Assessing Ground-Penetrating Radar (GPR) Responses: Impact of Sand-Clay Ratio in Burial Material on Forensic Target Detection - A Comparative Study Between Dry and Rainy Seasons

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Abstract

This study evaluates the influence of sand-clay ratios on detecting simulated forensic targets using ground-penetrating radar (GPR). Four experimental graves (SEPs) represented distinct burial scenarios. Objectives included assessing clay soil's impact on 2D and pseudo-3D GPR imaging of swine targets. Signal attenuation was observed in rainy seasons, with clearer results in drier conditions. SEPs with 85% sand and 15% clay material yielded optimal results. Controlled sites offer invaluable precision for geophysical investigations, enabling meticulous parameter adjustments and enhancing methodological accuracy. They serve as crucial platforms for refining and validating geophysical techniques, thus advancing forensic geophysics.

Introduction

Research in forensic geophysics employing ground-penetrating radar (GPR) has shown considerable potential for non-destructively detecting buried objects across diverse scientific domains (Schultz et al., 2016). However, GPR's application in this context faces limitations due to site-specific characteristics, soil composition, and target decomposition extent (Barone and Di Maggio, 2019).

The specific application of the GPR method for subsurface human body detection has encountered limitations such as site-specific characteristics, soil type, and the decomposition state of the targets.

Objectives

This study aims to evaluate how clay soil content and data collected under both dry and rainy conditions influence the recognition of forensic targets in a controlled environment simulating burial scenarios.

Materials and Methods

The controlled site for the conducted experiments was established within an approximate area of 100 m^2 situated within the Experimental Farm (FAL) of the Federal University of Brasília (UnB). The controlled site was established and it comprised four experimental inhumations (SEP's) involving the burial of target specimens (pigs) at depths of either 0.50 m or 0.90 m with different cover texture compositions (Figure 1). The Geophysical Survey System Inc. (GSSI) GPR SIR3000 equipment was employed for data acquisition.

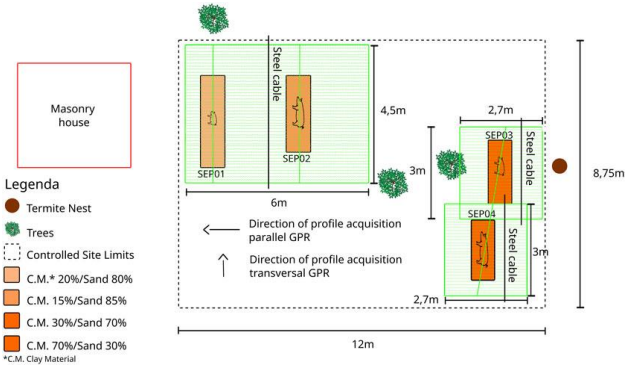

Figure 1 – Sketch of the controlled site area featuring the layout of the experimental graves.

Results

Signal attenuation was observed in the GPR data during the rainy season and after reflection from larger targets, primarily attributed to the conductive behavior of the soft tissues within the targets. More precise results were attained in an SEP composed of 85% sand and 15% clay material (Figure 2), irrespective of seasonality. Improved outcomes

were obtained during the dry season due to the enhanced penetrability of electromagnetic waves and clearer reflections.

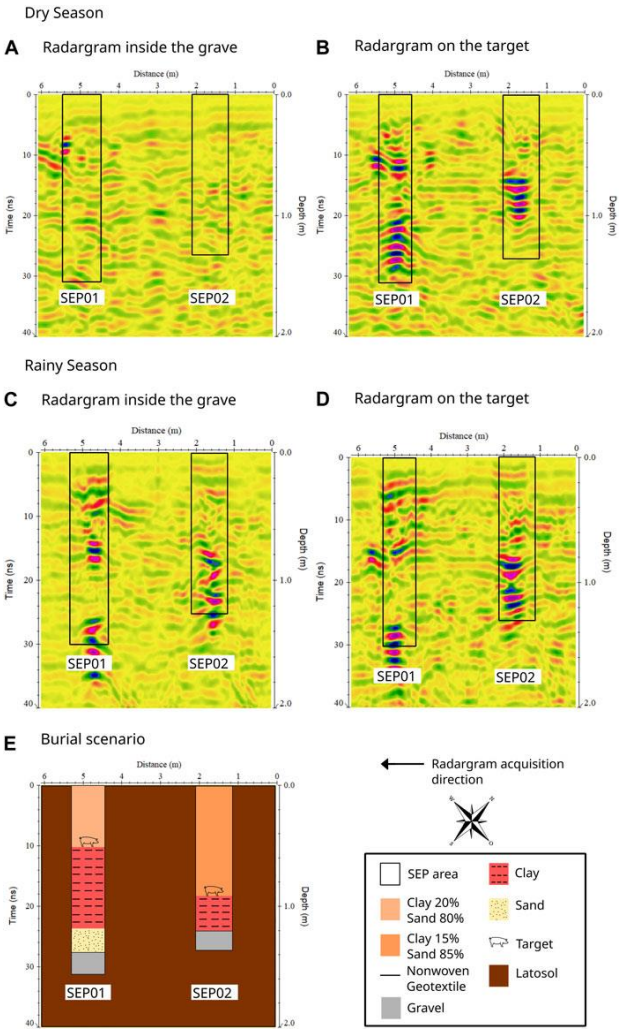

Figure 2 – Radargrams obtained over SEP01 and SEP02 during dry and rainy seasons with the 400 MHz antenna. Data acquired: (A) Inside the grave during the dry period. (B) Over the target during the dry period. (C) Inside the grave during the rainy period. (D) Over the target during the rainy period. (E) Illustrative model of the buried target in the burial scenario.

Discussions and Conclusions

Soils with higher moisture and clay content tend to exhibit significant attenuation in GPR signals, although clay mineralogy also influences penetration depth. In the dry season, results were clearer, especially in target visualization, whereas the rainy season featured diffuse reflections and limited visibility. Pseudo-3D diagrams highlighted the migration of decomposition fluids, influenced by soil composition and climatic conditions. Combining GPR with another geophysical method is recommended to resolve any ambiguities in data interpretation.

References

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SCHULTZ JJ, WALTER BS & HEALY C. 2016. Long-term sequential monitoring of controlled graves representing common burial scenarios with ground penetrating radar: Years 2 and 3. Journal of Applied Geophysics 132: 60–74. DOI: 10.1016/j.jappgeo.2016.06.015

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