D52 The Application of *In-Situ* Reflectance Spectroscopy for the Detection of Mass Graves

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After attending this presentation attendees will be able to understand how in-situ reflectance spectroscopy could aid in the location and detection of single or mass graves, will appreciate the potential for further research to be conducted at human natural burial grounds within the United Kingdom, will recognize that remote sensing in the form of *in situ* reflectance spectroscopy has definite potential to be applied in a soil forensic context, and will recognize the importance of conducting research on human burials rather than simulated or animal burials.

This presentation will impact the forensic science community by offering a quick, non-invasive tool which can be utilized within the initial search, location, and detection of mass graves.

Research was conducted to investigate the findings published within the paper "The Application of Remote Sensing for Detecting Mass Graves: An Experimental Animal Case Study from Costa Rica" (Kalacska et al. 2009). Kalacska et al. (2009) conducted spectral measurements using both *in situ* reflectance measurements and hyperspectral analysis on two simulated mass graves (one containing cattle and the other, disturbed soil) over a sixteen month period. The original study was conducted in the tropics of Costa Rica and thus, a recommendation was made for further research to be conducted in alternative climatic zones to ensure that the extent of the application could be ascertained and determine whether this form of remote sensing could provide the international community with a preliminary detection tool for mass graves.

Therefore, research was conducted into the application of *in situ* reflectance spectroscopy, monitoring within the visible to near infrared (350-2500nm) to ascertain whether there was potential for this technique to be used as a quick, non-invasive method for the detection and differentiation of soil from grave and non-grave areas. The *in situ* reflectance measurements were collected using a portable fibre type vis- NIR LabSpec Pro, Near Infrared Analyser from Analytical Spectral Devices Inc (ASDI), USA, were conducted.

Therefore, to assess the application of in situ reflectance spectroscopy, two investigations were designed and undertaken to allow a new research methodology to be created; a controlled laboratory based pilot study and field work, focusing on four natural burial grounds within the United Kingdom.

The methodology developed for the controlled laboratory pilot study included simulated mass graves containing organic minced beef being exposed to $30^{O}C$ over a period of six days. Reflectance spectra were obtained on days one and six of each of the experimental weeks; for statistical reasons the pilot study was repeated four times over four consecutive weeks. The collected spectra from the four pilot studies were subjected to Principal Component Analysis (PCA) to ascertain whether the spectra obtained from the soil from grave and non-grave areas on day six were significantly different to those collected on day one.

Consequently, it was found after subjecting all of the reflectance spectra obtained to PCA that within all of the similarity maps produced from the laboratory study, clear differentiation was observed between the spectra collected from grave areas in comparison to those from the non- grave areas on day six.

The second of the two investigations, the field work, was conducted at four Natural Burial Grounds within the United Kingdom. An operating procedure was devised which was employed for all of the twenty four graves measured; thirty three reflectance spectra were obtained from the soil from both grave and non-grave areas. The spectra collected from the natural burial grounds were also subjected to PCA, after which it was found that differentiation between the spectra obtained from the grave and non-grave areas was achieved within 75% of the graves measured, whereas, 25% of the similarity maps produced indicated that no differences between the spectra obtained existed.

In conclusion, it was found from conducting both a controlled laboratory study and also field work, that *in situ* reflectance spectroscopy monitoring within the visible to near infrared does have the potential to be utilized as a preliminary tool for the location and detection of single or mass graves during site assessment.

The aim of site assessment is to locate and define a potential area which may contain a mass grave; during which many disciplines are pooled to create a multidisciplinary team. Any information regarding the potential location of a mass grave is collected and investigated. The difference sources of information often utilized during area location are eye witness testimony, aerial imagery and geophysical survey; as these sources enable the investigation to become more focused on one particular area (Anderson et al. 2008).

Within literature it is documented that one of the most successful methods of mass grave location was found to be eye witness testimony; where evidence is often sought to corroborate the information obtained, to determine the mass grave location; this has been seen in countries such as Bosnia.

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Due to mass graves becoming the stimulant for criminal proceedings increasingly over the past decade, the emphasis placed on recovering evidence utilizing forensic principles has also increased dramatically. Consequently, the first standard operating procedure for the investigation of mass graves was published during 2008 by Cox et al., within which the forensic principles of site integrity and continuity were emphasized. Particular weight was placed on the methods used to detect mass graves, where the least intrusive techniques are employed prior to the more intrusive methods, to ensure that the site's integrity and also the integrity of the evidence is maintained.

Consequently, it is intended that this application of *in situ* reflectance spectroscopy could be used as part of the process towards confirming the information obtained from eye witness testimony or aerial photography during initial assessment missions; particularly during the processes of area and site location. The method proposed within this research is non-intrusive, quick and the instrument is portable and would therefore be a valuable addition to the multidisciplinary methods currently utilised within the location and detection of mass graves. **Mass Graves, Humanitarian, Remote Sensing**

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