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REVIEW OF VARIOUS METHODS OF FORENSIC ANALYSIS OF SOILS AND ITS IMPORTANCE AS EVIDENCE TO CONNECT THE PERPETRATOR

[1]Andaluri Naresh Babu., [2] Dr. Rupaali A Thakur

[1] Research Scholar, Singhania University, Rajasthan.

[2] Assistant Director and Scientist 'C', Forensic Psychology division, CFSL, DFSS, Delhi, India

Abstract

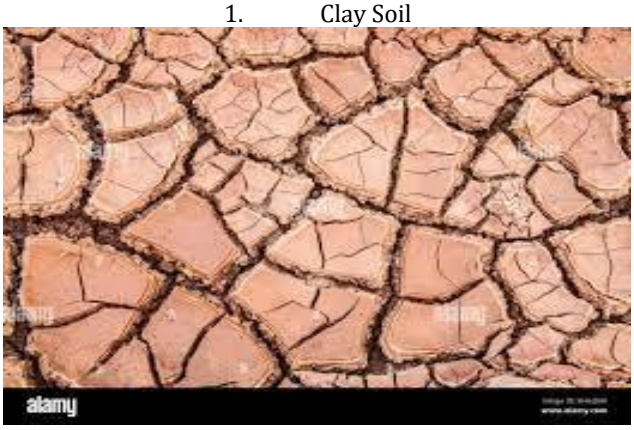
Forensic Soil Analysis is the use of soil sciences and other disciplines to aid in criminal investigation. Soil is the important physical evidence in all such relevant cases. Soils are like fingerprints because every type of soil that exists has unique properties that itself act as identification markers to include it as the admissible evidence in the court of law. This means that the origin of the soil sample can be tracked back to identify the perpetrator. For example, soil embedded in the footwear of a criminal can be traced back to a specific soil type found at scene of crime. A majority of soil cases involves footprints or tire marks that have been left in the soil. In this paper we are studying the evolution of Soil analysis in Forensic Science through various case studies. We will also study in-brief about procedures adopted in Forensic science for analysing the soil samples.

INTRODUCTION

According to Britannica, Soil can be defined as a biologically active, porous medium that has been developed in the uppermost layer of Earth's crust which evolves through weathering processes driven by biological, climatic, geologic, and topographic influences. There are many types of soil that are distributed around the world and these are generally classified into the following:

1. Clay Soil
2. Sandy soil
3. Loamy Soil
4. Silt Soil

1. Clay Soil



2. Sandy Soil

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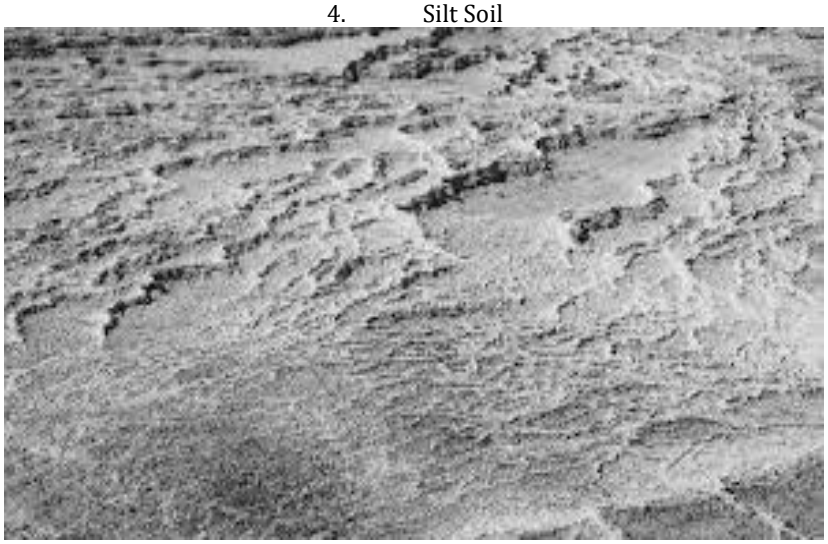
3. Loamy Soil

4. Silt Soil



According to Locards principle of Exchange in forensic science holds that **the perpetrator of a crime will bring something to the crime scene and will leave with something from it. I**n case of Soil the criminal can take along the Soil from Scene of Cases or bring the other soil from his travelling path.

In general, soil usually has a strong capacity to transfer and stick, especially the fine fractions in soils (clay and silt size fractions) and organic matter. The larger quartz particles (e.g., >2 mm size fractions) have poor retention on clothes and shoes and carpets. Fine soil material (e.g., their <50 –100 μm fractions) may often only occur in small quantities.

HISTORY

Different sources available to describe the beginning of Soil analysis in different domains and contribute to different Scientists,
Some of them are:

- According to Murray, forensic geology began with Sherlock Holmes writer, Sir Arthur Conan Doyle. The character Sherlock Holmes claimed to be able to identify where an individual had been by various methods, including his having memorized the exposed geology of London to such a degree that detecting certain clays on a person's shoe would give away a locale.

- Georg Popp, of Frankfurt, Germany, may have been the first to use soil analysis for linking suspects to a crime scene. In 1891, Hans Gross used microscopic analysis of soils and other materials from a suspect's shoes to link him to the crime scene.

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- The earliest published application of forensic soil science and forensic geology was in April 1856 (Science & Art 1856) when a barrel that contained silver coins was found on arrival at its destination on a Prussian railroad to have been emptied and refilled with sand.

- Professor Christian Gottfried Ehrenberg (1795–1876) natural scientist at the University of Berlin, acquired samples of sand from stations along railway lines and used a light microscope to compare the sand with the station from which the sand was most likely to have come from. This is arguably the very first documented case where a forensic comparison of soils was used to help police solve a crime (Fitzpatrick 2008).

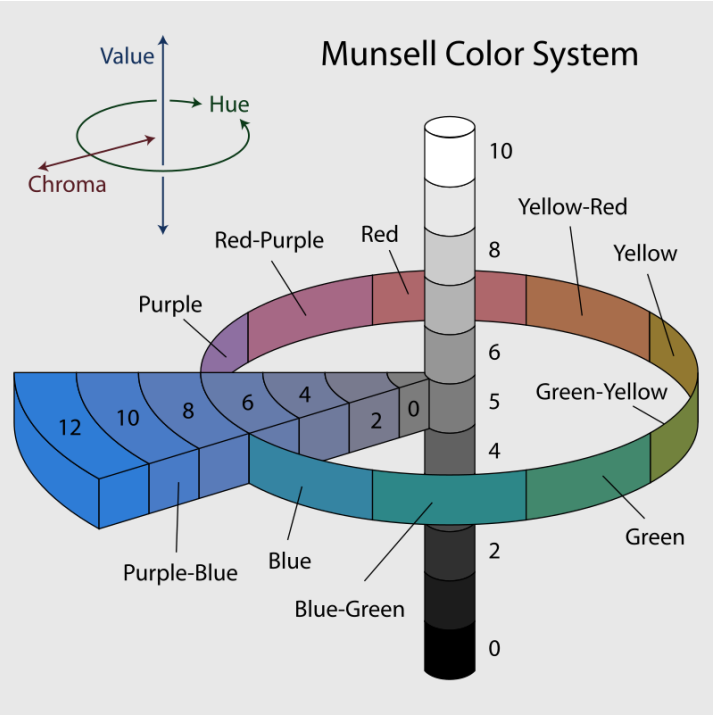
- Professor Ehrenberg is considered the founder of both soil microbiology (a discipline of soil science; Blume *et al.* 2012) and micro geology (i.e. micropalaeontology, which is a discipline of geology.

- **Georg Popp, of Frankfurt, Germany, may have been the first to use soil analysis for linking suspects to a crime scene**. In 1891, Hans Gross used microscopic analysis of soils and other materials from a suspect's shoes to link him to the crime scene
- The first known case where soil was used in helping solve a crime was in 1904 when German scientist Georg Popp examined soil collected from the trousers of a murder suspect. Two distinct soil samples from the trousers were collected. One sample was consistent in mineral composition to soil from where the homicide victim was found. The second soil sample was consistent with soil collected from the pathway that connected the crime scene to the suspect's home. When shown how the soil evidence tied him to the murder, the suspect confessed.

- In 1994, Dr Donnelly had been developing a new search strategy based on mineral exploration and engineering geology investigative methods (later to become known as **the Geoforensic Search Strategy, GSS)** to search for the last remaining victim of the Moors Murderers

These developments led us to aware of how information on earth materials can be used as trace evidence and in searches for burials so that informed decisions can be provided to support and help police/law enforcement officers/agents and forensic scientists with complex criminal and environmental investigations.
Different types of Forensic Analysis /Techniques:

- Colour is one of the most important physical characteristics associated with soil samples. One technique used is comparing the soil to the Munsell soil chart. In a majority parts of the world during a forensic investigation determining the soil colour are required. This analysis can be achieved in the field itself with the Munsell soil chart using human perspective. Although colour is a very subjective topic, two people can have a completely different perception of colour and could then associate it differently with the Munsell soil chart thus effecting the accuracy of this method.



Munsell soil chart

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- Spectrophotometry: To avoid the errors of simply using human perception, to obtain objective results computer-controlled spectrophotometry can be used. One computerized method is using CIELAB which consists of using an electronic spectrophotometer and calorimeter to create 3D plotting of colour. Using three coordinates L* relates to a reflection of lightness, a* refers to red/ green colours and b* yellow/ blue colours. This method uses a derivative mathematical system to achieve a uniform colour space for analysis. This technique provides numerical values to be associated with colour to then be using with accordance of the Munsell soil chart.

Spectrophotometry

- **Density:** Another physical characteristic used is measuring the density This can be achieved in regards to the *particle density* or *material density,* this measurement will vary depending on the specific type of Soil measured.

Digital Densitometer

- **Particle size distributions** One of the most discriminating physical characteristics consist of particle size where it is characterized as *particle size frequency distributions*. This consists of the materials weight, weight %, number of particles present, or the volume. Depending on the sample, different methods can be used such as examination use a microscope, laser diffraction, dry/ wet sieving, computer program analysis and many more.

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Particle analysers

- **P^{H}** is the measure of hydrogen activity present and to determine the pH they calculate the level of dissociation of the hydrogen ions. Within the realm of pH, it can be associated with acidic, basic or neutral. Although more can be determined with pH such as the elemental composition and the level of essential nutrients and toxicity. It can indicate the presence of many elements such as P, Zn, B, Cu, Fe etc., as well as estimating lime requirement. In recent years that has been much improvement to portable pH meters that are used in the field. Decades ago, the portable devices have numerous malfunctions regarding the electrodes. Nowadays pH meters due to microcircuitry and plastic not only reduces the cost of these devices but also allows for an overall better protection of the unit. Further studies are attempting a technique to produce a device to obtain microsite pH in various soil systems by using plant cells via micro-procedures. This would also be able to decipher the different pH present in the soil matrix.

Digital **P^{h}** meters

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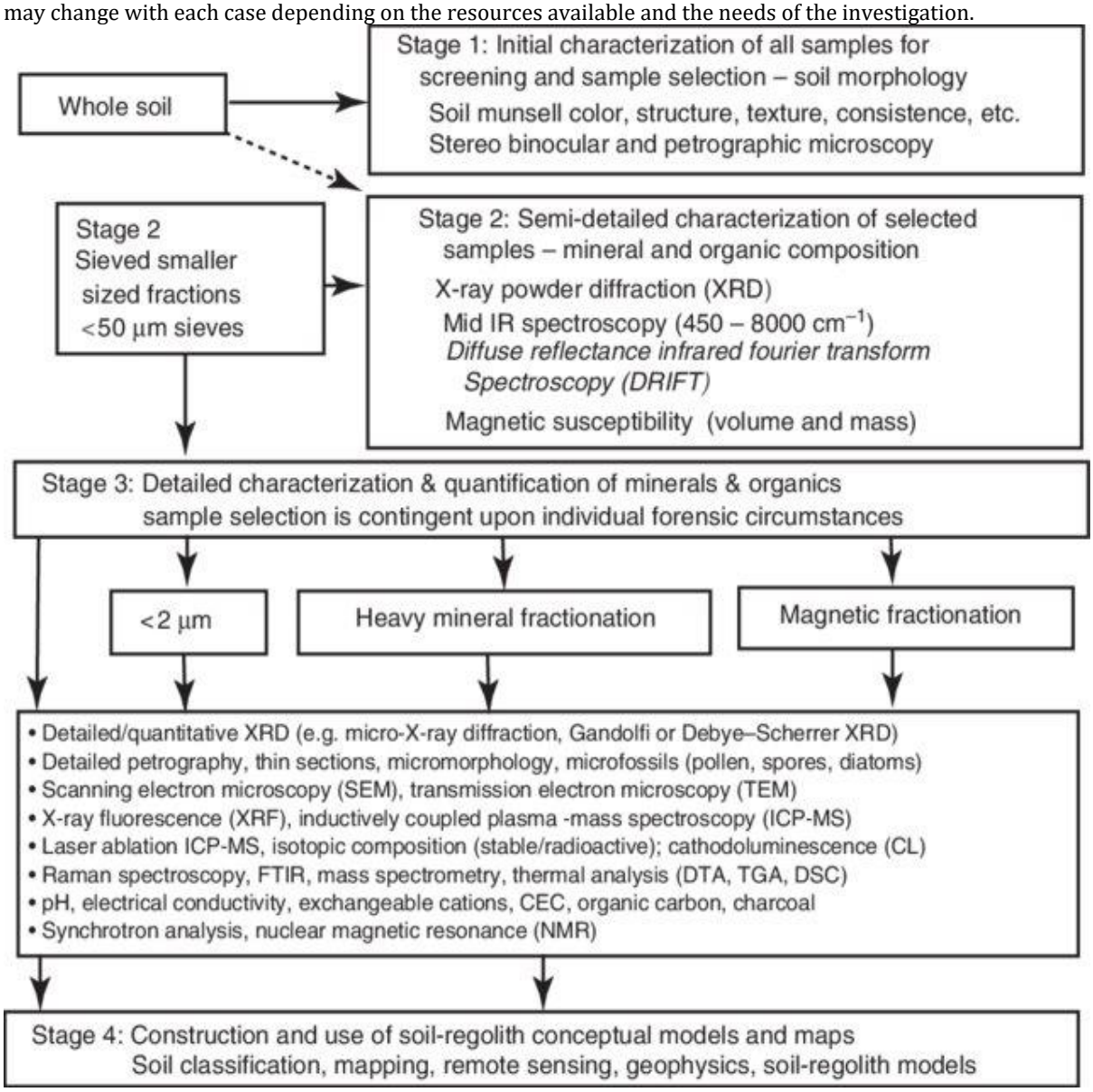
- Recently developed techniques, confocal RAMAN, laser induced breakdown spectrometry (LIBS) and laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS) are considered for their potential for cost effective discrimination of soils

FTIR Spectrometer

Outcomes of comparisons between techniques suggest that a hierarchy of techniques can be developed, which may change with each case depending on the resources available and the needs of the investigation.



CONCLUSION

Soil can be vital evidence in forensic investigation of case as seen through history of case studies. It is highly Valuable piece of evidence given the fact that it is as distinctive as a finger print of the human being and as the evolution progresses the changes do takes place in the nature of soil. It contains complex structure of multi-

faceted living organisms. If identified timely and carefully the very specific and complex structures tracks the perpetrator perfectly.
And for analysing, Various scientists have been contributing to invent newer & newer techniques with the support of latest technology & know how for identification of Soil and comparison of sample obtained from perpetrator connecting it to crime.

Though it has not gained value that ought to be as evidence in the court law for the following reasons:

- Ignorance of general public to preserve the crime scene
- Lack of awareness & knowledge among the relevant stake holders.
- Faulty evidence handling while crime scene management
- Inadequate facilities for transporting the samples to Forensic Labs.
- Contaminations while handling & collection of Samples
- Access to technology within the time frame
- Shortage of instruments for all.
- Law enforcement officers of the case do not give due importance to collection of Soil while initiating the investigation a crime.

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