeamento por Método Geofísico das Camadas Permeáveis na Área do Complexo de Destino Final dos Resíduos Sólidos da Região Metropolitana de Belém: Trabalho de Conclusão de Curso em Geologia, Centro de Geociências, Universidade Federal do Pará.

ACKNOWLEDGMENTS

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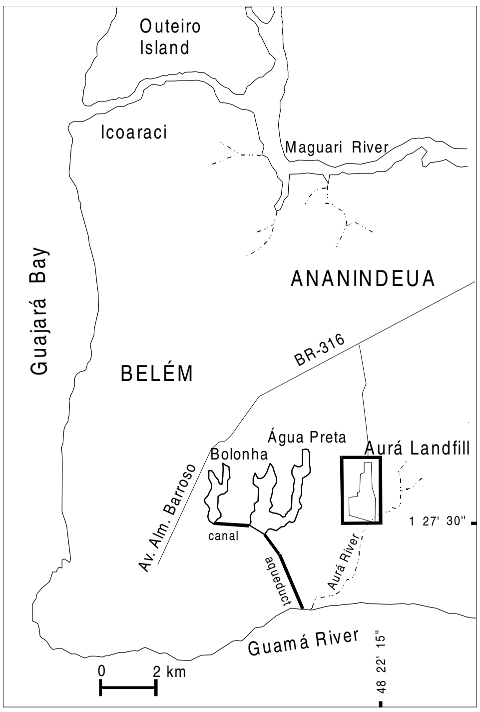

Figure 1 - Landfill location map.

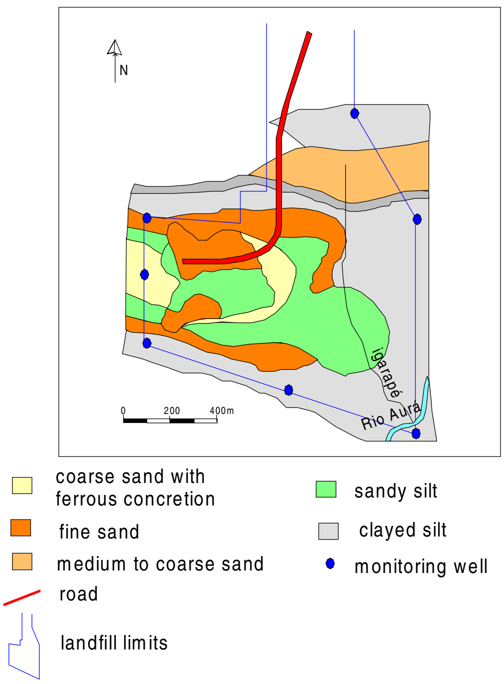

Figure 2 - Geological map of landfill area. Adapted from Bastos (1991).

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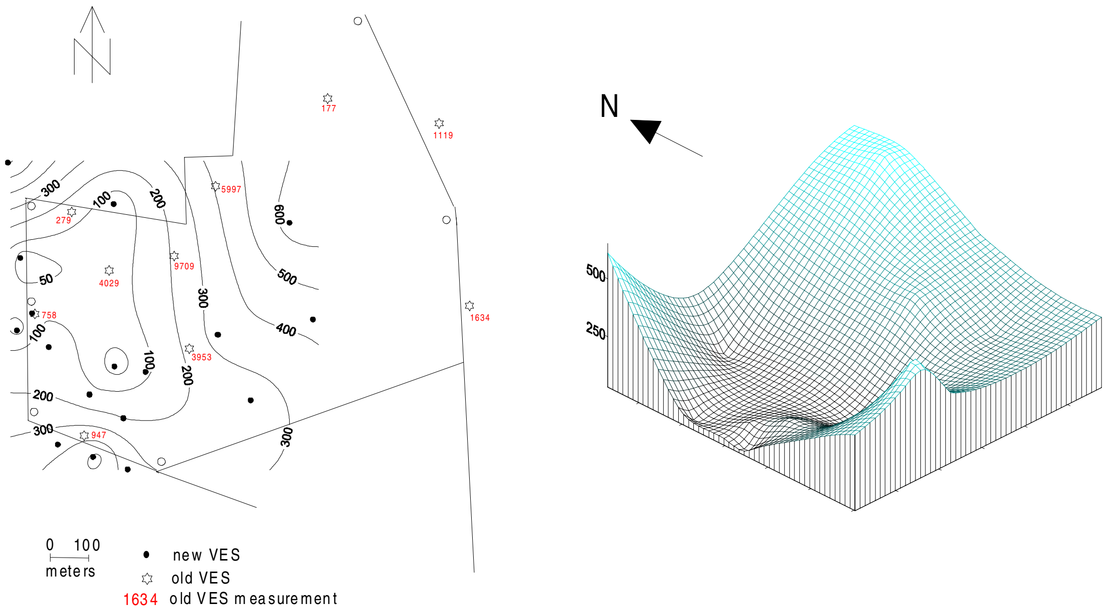

FIGURE 3 - Apparent resistivity map and 3D plot for electrode separation AB/2=1.0 m.

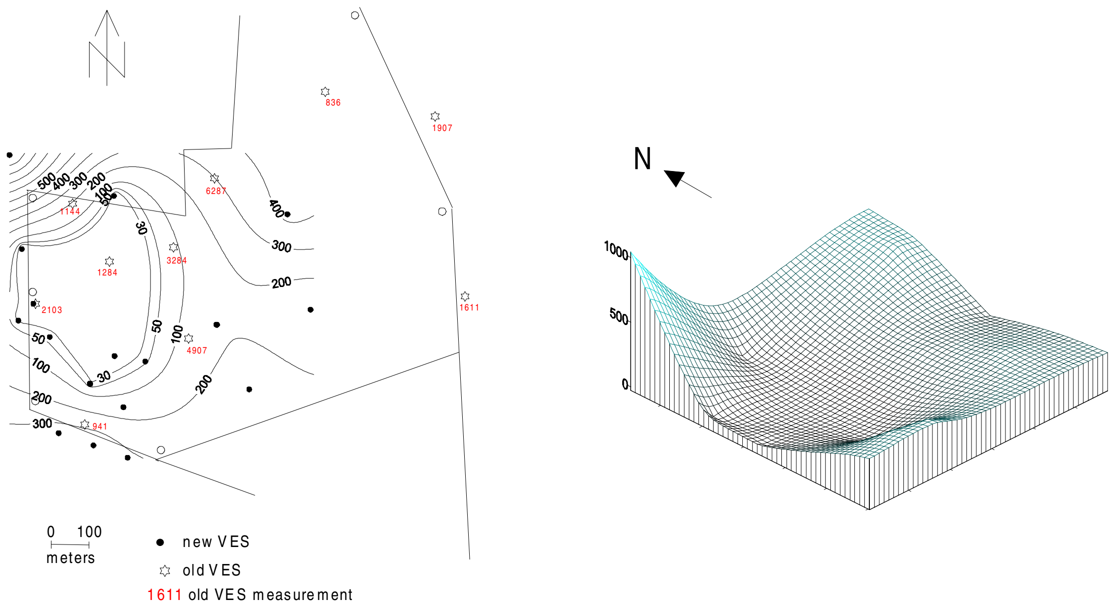

FIGURE 4 - Apparent resistivity map and 3D plot for electrode separation AB=5.5 m.

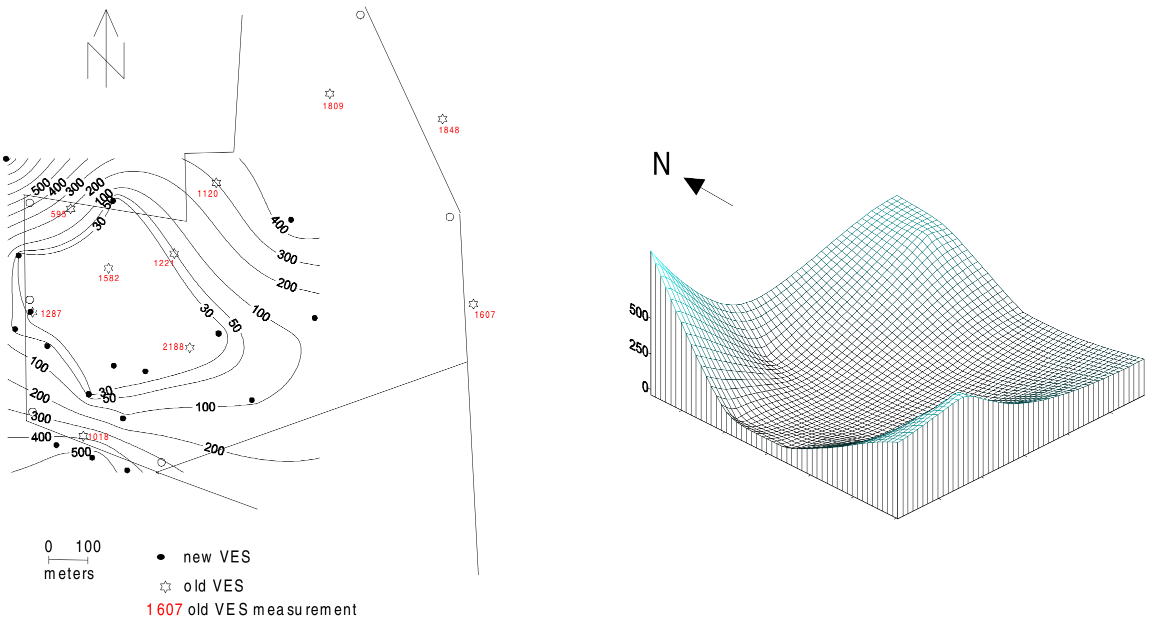

FIGURE 5 - Apparent resistivity map and 3D plot for electrode separation AB/2=18.0 m.

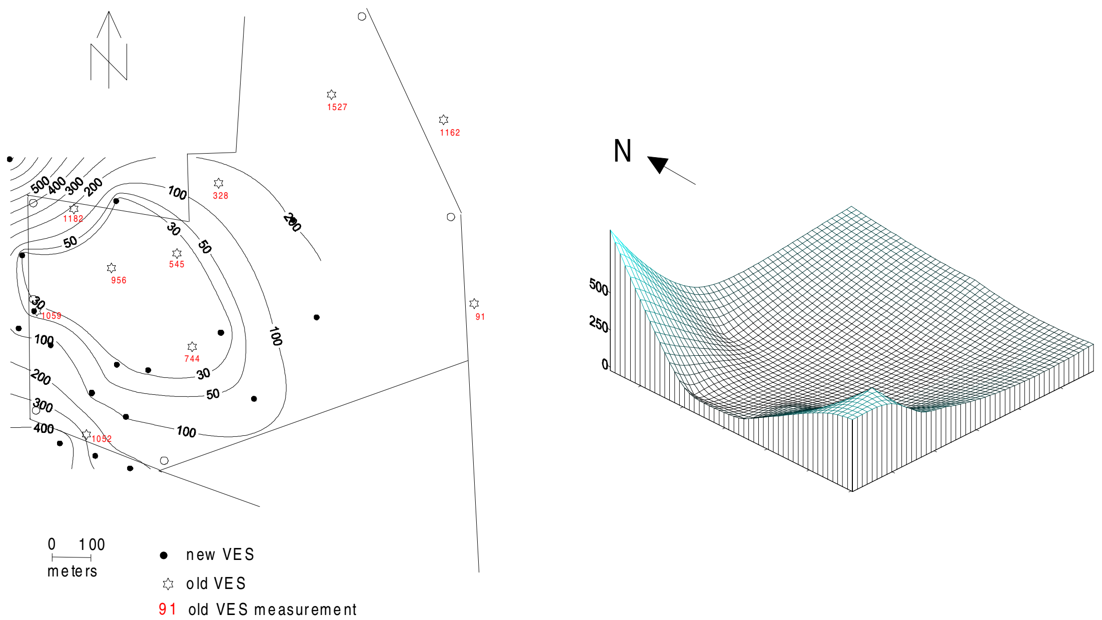

FIGURE 6 - Apparent resistivity map and 3D plot for electrode separation AB/2=42.0 m.