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Assessment of GPR Response in Detecting Metallic and Non-Metallic Objects (PET Bottles with Different Fluids) in a Controlled Site

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Introduction

Based on the principle of transmission and reflection of high-frequency electromagnetic waves (10 MHz – 2.6 GHz), the Ground Penetrating Radar (GPR) method is a non-destructive technique designed for high-resolution imaging of the shallow subsurface. Through a transmitting antenna, waves propagate through the subsurface and reflect upon encountering interfaces with significant contrasts in the electrical properties of the medium, specifically electrical conductivity and/or dielectric permittivity. The reflected waves are then captured by a receiving antenna. This study aims to evaluate the effectiveness of GPR in detecting and characterizing buried objects in a controlled environment. For this purpose, the Applied Geophysics Controlled Site (SCGA) was established at the Federal University of Bahia. In the first experimental phase, PET bottles containing different fluids (water, saltwater, motor oil, ethyl alcohol) and an empty one, along with aluminum cans, were buried in different trenches.

Method and/or Theory

Data acquisition was performed using the IDS GeoRadar RIS MF Hi-Mod system with 200 MHz and 600 MHz antennas. Prior to soil intervention, GPR profiles were obtained to characterize the environment and allow comparison with post-burial results. Six trenches, approximately 50 cm deep, were excavated along a line. After burying the objects, a new 2D profile was acquired over the modified area. Data processing initially involved dewow subtraction to eliminate low-frequency components caused by electromagnetic induction in the antennas, resulting in a zero-centered signal and improved detection of shallow reflections. Next, 1D filtering was applied to individual traces to reduce high-frequency noise (electronic interference) and low-frequency noise (reverberations). Static correction was then performed to align time-zero across all traces, ensuring horizontal coherence in the radargram and correcting for antenna height variations or topographic irregularities. To compensate for signal attenuation with depth, a gain function was applied, amplifying deeper reflections without saturating shallow ones. Methods such as exponential gain and Automatic Gain Control (AGC) were tested to balance signal energy at different depths. Finally, a 2D filter with background removal was used to eliminate horizontal noise.

Results and Conclusions

Our results demonstrate that the survey successfully distinguished buried materials through the appearance of hyperbolas at expected positions for each object. The characterization of materials was notably different in terms of composition but less clear regarding the specific fluid inside each bottle. Thus, the method proves more applicable for distinguishing materials with distinct compositions rather than identifying different types of fluid contamination.