Research Article

Comparative Soil Analysis from Different Crime Prone Areas of Kottayam and Kollam Districts of Kerala for Forensic Characterization

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Abstract

Soil is the loose surface material that covers land on which plants grow. It consists of a mixture of organic remains, clay, and rock particles, which gives it its uniqueness from place to place. Because of the uniqueness of soil, it has a high evidential value in the field of forensic science. In the present study, research has been conducted to check the range of variations in the soil collected from different crime-prone areas of Kottayam and Kollam districts of Kerala by physical, chemical, microscopic, and instrumental examination. In physical examination, soil colour, texture, consistency, and density were measured, and in chemical examination, pH and total soluble sulphate of the soil were measured. In instrumental examination, Heavy metal analysis was done by using Atomic Absorption Spectrometry (AAS), which helps to measure the amount of trace elements present in the soil. The study found that each soil has some significant variations that make it unique. In the field of forensic science, this can be highly helpful in determining the origin of soil by examining its colour, texture, structure, content, etc.

Keywords: Soil comparison, Physical, Chemical, Microscopical, Atomic Absorption Spectrometry (AAS)

Introduction

Soil is one of the most important resource of the nature. Soil can be found in all major environments on earth and it covers the surface of the planet. It is the fine earth which covers land surfaces as a result of the *insitu* weathering of rock material or accumulation of mineral matter transported by water, wind, ice.[8] Soil is formed as a result of weathering, which involves the breakdown of rocks and boulders into smaller pieces by erosive forces. It is a complex mix with a range of mineralogical, chemical, biological, and physical characteristics. Therefore, soil varies from place to place, has unique features, and so tells a lot about the geography of a region. In this way, soil acts as significant physical evidence that can yield vital information after being subjected to a chemical, physical, and biological analysis, making it relevant and trustworthy evidence in the field of forensic science.

Pedology is the scientific discipline of soil science, which examines all characteristics of soils, including their physical and chemical characteristics, the function of organisms in the production of soil and in relation to soil characteristics, the description and mapping of soil units, and the origin and formation of soils.

Chemical and physical changes lead to the formation of soil sediments, which cause differences

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in soil that vary from place to place. Because of the uniqueness of soil, it can be used to connect the crime scene, the victim, and the suspect and gather vital information about the type of ground surface there.

Soil is a common form of physical evidence, which are found at scene of crimes such as automobile accidents, hit and run cases, decoity, bulgury, theft, etc. Soil specimens can be obtained from shoes, shirts, pants, fingerring, watches, tool, tyres, etc., which can be easily collected, seperated and analysed. Soil is nearly invisible and suspects may be less aware of importance of soil in connecting crime scene, suspect and victim and it can be easily collected, seperated and analysed. In this way, soil serves as an ideal trace evidence which is highly individualistic with high probability of transfer and retension and can be easily collected, separatde and analysed.[2]

In accordance with the Locard exchange principle, when two things come into contact, physical components can be exchanged. This exchange could take the form of soil moving from one place to another.Soil can be used as an identification marker due to its unique features or characteristics.[10]

In forensic science, the examination of soil samples using various scientific techniques helps to resolve or support criminal investigations. A significant component of many forensic investigations is soil analysis. Comparing soils has relevance as evidence because of their extensive distribution, extremely variable composition, relative ease of transmission, permanence, and resistance to deterioration.

Comparative analysis of traces and micro-traces, which comprises a number of morphological and analytical tests, is particularly crucial in the field of forensics for figuring out the circumstances surrounding crimes. With the evolution of potent and effective technology, forensic examinations of soil has improved and it may now be carried out at the lowest scales of dimensions, with more sensitivity, and with vastly differentiating intervals. Moreover, it is feasible to find unexpected or previously inaccessible samples.

In the present study, by comparing the soil samples from different crime-prone areas of Kottayam and Kollam districts of Kerala and analysing their components or characteristics by classic and successful soil analysis methods from the point of view of forensic science. This experiment is carried out to investigate the soil samples from Kottayam and Kollam districts of Kerala. The reason this experiment was chosen was to see the difference in heavy metal concentration in each of the soil samples by AAS and study the differences found in each of the soil samples. This experiment allows us to compare the texture, size, colour, density, pH, and heavy concentration of soil samples from two districts in the same state (Kerala).

Materials and Methods

Kottayam is a city in the Indian state of Kerala. It is situated in the centre of Kerala and serves as the district of Kottayam's administrative centre. In the Kottayam district, alluvial and laterite soil types are most abundant. Another district, Kollam is located in the southern part of Kerala, 70 kilometres north of Thiruvananthapuram, the state's capital. The district experiences five main types of soil- Lateritic soils, Brown Hydromorphic soils, Greyish Onattukara soils, Riverine and Coastal Alluvium, and Forest Loam.

Materials required

Waterproof marking pen, Beakers(250ml, 500ml), Droppers, Measuring cylinder(10ml,500ml,1000ml), Glass rod, Burette, Conical flask, Density gradient column, Whatmann filter paper, Sieve, Munsell colour chart.

Distilled water**,** Hydrogen peroxide 30% (SRL Pvt. Ltd)**;** Buffer Solution of pH 7.0**;** Sodium hexametaphosphate, Extra pure, 65-70% (SRL Pvt. Ltd); Bromo form, Special Grade, 98% (Loba Cheme Pvt. Ltd); Bromobenzene Extra pure, 99% (Loba Cheme Pvt. Ltd); Phenolphthalein, 99% (Rankem); Sodium hydroxide, extra pure, 30% (SRL Pvt. Ltd);Ethyl alcohol 99.9%; Rhodizonate reagent 98.9% (Central Drug House Pvt. Ltd);Barium chloride 99% (SRL Pvt. Ltd); Silver nitrate, 99% (Loba Cheme Pvt. Ltd);Hydrochloric Acid extra pure 35% (Loba Cheme Pvt. Ltd) andNitric Acid 65% (Emsure) were used for sample preparation and analytical purposes.

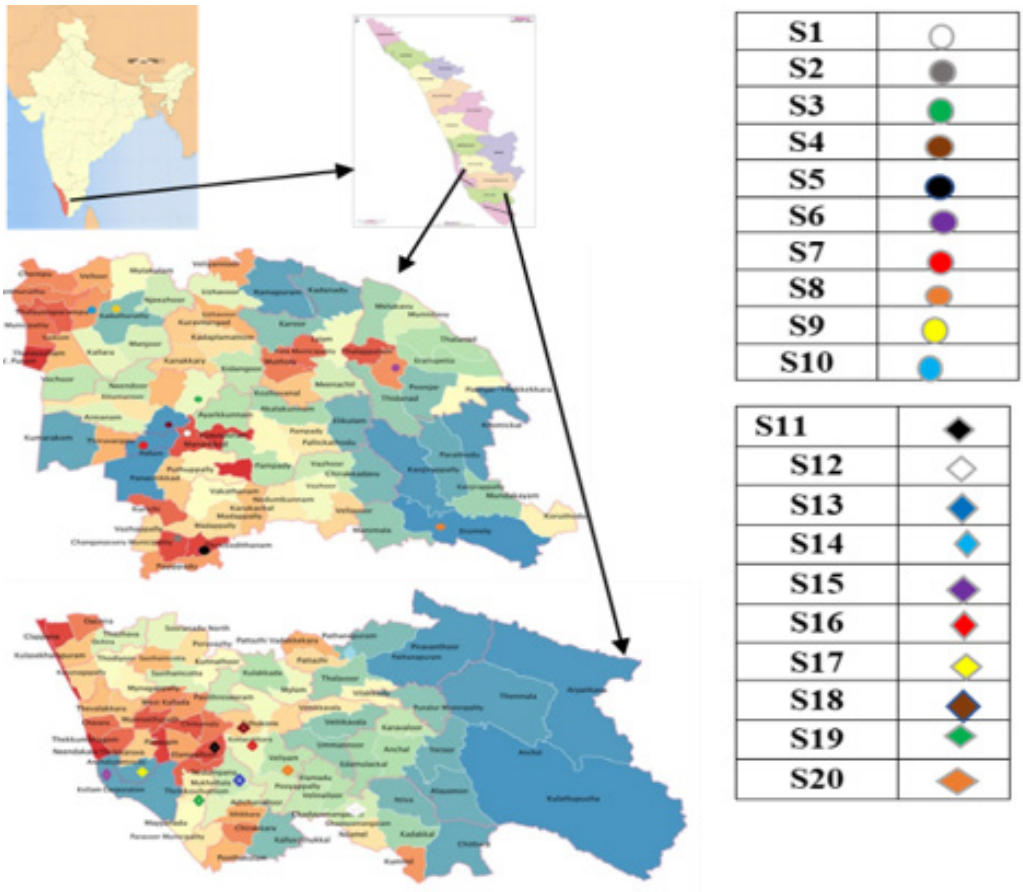
Atomic Absorption Spectrometer (Model no. AA240), Digital pH meter, Bouyoucos Hydrometer were used for analysis purpose.

Soil Sample collection

Total 20 samples were collected from 10 crime prone areas of each Kottayam and Kollam districts of Kerala. Collection was done with the help of spade and 5 samples (4 samples from the 4 corners and one from the centre) were collected from each selected site. Then quadrant method was followed for the collected samples. The samples were then packed in plastic zip-bags and were labelled accordingly.

Table 1: List of samples collected from both districts

KOTTAYAM		KOLLAM	
SAMPLE NO	**NAME OF AREA**	**SAMPLE NO**	**NAME OF AREA**
S1	Manarcadu	S11	Kundara
S2	Changanassery	S12	Chadayamangalam
S3	Ettumanoor	S13	Kilikollur
S4	Gandhinagar	S14	Pathanapuram
S5	Thrikodithanam	S15	Sakthikulamgara
S6	Erattupetta	S16	Kottarakara
S7	Kottayam west(kodimatha)	S17	Anchalummoodu
S8	Erumely	S18	Ezhukone
S9	Kaduthuruthy	S19	Kottiyam
S10	Thalayolaparambu	S20	Pooyapally



(Source: www.mapsofindia.com)(Source: www.ecostat.kerala.gov.in)

Fig 1: Geographical map of Study area

Sample Preparation

Each soil sample was air dried under shade to remove moisture. Then the samples were sieved using 2mm sieve to remove unwanted materials like roots, large stones, leaves, etc. Sieved samples were stored in plastic zip-bags and labelled accordingly.

Sample Analysis

Different methods were used for the analysis of the soil samples. In physical examination, soil colour determination was done by referring and comparing the colour of samples, both in dry and wet conditions, with the Munsell colour chart.[11] Soil texture represents the proportion of sand, slit and clay in the soil which was determined by Bouyoucos Hydrometer.[1] Wet soil samples were taken for measuring soil consistency through physically touching and feeling the soil grains; and the density gradient method was used for measuring the density of the soil.[7] In chemical examination, soil pH was determined with the help of Digital pH meter[9]and total soluble sulphate in soil was determined by titration method.[3]

In instrumental examination, Atomic Absorption Spectrometer (AAS) (Model no. AA240) was used for the heavy metal analysis of the soil samples. To digest the soil samples, 1g of soil was mixed with diacid (HCl: HNO3) in a 3:1 ratio by addition of 10 ml of the solution to each sample, and then the mixture was placed on a hot plate to digest until the digestion was complete or the soil was completely burned. After digestion, 100 ml of DDW was added to each beaker and the mixture was filtered using Whatmann No. 1 filter paper. After filteration, 5 ml of aliquot was poured 25 ml volumetric flask and diluted with double distilled water. An atomic absorption spectrophotometer was used to determine the concentrations of Mg, Cu, Fe, and Zn in the sample solution.[5]

All the data was compiled and entered in a Microsoft Excel worksheet, and the measurements were tabulated and statistical analysis was carried out using a t-test for two dependent means with a two-tailed hypothesis and a significance level of 0.05 to check for variation in the soil samples collected from districts of Kollam and Kottayam.

Results

The present study was carried out with an objective of comparative study of soil samples collected from each 10 crime prone areas of Kottayam and Kollam districts of Kerala by physical, chemical, microscopical and instrumental examination. There are five parameters that are statistically significant (density, pH, concentration of Mg, Cu and Zn) because their P value is less than 0.05. There are two parameters that are not statistically significant (Total soluble sulphate, concentration of Fe).

Table 1: Physical Examination of soil samples from Kottayam

KOTTAYAM						
Samples	Soil Colour		Soil Texture	Soil Consistency		Density
	Dry	Wet		Stickiness	Plasticity	
S_1	Yellowish Red	Dark Reddish Brown	Sandy Clay Loam	Slightly Stickiness	Slightly Plastic	1.778
S_2	Yellowish Red	Dark Red	Sandy Clay Loam	Slightly Stickiness	Slightly Plastic	1.778
S_3	Reddish Brown	Brown	Sandy Clay Loam	Slightly Stickiness	Slightly Plastic	1.778
S_4	Dark Brown	Dark Brown	Sandy Clay Loam	Non- Sticky	Non- plastic	1.778
S_5	Strong Brown	Strong Brown	Sandy Clay Loam	Slightly Stickiness	Slightly Plastic	1.778
S_6	Brown	Dark Brown	Sandy Clay Loam	Slightly Stickiness	Slightly Plastic	1.778
S_7	Dark Reddish Brown	Dark Reddish Brown	Sandy Clay Loam	Slightly Stickiness	Slightly Plastic	1.778
S_8	Brown	Dark Brown	Sandy Clay Loam	Slightly Stickiness	Slightly Plastic	1.778
S_9	Reddish Brown	Dark Reddish Brown	Sandy Clay Loam	Slightly Stickiness	Slightly Plastic	2.334
S_{10}	Reddish Brown	Yellowish Red	Sandy Clay Loam	Slightly Stickiness	Slightly Plastic	1.778

Table 2: Physical Examination of soil samples from Kollam

KOLLAM						
Samples	Soil Colour		Soil Texture	Soil Consistency		Density
	Dry	Wet		Stickiness	Plasticity	
S_{11}	Reddish Brown	Dark Reddish Brown	Sandy Clay Loam	Slightly Stickiness	Slightly Plastic	2.612
S_{12}	Dark Reddish Brown	Yellowish Red	Sandy Clay Loam	Slightly Stickiness	Slightly Plastic	1.778
S_{13}	Dark Reddish Brown	Dark Reddish Brown	Sandy Clay Loam	Slightly Stickiness	Slightly Plastic	1.778
S_{14}	Reddish Brown	Yellowish Red	Sandy Clay Loam	Slightly Stickiness	Slightly Plastic	2.473
S_{15}	Reddish Brown	Dark Reddish Brown	Sandy Clay Loam	Non- Sticky	Slightly Plastic	1.778
S_{16}	Yellowish Red	Yellowish Red	Sandy Clay Loam	Slightly Stickiness	Slightly Plastic	2.473
S_{17}	Dark Reddish Brown	Dark Reddish Brown	Sandy Clay Loam	Non- Sticky	Slightly Plastic	2.612
S_{18}	Reddish Brown	Dark Reddish Brown	Sandy Clay Loam	Slightly Stickiness	Slightly Plastic	2.612
S_{19}	Reddish Brown	Dark Reddish Brown	Sandy Clay Loam	Slightly Stickiness	Slightly Plastic	2.612
S_{20}	Strong Brown	Strong Brown	Sandy Clay Loam	Slightly Stickiness	Slightly Plastic	2.473

Table 3: Assessment of Chemical Examination

KOTTAYAM			KOLLAM		
SAMPLES	pH	Total Soluble Suphate	SAMPLES	pH	Total Soluble Suphate
S_1	4.86	0.09168	S_1	5.68	0.09696
S_2	5.31	0.09888	S_2	5.98	0.09072
S_3	5.61	0.10896	S_3	6.35	0.1032
S_4	5.9	0.10416	S_4	6.21	0.08832
S_5	6.27	0.09168	S_5	6	0.09168
S_6	5.16	0.08928	S_6	6.05	0.10704
S_7	5.94	0.11088	S_7	5.6	0.09648
S_8	5.96	0.09456	S_8	6.24	0.10224
S_9	5.56	0.10176	S_9	5.85	0.09696
S_{10}	5.54	0.09984	S_{10}	5.82	0.09264

Table 4: Heavy metal concentration in soil samples of both districts

KOTTAYAM					KOLLAM				
Sample	Mg	Cu	Fe	Zn	Sample	Mg	Cu	Fe	Zn
S_1	101.76	3.9	36.14	3.84	S_{11}	102.69	2.8	64.6	48.2
S_2	79.8	1.93	29.04	7.66	S_{12}	65.98	1.2	39.57	4.79
S_3	94.89	3.23	20.91	9.28	S_{13}	43.03	4.26	180.25	38.53
S_4	103.86	6.7	128.6	12.61	S_{14}	53	2.83	113.41	10.3
S_5	81.96	1.07	47.15	3.2	S_{15}	9.66	3.08	205.75	28.52

Continue.....

S_6	98.79	5	23.46	2.14	S_{16}	43.61	2.54	34.78	50.6
S_7	96.21	6.83	222.25	30.29	S_{17}	55.78	3.04	28.17	29.59
S_8	80.48	7.45	166.5	46.61	S_{18}	18.23	3.32	168	31.92
S_9	166.23	11.5	56.97	6.07	S_{19}	57.18	4.73	27.66	12.17
S_{10}	152.28	4.55	127.55	10.47	S_{20}	79.74	3.76	28.14	48.65

Table 5: Result of differences between Kottayam and Kollam soil samples

Parameters	Mean	μ	S^2	S^2M	SM	t	P
Density	0.49	0	0.14	0.01	0.12	4.13	0.00254
Ph	0.37	0	0.18	0.02	0.13	2.72	0.02364
Total soluble sulphate	0	0	0	0	0	-0.774	0.45837
Concentration of Mg	-52.74	0	954.77	95.48	9.77	-5.4	0.00043
Concentration of Cu	-2.06	0	7.03	0.7	0.84	-2.46	0.03639
Concentration of Fe	3.18	0	11125.9	1112.59	33.36	0.1	0.92623
Concentration of Zn	17.11	0	512.23	51.22	7.16	2.39	0.04051

In the physical examination, soil colour, texture, consistency, and density were analysed, which are the most important distinguishable characteristics of soil during the preliminary examination of a forensic investigation. In Kottayam and Kollam district, soil colour in dry condition and dry condition varies from Yellowish Red, Reddish Brown and Brown. The presence of numerous organic matters and colouring compounds in soil gives soil it's colour. The wet soil is darker than the dry soil. Agricultural sub soil contains moisture and hence it appeared dark.[4] The texture of the soil collected from all the sites was found to be sandy clay loam in nature, in which the sand, silt and clay percentage of soil from Kottayam district varied from 68.177 - 71.16 sand, 4.82 -7.81 silt and 22.9 - 24.024 clay and the sand, silt and clay percentage of soil from Kollam district varied from 68.86 - 71.193 sand, 4.78 - 7.1 silt and 24 - 24.041 clay, respectively. Soil consistency depends on texture, organic matter content, and the amount of clay in the soil. In Kottayam, soil consistency (wet condition) was mostly found to be slightly sticky and slightly plastic, whereas in Kollam district, all the samples were found to be slightly sticky, non-sticky, and slightly plastic. The density gradient column is the most commonly used method for soil comparison. It was observed that the density of soil from Kottayam is 1.778 g/cm^3, except for sample S_9 (Kaduthuruthy), which has 2.334 g/cm^3. In Kollam, the density ranges from 1.778 g/cm^3 to 2.612 g/cm^3, with the highest density found in 4 places (S11, S17, S18, and S19) due to different size particles than in other samples.

The pH value of soil from Kottayam district ranged from 6.27 to 4.86, which is from slightly acidic to very strongly acidic, and that of Kollam ranged from 6.35 to 5.6, which is from slightly acidic to strongly acidic. All the soil samples were observed to be acidic, which might be due to heavy rainfall, which leads to continuous removal of basic cations by leaching and high use of chemical fertilisers.[12]In the soil samples from Kottayam, the concentration of soluble sulphate in S_7 (0.11088) from is higher because Kodimatha is an area where there is a large amount of pollution from industries and vehicles, and the lowest concentration is in S6 (0.08928) from Erumely, whereas in Kollam, the concentration of soluble sulphate in the sample from S_{16} (0.10704) is higher, while in S_{14} (0.0864) has the lowest concentration, which indicates that in the region of S_{16} there must be anthropogenic activities in the soil

In Kottayam district, the higher concentration of Mg in S9 (Kaduthuruthy) is maybe due to the high occurrence of parent material and presence of minerals in soil or due to amount the rainfall, while Cu in S9 (Kaduthuruthy) was observed to be high which may be due to the high use of fertilisers, organic matter. In S8 (Erumely) have higher concentration of Zn and S7(Kodimatha) have higher concentration of Fe possibly because of industrial waste, fertilisers, organic matter, whereas in Kollam the higher concentration of Mg in S11 (Kundra) maybe due to presence of minerals in soil, while Cu in S19 (Kottiyam) may be due to natural processes like weathering and human activities, Fe in S15 (Sakthikulangara) may be due to human activities like industrial processes, Zn in S16 (Kottarakara) were observed to be high maybe due to the high use of fertilisers, industrial waste may result to pollution.[6]The amount of trace elements present in soil samples from Kottayam was in the following order: Mg > Fe > Zn> Cu, while that of soil from Kollam was in the following order: Fe >Mg > Zn > Cu. In forensic science, testing soil for heavy metals gives each soil its own unique imprint.

In statistical analysis it is found that five parameter like density, pH, concentration of Mg, Cu and Zn because the p value is less than 0.05) are statistically significant and 2 parameter Total soluble sulphate, Concentration Fe are not statistically significant because p value is greater than 0.05. The results obtained from the above methods reveal that there were significant variations in some parameters like density, pH, concentration of Mg, Cu and Zn and soil samples from both the districts show differences in soil colour and consistency. This uniqueness in soil will help forensic investigators to determine the origin of soil samples found at a crime scene and potentially link the soil to a particular location.

Conclusion

The present study focused on identifying any distinguishable differences in the soils of Kollam and Kottayam districts of Kerala state which could be used in forensic investigations. From this study, it is concluded that soil samples from both districts have the same soil texture with different proportions of sand, silt, and clay, and the granular structure observed for all the soil samples and it showed variation in soil colour and consistency. The more differences in both soil samples were measured by seven parameters, of which five are statistically significant (density, pH, Concentration of Mg, Cu and Zn) as their p value is less than 0.05. So it can be concluded that we can compare the soil samples from both districts using five methods that show statistical significance along with soil colour and consistency. These characteristics of soil, which individualise the soil from one place to another, make soil an important form of forensic evidence. This can be very useful in the field of forensic science to identify the origin of soil samples found at a crime scene by analysing their colour, texture, structure, composition, etc.

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