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Three-Dimensional Spatial Visualization of Geophysical Data Applied to Contaminated Sites, Engineering Projects, and Environmental Management

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Introduction

This paper discusses the application of geophysical methods—specifically electrical resistivity—in the investigation of complex subsurface conditions. Three distinct case studies are presented: two related to soil contamination (creosote and leachate) and one involving civil engineering works (a tunnel collapse during construction). In these scenarios, 3D visualization technologies were employed to enhance the interpretation of geophysical data collected in the field. The Oasis Montaj software, utilizing the Voxel modeling module, was used to perform volumetric interpolation based on kriging algorithms. The results obtained demonstrated that 3D visualization is a critical technique, requiring tailored planning for each method applied. The final 3D models provided technically coherent integration of resistivity data. This reliable and validated visualization approach supported the implementation of environmental remediation solutions and contributed to a more effective assessment of contamination plumes and geomechanical instabilities.

Method

Three-dimensional subsurface models (3D visualizations) of the study sites were developed from electrical resistivity data using Oasis Montaj software and its 3D Voxel module, which facilitated volumetric interpolation of the subsurface properties. The resistivity data used for 3D modeling were post-processed using Res2Dinv software, ensuring refined and accurate results. Using spatial coordinates (X, Y, Z) and measured physical properties (e.g., resistivity), 3D models were constructed. Each voxel represents a volumetric unit assigned a geophysical value, allowing for detailed analysis of subsurface features. These models support operations such as zooming, rotation, cross-sectioning, and, importantly, the extraction of statistical data. The adopted methodology proved effective in delineating contamination plumes caused by creosote and leachate, as well as identifying zones of geomechanical instability at the tunnel collapse site, providing essential information for environmental assessment and construction safety planning.

Results and Conclusions

The studies yielded the following outcomes:

- Creosote-contaminated area in São Paulo, SP: The 3D model mapped the subsurface contamination plume, providing guidance for remediation actions.
- Sanitary landfill in Sete Barras, São Paulo: 3D electrical resistivity profiles facilitated volumetric assessment of the leachate-impacted mass, aiding remediation planning.
- Tunnel collapse in São Paulo, SP: 3D resistivity data helped identify zones of geomechanical instability and supported risk analysis for resuming excavation activities.

In all applications, 3D visualizations revealed specific and complex patterns of geophysical anomalies, highlighting contamination extents and areas of geomechanical instability. The ability to rotate, segment, and statistically analyze the volumetric model significantly enhanced interpretation. This methodology effectively transforms complex datasets into visual insights. However, it is important to emphasize that achieving reliable 3D models requires prior and method-specific planning. Moreover, 3D modeling, which integrates data with varying attributes and scales, demands careful interpretation to ensure accurate results.