A Research Article

Soil Analysis from Crime-Prone Areas of Sultanpur City for Forensic Aspect: A Research

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Abstract

The soil is a crucial resource in many criminal trials and the same has received a recent research approach in recent years, with numerous groups researching with objectives that allow for improved differentiation of soil profiles. This investigation was conducted in 2022-2023 with the objective of assessment of soil characterization from several areas in Sultanpur City, Uttar Pradesh. The primary goal of this study was to conduct a quantitative analysis of the samples using physical, chemical, microscopic and instrumental examination techniques. The soil samples were collected from a depth of 0-15 cm and after analysing the samples, it was found that the colour of the soil varies according to its composition. Soil features like texture, stickiness, plasticity, density, pH, and percentage of soluble sulphate were examined using different physical and chemical tests. Soil texture was classified under the sandy clay loam category and stickiness and plasticity were measured to be less, medium or more. The soil density ranged from 1.794 g/cm3 to 2.479 g/cm^3. The pH of the soil samples was overall acidic, ranging from 6.27 - 7.77. The percentage of soluble sulphate in soil varied from 0.11184 - 0.0864.A stereo microscope was used to observe the granular and prismatic structures of soil samples. Atomic Absorption Spectrometry (AAS) was used for quantitative analysis of soil samples to measure the amount of trace elements present in the soil. The study results showed that each soil sample varied from another and the parameters used for soil profiling helped in the differentiation of these soil samples. The results from this study can be helpful in preparing soil which can further assist the forensic scientists in their investigations related to soil as evidence.

Keywords: Soil, Physico-Chemical Properties, Heavy Metal, Atomic Absorption Spectrometry (AAS), Forensic Science.

Introduction

A subfield of forensic science called forensic paedology is used to examine the soil for forensic purposes. Generally, the soils samples encountered in forensic casework are composed of mineral grains and fragments of vegetable matter. Along with color, the identification and relative quantity of each mineral species present in a soil exemplar has been a subject of interest in the forensic literature[8]. Various methods of soil evaluation have been described in the literature. In the current study, an effort has been made to physically examine soil gathered using various scientific techniques to resolve or support criminological inquiries. Due to its distinctive qualities or attributes, it can be used as a marker for identification. The primary goal of this paper is to

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provide an overview of forensic soil identification. Several qualitative and quantitative investigations are conducted from a forensic science standpoint to guide the inquiry. Microscopic techniques using different magnifications, for particle visualization using a stereo-microscope. Several traditional procedures for soil analysis are used, including sample colour identification, Ph measurement, soil consistency and texture, density gradient technique measurement, soluble sulphate analysis, and atomic absorption spectroscopy. However, the transition from traditional soil science and pedology to forensic soil science is not simple and necessitates a thorough knowledge of crime scene procedures, forensic workers' evidential needs, and the types of legal restrictions that govern forensic work.

Examination of the soil samples follows from sampling to interpretation of the results. During the analysis, there must be a preference for constructive methods first then destructive methods. There are physical, chemical and instrumental methods for the analysis of the integrity of soil samples. In the laboratory, the analysis of soil samples is followed by a preliminary examination in which microscopic examination, soil colour, soil pH, density gradient and soil texture and consistency by following the chemical examination and then instrumental examination. Soils may become contaminated by the accumulation of heavy metals and metalloids through emission from the rapidly expanding industrial areas, mine tailings, disposal of high metal wastes, leaded gasoline and paints, land application of fertilizers, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, spillage of petrochemicals, and atmospheric deposition[6].

Soil as an Evidence.

Locard' sex change principle states that "when two surfaces come in physical contact the reisa mutual exchange of trace evidence between them". Exchange of soilisa common thing at crime scenes[7]. Police, crime scene investigators, and forensic personnel regularly spot soil materials on the surfaces of items like shoes and clothing used as evidence. Such soil proof must first be acknowledged on all likely investigation-related items. The soil evidence must also be properly recorded. In order to preserve the integrity of the soil evidence, careful soil samples must be collected and stored, and this must be done before the soil is characterized, mainly in the lab.

Material and Method

Study Area: Sultanpur district lies between 81°32' to 82°41' E and 25°59' to 26°40' N in eastern Uttar Pradesh and covers about 4.4 lakh hectare area with a mean annual temperature of 25°C and mean annual rainfall of 1025 mm representing old and recent flood plain of Gomati River with elevation ranging from 95 to 111 m above MSL[3].

Table 1: Sample description collected from different locations

SAMPLES	LOCATIONS	COORDINATES
A	Sitakund	26.2595° N, 82.0738° E
B	Paryawaran Park	26.2682° N, 82.0820° E
C	Karaundia	26.2547° N, 82.2814° E
D	Amahat	26.2537° N, 82.0475° E
E	Police line	26.2680° N, 82.0682° E
F	Stadium	26.264776° N, 82.072708° E.
G	Fireman's colony	26.2637° N, 82.0749° E
H	KNI Kasba	26.2805° N, 82.0816° E
I	KNIPSS Haripur	26.2892° N, 82.0808° E
J	GIC Field	26.2660° N, 82.0650° E

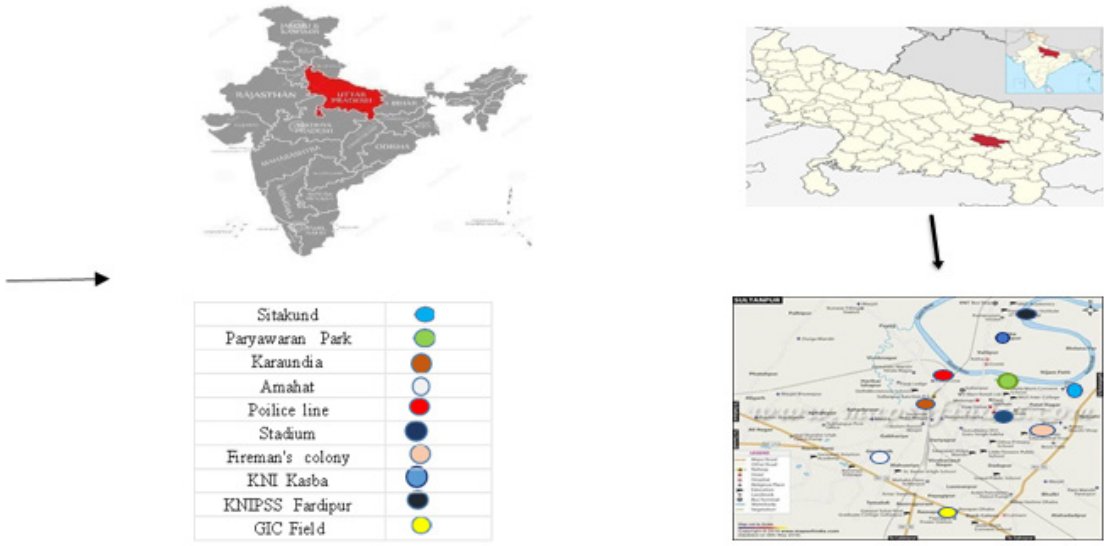

Fig 1: Show the legend with the located regions

Collection and Sampling of the Soil Sample

To prevent sample contamination, adequate collection, packaging, and preservation are crucial. Soil examination can provide useful forensic information about the spatial location and suspect's activities[2]. The soil samples were collected from 10 different places from Sultanpur City and the soil samples were collected with the help of spade separately and kept in plastic bags with appropriate labelling. Collect samples up to a depth of 0-15cm using suitable tools and soil collected from all four corners by following the centre from an area. Mix together the soil collected from all the spots within one area by hand and reduce the bulk to about 500gm.Each soil sample was air dried under shade to remove moisture. Then sieved the soil samples using a 2mm sieve to clear away unwanted materials like roots, large stones, leaves, etc.

Methodology

The work was carried out in "Sam Higgin bottom University of Agriculture Technology and Sciences", SHUATS, Prayagraj, U.P(2023). Analysis of soil sample were under the physical parameter including soil colour, density gradient, soil consistency and texture whereas chemical parameter included pH and soluble sulphate in soil. Soil colour was determined by using a Munsell colour chart (Albert H. Munsell, 1954)[9]. The colour of the soil can differ from one soil to the other. This depends on the amount of organic matter, the oxidation degree, and drainage conditions. The colour of the soil can be due to the various iron minerals found in the soil[4] & also due to the color of rocks from which these are made, due to pollutants and so on[10]. The texture of the soil was determined by using the Bouyoucos Hydrometer& because of these important roles, soil texture is considered a master soil variable Consistency with the feel method. The density gradient was determined by the column method, prepared by the bromoform and bromobenzene ratio. pH was estimated with the help of a digital pH meter after making 1:2 soil water suspension (Jackson, 1958)[1]. Percent of soluble sulphate in the soil sample was estimated by titration. 3-D estimation of the structure of soil sample by using a stereo-microscope.

The availability of trace metals Mg, Cu, Fe and Zn in soil samples using AAS (model no. AA240).

- Digestion of sample: To digest the soil samples, combine 1g of soil with diacid (HCl: HNO3) in a 3:1 solution by adding 10-10 ml of the solution, and then put the mixture on a hot plate to digest until the digestion is complete or the soil is fully burned. After digestion, add 100 cc of DDW to each beaker and filter the mixture carefully with What man No. 1 filter paper. After filtering, dilute 5 mL of an aliquot in a 25 mL volumetric beaker with DDW.
- Analysis of soil samples: AAS AA240 model used in determining the content of heavy metals in the previously digested soil samples.

Result and Discussion

Physical Properties

The physical inspection was performed using soil colour, texture, consistency, and density gradient. In which colour of the soil (dry condition) was observed as pale brown and it can be seen as a result of soil materials. Iron found within the soil develops a rusty colour. Thesoil colour (wet condition) of the soil was observed as dark yellowish brown because Iron oxides and humic substances make the soil darker[5]. The density gradient column is the most traditional method used for soil comparison so it was observed that the density gradient lies between 1.794 g/cm3 to 2.479 g/cm3 and the highest density was found in Sita kund (2.479 g/cm3) which is due to different size particles the density is high as compared to other samples. The texture of the soil samples was Sandy clay loam but the relative proportion of soil separates (sand, silt and clay) in a particular soil makes it unique. Soil consistency (wet condition) was found sticky. Changes in soil consistency are useful surrogate measures for the identification of restrictive layers. Plasticity (wet condition) was shown as slightly plastic, indicating the fineness of soil, and non-plastic basically indicates the confined property of soil.

Table 2: Physical Parameters of Soil

	PHYSICAL PROPERTIES					
SAMPLES	DENSITY GRADIENT	TEXTURE	CONSISTENCY		SOIL COLOUR	
			Stickiness	Plasticity	Dry Condition	Wet Condition
A	2.479	Sandy Clay Loam	Slightly sticky	Slightly plastic	10 YR 6/3(Pale Brown)	10 YR 3/3(Dark Brown)
B	1.794	Sandy Clay Loam	Non- sticky	Slightly plastic	10 YR 6/4(Light Yellowish Brown)	10 YR 3/3(Dark Brown)
C	1.794	Sandy Clay Loam	Slightly sticky	Slightly plastic	10 YR 5/4(Yellowish Brown)	10 YR 4/3(Brown)
D	1.794	Sandy Clay Loam	Slightly sticky	Slightly plastic	10 YR 6/4(Light Yellowish Brown)	10 YR 5/4(Yellowish Brown)
E	1.794	Sandy Clay Loam	Sticky	Plastic	10 YR 5/6(Yellowish Brown)	10 YR 5/4(Yellowish Brown)
F	1.794	Sandy Clay Loam	Sticky	Plastic	10 YR 5/4(Yellowish Brown)	10 YR 3/3(Dark Brown)
G	1.794	Sandy Clay Loam	Slightly sticky	Non- Plastic	10 YR 7/3(Very Pale Brown)	10 YR 3/3(Dark Brown)
H	1.794	Sandy Clay Loam	Non- sticky	Non- Plastic	10 YR 6/4(Light Yellowish Brown)	YR 4/4(Dark Yellowish Brow
I	2.068	Sandy Clay Loam	Non- sticky	Plastic	10 YR 6/6(Brownish Yellow)	YR 4/4(Dark Yellowish Brow
J	2.342	Sandy Clay Loam	Slightly sticky	Non- Plastic	10 YR 7/4(Very Pale Brown)	10 YR 3/3(Dark Brown)

Chemical Properties

A chemical examination was performed using soil pH and total soluble sulphate. The pH showed a variation from 6.27 to 7.77. The H+ ion concentration is in dynamic equilibrium with the majority of charged surface soil particles which defines the pH of the soil. The value of soluble Sulphate (%) showed a variation from 0.0864 % to 0.11184%. Soluble sulphate in soil samples was done per the method mentioned in A.K Gupta, 's (1989) Practical Manual for Agricultural Chemistry. Soluble sulphate analysis can provide information about a soil sample's geological history and age, which can be helpful in forensic investigations involving soil evidence analysis. So, in the given soil sample the concentration of soluble sulphate of KNI Kasba (0.11184) is higher while in Karaundia (0.0864) has the lowest conc. This indicates that in the region of KNI Kasba, there must be more anthropogenic activities in the soil, making it unique in its forensic aspect.

Table 3: Chemical Parameters of Soil

Chemical Parameters		
Samples	**Soil pH**	**% Soluble Sulphate**
A	6.52	0.08832
B	6.46	0.0864
C	7.27	0.11088
D	7.10	0.1176
E	7.38	0.108
F	7.77	0.0984
G	7.30	0.09744
H	7.17	0.11184
I	6.94	0.1008
J	6.27	0.0984

Instrumentation Analysis

Atomic Absorption Spectroscopy

The findings of this research demonstrate how the soil samples from river sites, institutional areas, urban areas, and industrial areas differ from one another. Higher concentration of Mg in sample D (Ahmat), Cu in sample F (stadium), Fe in sample A (Sitakund) and Zn in sample B (Paryawaran park). The above-mentioned contamination may be the result of manmade activity like the discharge of sewage and industrial waste into the environment. The permissible limit of heavy metal in the soil is Zn (600), Mg (20), Cu (270), and Fe (425.6).

The study's findings showed that the soil sample contained greater concentrations of Fe and Mg. But Cu and Zn are at a lesser concentration. Trace amounts were in the following order Mg>Cu>Fe>Zn.

Table 4: Presence of Heavy Metals in Soil Sample

Samples	Mg	Cu	Fe	Zn
	pppm			
A	114.70	1.74	320.00	2.66
B	48.50	0.58	109.96	2.94
C	171.98	1.04	10.07	0.73
D	301.71	1.04	8.23	1.27
E	276.44	0.70	8.79	0.46
F	191.88	2.41	11.64	7.37
G	203.84	1.033	6.38	1.17
H	98.00	0.44	10.92	1.06
I	120.59	0.10	58.98	0.99
J	168.09	0.58	73.13	2.45

Conclusion

The present study summarizes the variation of different physio-chemical properties. The physical Assessment of soil samples like the colour of the soil in both conditions (Dry and Wet) observed different colour. The texture of soil lies in Sandy clay loam and density are ranged from 1.794 g/cm^3 to 2.479 g/cm^3. In a chemical examination, it was concluded that the pH of the soil is acidic in nature while the presence of soluble sulphate is high in five sites. This experiment proves that heavy metal analysis of soil samples is valuable evidence for forensic purposes Significantly high levels of hazardous metals can affect soil quality as well as human health through the tropic food chain. Heavy metals give each soil its own distinct imprint. It provides a distinctive soil profile from one place to another, which aids forensic investigations. When it comes to many different types of crime, such as murder, cases of poisoning, hit and run, burglary, cases of poisoning, etc.

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Conflict of interest: Nil

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