A Comparative Study of Environmental Subsoil Profile in Four Different Points at Four Different Depths in Kelantan Agricultural Land at Kota Bharu

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ABSTRACT: Soil is present on the outermost layer of the Earth's terrestrial landmass and playing a pivotal role in the functioning of the contemporary earth system. As soil particles can readily adhere to, and transfer from, items such as clothing, shoes, vehicles and tools, they have the potential to be used as trace evidence, potentially linking or eliminating suspects to and from a crime scene. The environmental soil density analysis has immense applications in various fields like agriculture, forensic science and so on. The research presented here a comparative study of subsoil profile in four different points in four different depths to determine whether the subsoil samples collected from a particular point differs in density with reference to the soil from a different point. Soil samples in an agricultural field, at Kampung Sireh Bawah Lembah, Kota Bharu were studied. So far no subsoil analysis study was conducted in agricultural land using density gradient tube technique. In each point, collected about 500g soil in 4 different depths viz. top soil, soil under ½ foot depth, 1 foot depth and 1½ feet depth. Density gradient tube technique was used in this research, in addition to visual and stereomicroscopic examination for soil comparison. The density gradient column was prepared using bromoform (d = 2.87 g/mL) and bromobenzene (d=1.49 g/mL). The finding of this research indicated discrimination in the soils collected in different points and depths even within the same plot of agriculture field.

Keywords: Environmental soil, subsoil profile, soil comparison, density gradient technique.

Introduction

Soil is present on the outermost layer of the Earth's terrestrial landmass and as such cover a large proportion of the planetary surface, playing a pivotal role in the functioning of the contemporary earth system (Ritz *et al.*, 2009). As soil particles can readily adhere to, and transfer from items such as clothing, shoes, vehicles and tools, they have the potential to be used as trace evidence, linking or eliminating suspects to and from a crime scene (Andrew *et al.*, 2009). The five main soil forming factors are parent material, climate, organism, topography, and time. The living organisms also gain a foothold to modify parent material lichens often form a pioneer community that traps small particles and chemically alters the underlying rock, causing further fragmentation (Enger and Smith, 2000). In forensic point of view, the value of environmental soil as evidence rests with its prevalence at crime scene and its transferability between the scene and the criminal (Saferstein, 2004). In fact, soil is a complex mixture with varying mineralogical, chemical, biological and physical properties (Marumo, 2003). Considering such complexity, a variety of methods has been developed such as examination of gross appearance, comparing the color and texture of the sample, spectrographic analysis, X-ray diffraction, differential thermal analysis, and others (Nickell and Fischer, 1999). The soil density are being used for many field applications such as in the agriculture field to study the growth of plants (Clifford Tafangenyash *et al.*, 2011), to predict saturated hydraulic conductivity (Rawls *et al.*, 1998) to study soil compaction (Lal, 1999) and application in forensic investigation to solve crimes (Petraco and Kubic, 2000). Soil varies in its chemical and physical properties from place to place, even within the same plot of ground (Siegel and Mirakovits, 2010). Studies have shown that soil profile may differ markedly within a few feet (Nataraja *et al.*, 2005) and meters (Siegel and Mirakovits, 2010) of each other horizontally and vertically.

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Objective

This research aimed to study the soil density of subsoil profile in an agricultural field, at Kampung Sireh Bawah Lembah, Kota Bharu in 4 different points [designated as S1 to S4] formed the corners of a square with an interdistance of 70 m, within the same plot of ground. At each point, four soil samples of each about 500 g were collected in different depths viz. top soil, soil under ½ foot depth, 1 foot depth and 1½ feet depth. The color of the soil, texture and presence of any foreign material present in the sample were observed and recorded. The density gradient tube technique was used (Petraco and Kubic, 2000, Dubley, 1979, Nataraja *et al.,* 2005).

Materials and methods

Soil samples collection

The soil samples were collected in an agricultural land situated at Kampung Sireh Bawah Lembah in Kota Bharu, about 15 kilometers from Universiti Sains Malaysia, Kubang Kerian. About 500 g of soil sample from each point and depths and thus a total of 16 soil samples were collected and preserved for analysis. The four points, which formed the corners of a square with an interdistance of 70 m were designated as S1 (first point), S2 (second point), S3 (third point), and S4 (forth point). In each point, four soil samples of each 500 g were collected viz. top soil (S1/1), soil under ½ foot depth (S1/2), 1 foot depth (S1/3) and 1½ feet depth (S1/4). Similar types of collections were made in other points also (**FIG. 1**).

Soil preparation

The soil samples were allowed to dry under sunlight for two days. About 100 grams of each soil samples were taken into a dish and heated in an oven at 100˚C for overnight to remove the moisture if any and then allowed the samples to cool to room temperature (**FIG. 2**). The samples were then passed through the sieves with 125 micron meshes. Then 1 gram of soil sample was weighed for density gradient analysis.

Density gradient column Preparation

A stock solution of bromoform and bromobenzene mixtures was prepared in a 250 mL volumetric flask as shown in **TABLE 1** and four identical graduated tubes of 50 cm length with 10 mm diameter were clamped vertically in glass tube stand.

The density gradient columns were prepared using the stock solutions. The column has seven layers with 6 mL each. The top layer is bromobenzene, a low density liquid (1.49 g/mL) and the bottom layer is high density liquid, bromoform (2.87 g/mL). In between these two layers have five layers of bromoform and bromobenzene mixture with varying densities. Thus the ratios of the two liquids in each layer are such that each successive layer has a lower density than the preceding one, from the bottom to the top of the tube.

The open ends of graduated tubes were sealed with parafilm and then covered with plasticine to prevent evaporation of the liquid mixture. The graduated tubes were allowed to stand for overnight for stabilization.

The density of the mixture was calculated using the following formula as used by Nataraja *et al*., 2005,

$$\text{Density of a mixture, DM} = \frac{[(D_{BB}V_{BB}) \times (D_{BF}V_{BF})]}{V_{BB} + V_{BF}}$$

where; D_{BB} = Density of bromobenzene, D_{BF}= Density of bromoform, V_{BB}= Volume of bromobenzene, and V_{BF}= Volume of bromoform

Density Gradient Analysis

After the stability of the column, 1 g of sieved soil sample was added gently into the graduated tubes. The graduated tubes were left for overnight to allow the distribution of soil particles in the gradient. The soil particles sank to the portion of the tube that has a density of equal value; the particles remain suspended in the liquid at this point. The distribution pattern of soil particles (Saferstein, 2004) have been obtained and recorded (**FIG. 3-6**). The temperature of the laboratory was maintained and recorded.

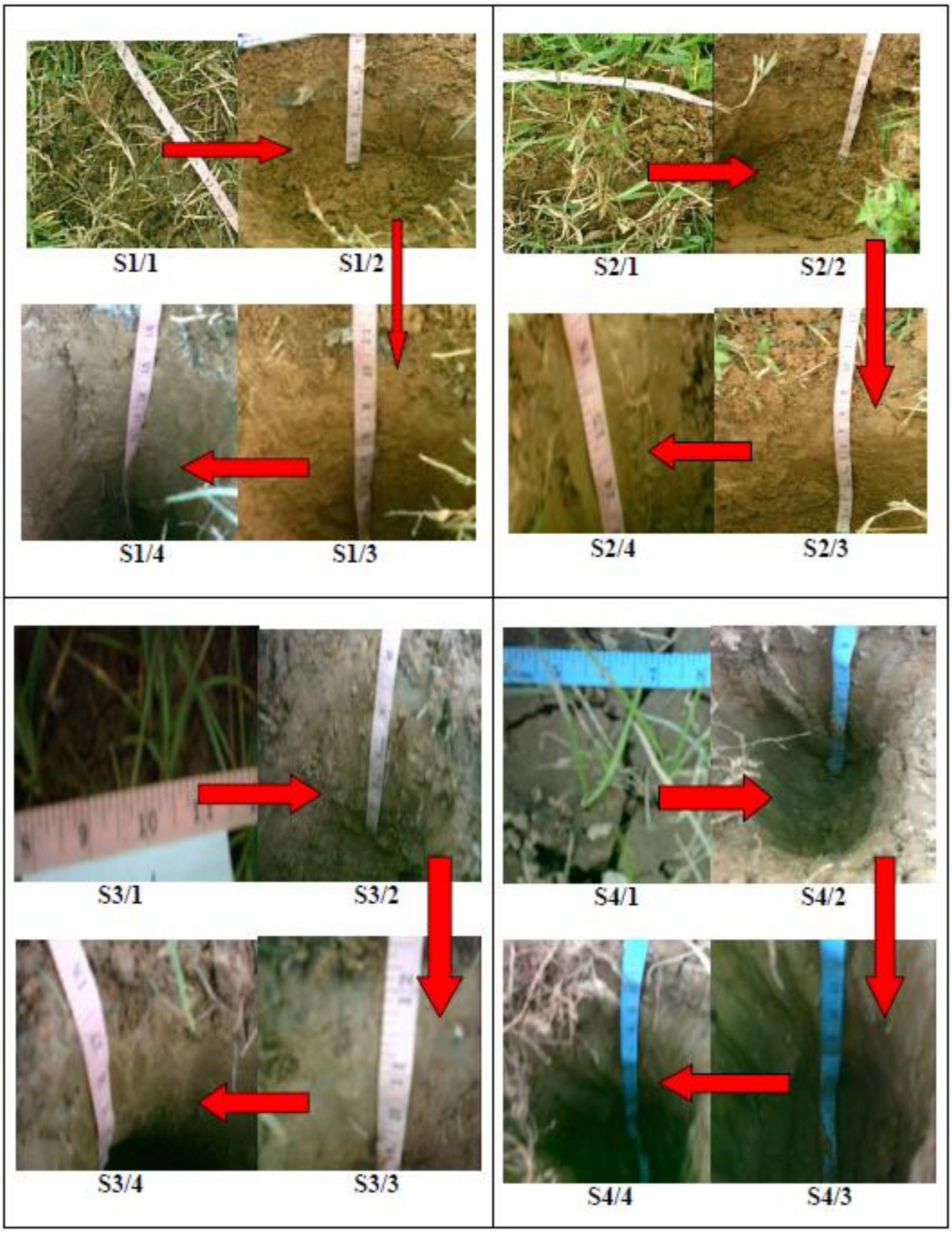

FIG. 1- Collection of soil samples in 4 different points and depths (clockwise from top left: S1, S2, S3 and S4)

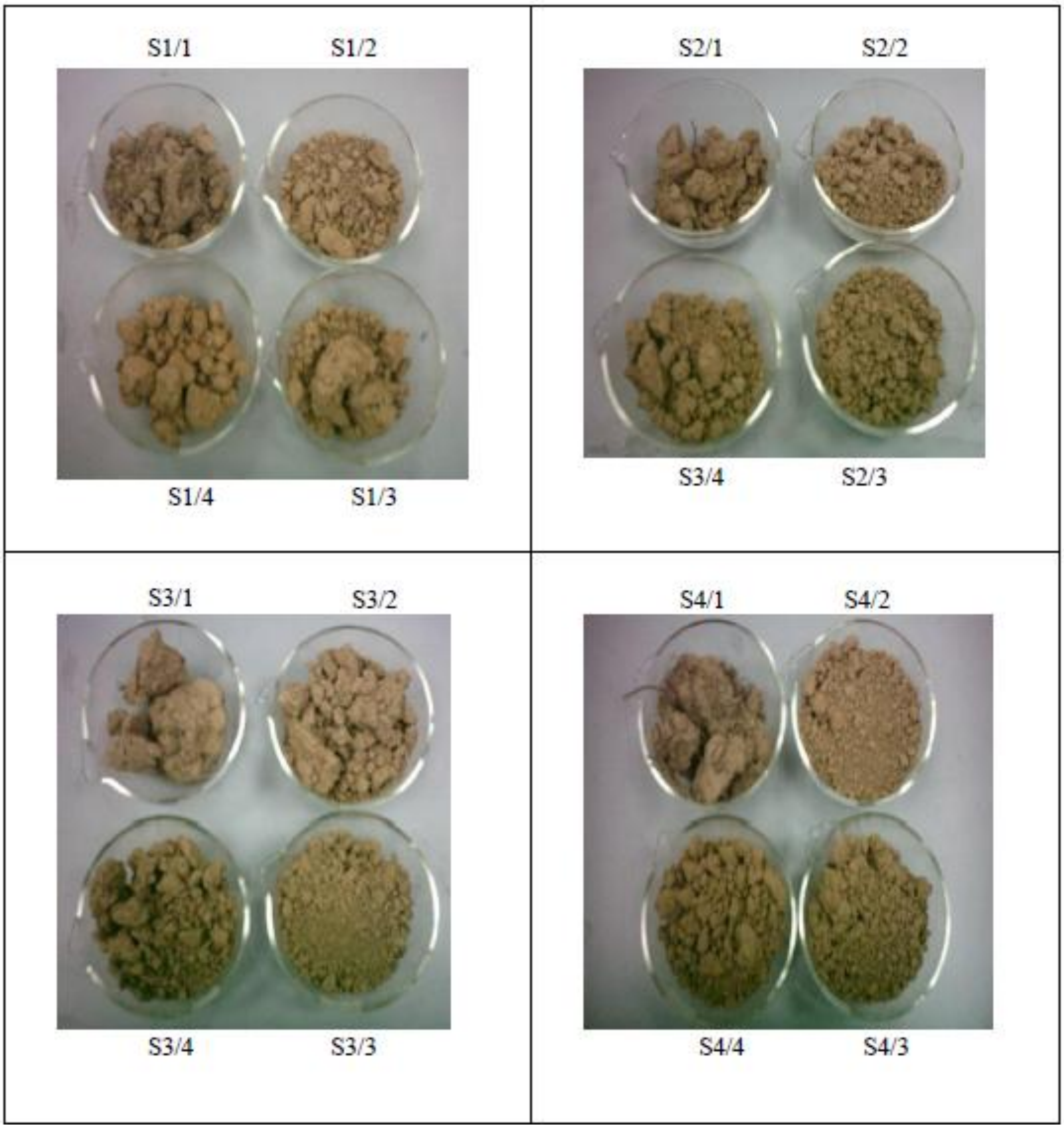

FIG. 2- Dried soil samples (clockwise from top left: soil sample marked S1, S2, S3 and S4)

TABLE 1- Bromobenzene and Bromoform Mixture Ratio in the Layers

Layer	Bromobenzene (1.49 g/mL)	Bromoform (2.87 g/mL)	Total volume of mixture of each layer (mL)	Density (g/mL)
(Top)	6	0	6	1.49
	5	1	6	1.72
	4	2	6	1.95
	3	3	6	2.18
	2	4	6	2.41
	1	5	6	2.64
(Bottom)	0	6	6	2.87
Total column volume			42	

Results

The visual and stereomicroscopic examination for the samples collected at the point S1 is as shown in **TABLE 2**. Similar observations were made for the samples collected at the points S2, S3 and S4 and recorded. Foreign materials like grass root fragments, dead leaves and paint flakes were also found in soil samples when examined through visual and stereomicroscope.

The density gradient analysis of top soil at point S1 with different depths and soil at point S3 in different depths showed variation in pattern. No two samples were found to have the similar distribution pattern of soil particles (**FIG. 3 and 4**). The density distribution pattern of soil samples collected in points S1 and S3 in different depth is as shown in **FIG. 3** and **4**.

Similar variations in density distribution pattern of soil particles were observed in the points S2 and S4 and recorded. Also soils samples collected at different points, S1 to S4 with similar depths viz. top soil samples and soil samples at 1 foot depth showed variations in density distribution pattern as shown in **FIG. 5** and **6**. Similar variation in density gradient pattern was observed in soil samples collected at the depth of ½ foot and 1½ feet depths and were recorded.

Blind test was conducted in order to verify these findings by collecting top soil samples in different points viz. C1 to C4 (known soil samples) and soil adhered in the bottom outsole in a shoe (J-questioned sample) that stepped on point C4. The color, texture, presence of foreign materials in the samples J and C4 including the density gradient pattern showed similarity and recorded this observations. The questioned soil sample J and known soil sample C4 showed similar density gradient pattern as shown in **FIG. 7** and **8**.

TABLE 2- Visual and stereomicroscopic examination of soil samples at point S1

Types of examination	Sample	Color	Texture	Foreign material
Visual examination	S1/1	wet: Dark brown dry : Light yellowish brown	Felt sticky and hard to squeeze. Became powder on application of force. So it is clay.	Presence of some fragment of grass roots. Presence leaf fragments Presence of a small red paint flake
	S1/2	wet: Dark yellowish brown dry: Yellowish brown	Clay soil.	Presence of grass root fragments Presence of dead leaves fragments.
	S1/3	wet: Brownish dry: Yellowish	Clay soil.	No foreign material present
	S1/4	wet: Brownish dry: Yellowish	Clay soil	No foreign material present
Stereomicroscopic examination	S1/1	Color ranges from light yellowish brown, dark brown, to orange	Clay soil.	Presence of grass hair root fragments Presence of pieces of black dead leaves Small blue paint flake present
	S1/2	Color range from yellowish brown, light brown, to dark brown Some soil has lustrous appearance	Clay soil.	Presence of grass root fragments
	S1/3	Yellowish to black lustrous appearance	Clay soil.	Presence of plant root pieces. black vegetations
	S1/4	Yellowish to dark brown.	Clay soil.	No foreign material present

S1/1 S1/2 S1/3 S1/4

FIG. 3- Density gradient pattern of soil collected at point S1

S3/1 S3/2 S3/3 S3/4

FIG. 4- Density gradient pattern of soil collected at point S3

S1/1 S2/1 S3/1 S4/1

FIG. 5- Density gradient patterns of top soil samples

S1/3 S2/3 S3/3 S4/3

FIG. 6- Density gradient patterns of soil sample under 1 foot depth

FIG. 7- Density gradient patterns obtained from different top samples and from shoe J

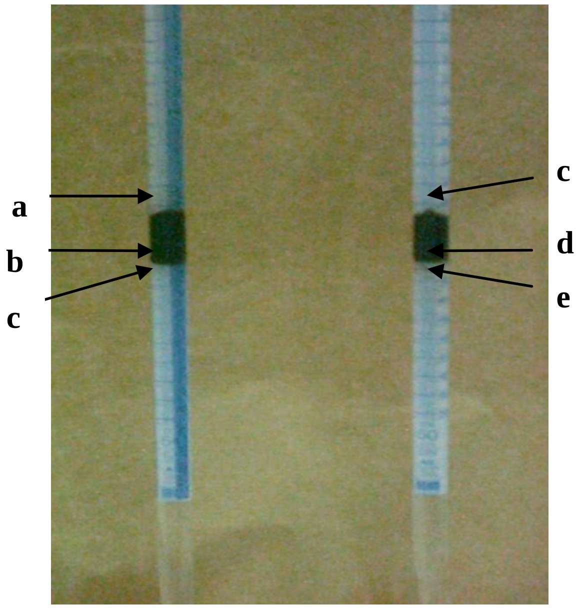

FIG. 8- Known sample (C4) and questioned sample (J) have the same density distribution pattern of soil.

Discussion

The colour of soil is resulted from the presence of various organic matter and coloring agents present in soil. The soil color when wet and dry were observed carefully using munsell chart and recorded. The wet soil is darker than the dry. Agricultural sub soil contains moisture and hence it appeared dark. On physical observation of the land, the claylike color and texture of the soil appeared same throughout that agricultural land. But after drying, sieving, examining of soil samples through the stereomicroscope and subsequent density gradient tube technique analysis showed difference in colors and variation in density distribution pattern. The density gradient tube technique indicated discrimination in the soils collected in the agriculture field, Kota Bharu.

Conclusion

Even though the agricultural land appeared same color and same clay type, examination of soil samples by color, presence of foreign material and by density gradient tube technique showed discrimination of soil even within the same plot of ground. The density gradient tube technique is a simple, easy and inexpensive technique for environmental soil analysis and can be applied for forensic science investigation to link the crime and criminal.

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