ATR-FTIR Spectroscopic Studies On Rural Area Soil Samples From Prayagraj For Forensic Considerations

Neha Yadav[1*], Lav Kesharwani[2]

[1*]Research scholar, Department of Forensic Science SHUATS, Sam Higginbottom University of Agriculture,
Technology and Sciences, Madhwapur, Prayagraj, Allahabad, UP, INDIA-211003,
Email id- nehapcfs@gmail.com
[2]Assistant professor, Department of Forensic Science SHUATS, Sam Higginbottom University of Agriculture,
Technology and Sciences Allahabad, UP, INDIA-211007

***Corresponding Author:** Neha Yadav
*Email id- nehapcfs@gmail.com

ABSTRACT

The ATR-FTIR spectroscopy is a versatile tool which is used to characterize the organic/inorganic part of soil samples including plant materials along with their various decomposition stages, flora/fauna, humic substances, suspended organic minerals. FTIR is also useful tool for analysis of soil minerals that includes primary i.e. quartz, feldspars; secondary i.e. silicates, clays, aluminosilicates soil minerals. Infrared spectroscopy with the transformation of (FTIR) gives detailed characteristics of the soil from the smallest samples (1 mg), making it a very important aid for forensics science. FTIR spectra of 69 samples (from the surface layer, at 15 cm depth) are qualitatively analysed. The absorption frequencies of the peaks in the spectra of each site in wave number units (cm-1) are reported along with the with the identified minerals. The minerals in the study were identified as quartz, Feldspar (albite, microcline, orthoclase) clay minerals (kaolinite, montmorillonite, illite,) and metal oxide (Hematite), in the soil samples. From the study of number of i.r. absorption peaks it can be concluded that quartz and feldspars are the primary minerals in the study area while clay mineral and metal oxide is a minor constituent.

KEYWORDS: ATR-FTIR, Minerals, Forensic Science.

INTRODUCTION

A soil sample typically contains more than simply rocks and minerals. The presence of leaves, seeds, pollen, and other organic components is widespread. FTIR spectroscopy may be used to characterize bulk soil organic components such as plant lipids and waxes, proteins, lignin, and cellulose.**[3]** Infrared spectroscopy with the transformation of (FTIR) gives detailed characteristics of the soil from the smallest samples (1 mg), making it a very important aid for forensics. The FTIR gives a common chemical impression of the main organic and mineral components in the soils. It may also identify components that are not soil particles that may be serious and are difficult to detect by any other analytical method; it may also distinguish between soil samples under different vegetation and soil conditions; and it may provide some information on the range of minerals present in the sample. In addition, the information obtained by this method can be expanded by comparing the spectrum before and after pyrolysis (with and without organic matter) with increased discrimination. Soils with the same colour values for Munsell could be distinguished by this sub-track FTIR method. In addition to infrared analysis of samples before and after pyrolysis, a new auxiliary method using thermogravimetric analysis has been applied to soils, which can provide more valuable information for soil identification. Another advantage of IR is that it is generally non-destructive and can be used with microsamples. Subtraction of background features is also possible as a digital technique, enabling soil spectra to be obtained from evidence material, such as splashes onto jeans material. Subtle differences in spectral patterns can also indicate the presence of rare minerals or organic phases or more common specific features, such as iron substitutes in clay minerals; these features are not readily accessible by other methods. The use of Raman spectroscopy of materials can also be considered as an indicator of composition and can characterize resins, waxes, and gums as well as minerals without separating the material. However, although many labor. **[3]** Most soils are primarily made up of minerals, many of which are derived from geological parent materials. The elemental composition of the inorganic part of soils is fundamentally influenced by the mineralogical composition, yet mineralogy is more than just chemical compositions. A mineral is a solid substance made up of set amounts of various chemical elements that are organized and bound together to form a regular pattern known as a crystal structure. As a result, different types of minerals not only have varied elemental compositions, but also a wide range of distinct physical and chemical characteristics defined by their various forms. Minerals may be studied and measured using a variety of techniques. In theory, any of these approaches might be used in the forensic testing of minerals.**[10]**

Organic Examination of Soil

That being said, infrared spectroscopy has been used by geologists as a method to predict the organic carbon content, the presence of nutrients and trace metals, the pH, the redox potential, and the conductivity of soil sample as well as to identify the presence of minerals in soil sample.**[9]** By predicting these parameters, the soil scientist may be able to recommend procedures to improve soil quality. Fourier transform infrared spectroscopy (FTIR) can be used to determine the chemical composition of a sample. Organic materials are composed of atoms bonded together in a specific manner unique to that material. The absorption of infrared light by a sample result in frequencies generated from bending and stretching of bonds between atoms or group of atoms. The resulting absorption or reflection of wavelengths is unique for a material. Alternatively, the IR spectra could be used to compare samples or standards to determine similarities or difference. There are two main methods geologists use to present a soil sample to the FTIR spectrometer: the manufacture of potassium bromide (KBr) discs and the use of a Diffuse Reflectance infrared Fourier transform spectroscopy (DRIFTS) holder. KBr is an IR inactive salt. The preparation of a KBr disc involves finely grinding a quantity of KBr with a sample of milled soil. The soil needs to be milled and the KBr mixture finely ground to remove the scattering effects from large crystals. The mixture is then placed in a KBr die set and pressure applied creating in a translucent, indurate disc. The KBr method requires a very small amount of soil sample, approx. 1.5mg. The KBr disc is analysed using transmission spectroscopy. The DRIFTS method of IR analysis involves placing the soil sample in a sample holder and the spectrum is collected on the bulk sample. The DRIFTS sample method utilizes reflectance IR spectroscopy. In a forensic trace evidence laboratory transmission FTIR with a microscope attachment and attenuated total reflectance (ATR) FTIR are commonly used for comparison of typical samples- including paints, fibres, rubbers, tapes, adhesives, and other miscellaneous materials. **[1,8]**

Forensic Application of Soil Analysis through ATR-FTIR

ATR-FTIR is particularly useful to the forensic scientist as the examination requires little or no sample preparation, only a very small sample is required, and the non-destructive nature of the analysis means that the sample is still available for further testing. ATR is an FTIR sampling technique that enables samples to be examined directly without further preparation. A beam of infrared light is passed through the ATR crystal such that it reflects off the internal surface in contact with the sample. This reflection forms a wave that extends into the sample. The beam is then collected by a detector as it exits the crystal. There has been limited work using ATR-FTIR for the examination of soils, and very little ATR-FTIR soil comparisons work in a forensic context. In 2004, linker **[2]** proposed the use of ATR-FTIR to determine the nitrate concentration in soils. Weinger et al **[7]** in 2009, expanded on this work and proposed the use of ATR-FTIR for the identification of silicates, phosphates, nitrates, and carbonates, while Madejova **(10)** concentrated on identifying clay minerals. Schulz and Baranska **[4]** examined plant metabolites using ATR-FTIR to determine the quality parameters in horticulture and agriculture crops. This work could be used to form the foundation of work on the organic humic content of soil sample. Morrison et al **[6]** used ATR-FTIR as part of a wider soil examination process to examine the soil organic matter and the mineral composition for the discrimination of soil from urban areas around Scotland. The research to date shows that IR examination can provide information on both the organic and inorganic components of a soil sample. As both the KBr and DRIFTS FTIR examination have limitation in a forensic context and ATR-FTIR is a technique commonly available in forensic trace evidence laboratories which requires no sample preparation.

Material And Methods

A. Sample location- Prayagraj

The soils employed in this study were collected from Prayagraj district (23 blocks, 3 sample from each block) in total 115 samples were collected and combined into 69 sample were tested. The specified areas which were included for the sampling were block area, agriculture land, and playground of the rural area. These areas were selected for the sampling because there were great chance of characterization of soil as it undergoes through different environment and also for forensic consideration.

B. Soil Samples preparation

Soil samples are generally prepared by grinding and in some cases, sieving to obtain a fine powder. The sample is then placed in direct contact with a crystal element like Zinc Selenide Germanium which is generally used in ATR-FTIR.

C. Analysis of soil samples

The radiation from the broadband infrared source is collimated and steered into the interferometer, where it hits the beam splitter. At the beam splitter, half of the IR beam is sent to the fixed mirror and the other half is reflected to the moving mirror. After being reflected from the two mirrors, the divided beams are recombined at the beam splitter. When the relative location of the moving mirror changes, an interference pattern is formed. After passing through the sample, the resulting beam is focused on the detector.

RESULT AND DISCUSSION

The qualitative examination was carried out to determine the major and minor constituent minerals present in the soil samples from the band position or location of the peaks from the prominent ATR-FTIR absorption peaks. The minerals in the study were identified as quartz, Feldspar (albite, microcline, orthoclase) clay minerals (kaolinite, montmorillonite, illite,) and metal oxide (Hematite), in the soil samples. From the study of number of i.r. absorption peaks it can be concluded that quartz and feldspars are the primary minerals in the study area while clay mineral and metal oxide is a minor constituent. The following is a discussion of minerals. The positions of the observed absorption bands in wave number units are summarized in Table-1 together with minerals.

Quartz

Quartz is the one of the most common minerals which is composed of silicates. The quartz mineral chemically is silicon dioxide, SIO_2.By the existence of Si-O bonding we can identify quartz minerals. From the Table 1 it could be observed the presence of quartz minerals indicated by the IR absorption bands at 455-460 cm^{-1}, 515-520 cm^{-1},688-689 cm^{-1},690-692 cm^{-1},693-695 cm^{-1},770-777 cm^{-1}, and 775-780 cm^{-1}. The strong absorption band observed at 695 cm^{-1} belongs to Si-O symmetrical bending vibration of quartz. The IR absorption band at 775^{-1} cm belong to Si-O symmetrical stretching vibration. Si-O bond is due to stretching mode is in the range of 900-1100cm^{-1} and bending mode in the range of 400-800 cm^{-1}.

Feldspar Minerals

Feldspar is the most abundant group of minerals on the earth and is constitute 60% of the earth crust. The compositions of the feldspar contain silicates of aluminium combined with extra metals such as sodium, potassium, iron, calcium, and barium. From the Table 1, the IR absorption peaks appearing at 405-410 cm^{-1}, 425-430 cm^{-1},430-435 cm^{-1}, 465-470 cm^{-1},533-538 cm^{-1}, 585-588 cm^{-1}, 641-649 cm^{-1}, 740-745 cm^{-1}, 765-770 cm^{-1}, 990-995 cm^{-1}, and 1744-1745 cm^{-1}, was referred to Feldspar mineral. There are different variety types of feldspar minerals which are given below.

- Microcline feldspar: The IR absorption peak at 425-430 cm^{-1}, 585-588 cm^{-1}, 740-7456 cm^{-1}, specify the presence of microcline feldspar.
- Orthoclase feldspar: The IR absorption peak at 430-435 cm^{-1}, 465-470 cm^{-1}, 533-538 cm^{-1}, 641-649 cm^{-1}, 765-770 cm^{-1}, and 1744-1745 shows the presence of orthoclase feldspar.
- Albite feldspar: The IR absorption peak at 405-410 cm^{-1}, 765-770 cm^{-1}, and 990-995 cm^{-1}, indicates the presences of albite feldspar.

Clay minerals

There is different type of clay minerals are present in the soil such as kaolinite, montmorillonite and illite. Kaolinite clay is the mineral which crystalize in the monoclinic system. Kaolinite minerals are found in China clay and kaolin as the chief constituent. The Kaolinite clay is used in ceramics products as a raw material. It is also used in manufacture of the coated paper. From the Table 1, we can observe that the IR absorption peak at 991-1000 cm^{-1}, 1000-1009 cm^{-1}, 1031-1034 cm^{-1}, and 3614-3620 cm^{-1}, in the soil sample indicates the presence of the kaolinite clay mineral.

Montmorillonite is formed in microscopic crystals to form clay mineral. These are very soft phyllosilicate form of minerals. Montmorillonite belongs to smectite family and is 2:1 clay, which means it has two tetrahedral sheets which is sandwiching a central octahedral sheet. The IR absorption peak at 1640–1645 cm^{-1}, in the soil sample indicates the presence of the montmorillonite clay mineral.

The IR absorption peak found at the range of 1645–1650 cm^{-1} in the soil samples indicate the presence of illite and are belongs to Al-O-H stretching vibrations. Both Illite and kaolinite are the two main primaries constitute of the clay minerals found in soils and natural aerosols. Kaolinite and montmorillonite are present in the soil due to the weathering process of a various types of rocks under different climatic circumstances.

Metal oxides

ATRFTIR can be used for the identification and characterization of metal oxide, a type of mineral class which is common in soil and it includes oxides, oxyhydroxide and hydroxide of metals such as manganese, iron, and aluminium. Through atrftir we can investigate both crystalline and weak crystalline metal oxide which is one of the advantages over XRD, which is primarily limited to crystalline soil sample. Metal oxide highly influences the color of soil. Hematite is one of the most common types of iron oxide found in soil sample. From the Table 1, we can observe that the IR absorption peak at 520-530 cm^{-1}, in the soil sample indicates the presence of the Hematite. Beside hematite other iron oxide present in soil are goethite, magnetite, ferrihydrite, lepidocrocite and schwertmannite.

Soil sample	Soil sample location ID
Chaka block	C1
Chaka AL	C2
Chaka PG	C3
Jasra B	J1
Jasra AL	J2
Jasra PG	J3
Shankargarh B	S1
Shankargarh AL	S2
Shankargarh PG	S3
Kaundhiyara B	KA1
Kaundhiyara AL	KA2
Kaundhiyara PG	KA3

Karchana B	K1
Karchana al	K2
Karchana pg	K3
Meja B	M1
Meja AL	M2
Meja PG	M3
Uruva B	U1
Uruva al	U2
Uruva PG	U3
Koraon B	KO1
Koraon AL	KO2
Koraon PG	KO3
Manda B	MN1
Manda AL	MN2
Manda PG	MN3
Saidabad B	SA1
Saidabad AL	SA2
Saidabad PG	SA3
Handia B	H1
Handia AL	H2
Handia PG	H3
Dhanupur B	D1
Dhanupur AL	D2
Dhanupur PG	D3
Pratappur B	P1
Pratappur AL	P2
Pratappur PG	P3
Shasho B	SH1
Shasho AL	SH2
Shasho PG	SH3
Phulpur B	PH1
Phulpur AL	PH2
Phulpur PG	PH3
Bahariya B	BA1
Bahariya AL	BA2
Bahariya PG	BA3
Bahadurpur B	BAH1
Bahadurpur AL	BAH2
Bahadurpur PG	BAH3
Svd b	SVD1
Svd al	SVD2
Svd pg	SVD3
Soran b	SO1
Soraon al	SO2
Soraon pg	SO3
Kaurihara b	KAU1
Kaurihara al	KAU2
Kaurihara pg	KAU3
Maumima b	MAU1
Maumima al	MAU2
Maumima pg	MAU3
Holagarh b	HO1
Holagarh al	HO2
Holagarh pg	HO3
Bhagwatpur B	BHA1
Bhagwatpur al	BHA2
Bhagwatpur pg	BHA3

Peak (cm^{-1})	**PEAK Regions (cm^{-1})**	**Minerals**	**Soil SAMPLES location ID**	**Reference**
3619	3614-3620	Kaolinite	BAH1, SH1	K.M Murthuza *et.al* [11] and N. Oumabady Alias Cannane *et .al* [14]
3618	3614-3620	Kaolinite	P1, KA1	K.M Murthuza *et.al* [11]and N. Oumabady Alias Cannane *et .al* 14]
3616	3614-3620	Kaolinite	BA1, U1	K.M Murthuza *et.al* [11]and N. Oumabady Alias Cannane *et .al* [14]
3614	3614-3620	Kaolinite	SVD1	K.M Murthuza *et.al* [11]*and* N. Oumabady Alias Cannane *et .al* [14]
1744	1744-1745	Feldspar	BA1	N. Oumabady Alias Cannane *et .al* [14]
1648	1645–1650	Illite	BA1	K.M Murthuza *et.al* [11]
1645	1640–1645	Montmorillonite	D1	S. Sivakumar *et.al* [12]
1427	1423-1428	Calcite	SO3	Paramasivam *et.al* [13]
1033	1031-1034	Kaolinite	BHA3,	K.M Murthuza *et.al* [11]
1O32	1031-1034	Kaolinite	S2, D2, BAH2, C2	K.M Murthuza *et.al* [11]
1008	1000-1009	Kaolinite	H1	K.M Murthuza *et.al* [11]and R. Vijayaragavan *et.al*
1007	1000-1009	Kaolinite	KO2, HO1	K.M Murthuza *et.al* [11]and R. Vijayaragavan *et.al*
1006	1000-1009	Kaolinite	BAH1	K.M Murthuza *et.al* [11]and R. Vijayaragavan *et.al*
1004	1000-1009	Kaolinite	S3, SA1, P1	K.M Murthuza *et.al* [11]and R. Vijayaragavan *et.al*
1003	1000-1009	Kaolinite	BHA3, KA1, SH1	K.M Murthuza *et.al* [11] and R. Vijayaragavan *et.al*
1002	1000-1009	Kaolinite	U1, KAU1, BA1	K.M Murthuza *et.al* [11] and R. Vijayaragavan *et.al*
1001	1000-1009	Kaolinite	S2, BAH2, C2, PH2, BHA1, SH2, KO1, K1.	K.M Murthuza *et.al* [11] and R. Vijayaragavan *et.al*
1000	1000-1009	Kaolinite	HO3, BHA2, J2, KO2, MN2, S1, PH1	K.M Murthuza *et.al* [11]and R. Vijayaragavan *et.al*
999	991-1000	Kaolinite	D1	K.M Murthuza *et.al* [11]
995	990-995	Feldspar albite	MAU1	S. Sivakumar *et.al* [12]
992	990-995	Feldspar albite	U3, SA3, SO3, MN3, P2, KA2, SVD1	S. Sivakumar *et.al* [12]
991	990-995	Feldspar albite	SO1	S. Sivakumar *et.al*
778	775-780	Quartz	HO1	K.M Murthuza *et.al* [11]
777	775-780	Quartz	PH3, SA3, SO2	K.M Murthuza *et.al* [11]
776	775-780	Quartz	KAU3, U3, M3, SH3, KO3, P3, SVD3, C3, K3, SVD2, KA2, KA1	K.M Murthuza *et.al* [11]
775	775-780	Quartz	BAH3, J3, S3, BHA3, SO3, HO3	K.M Murthuza *et.al* [11]
774	770-777	Quartz	K2, SH1, P1	K.M Murthuza *et.al* [11]
773	770-777	Quartz	P2, HO2, BA2, M2, PH1	K.M Murthuza *et.al* [11]
772	770-777	Quartz	S2, H2, MAU2	K.M Murthuza *et.al* [11]
770	770-777	Quartz	D1, U1	K.M Murthuza *et.al* [11]
768	765-770	Orthoclase feldspar	D3,	S. Sivakumar *et.al* [12]
766	765-770	Orthoclase feldspar	MAU3, BHA2, KA2, MN2	S. Sivakumar *et.al* [12]
765	765-770	Orthoclase feldspar	C2	S. Sivakumar *et.al* [12]
745	740-745	Microcline	MAU3	S. Sivakumar *et.al* [12]
743	740-745	Microcline	BHA3	S. Sivakumar *et.al* [12]
695	693-695	Quartz	KAU3	K.M Murthuza *et.al* [11]
694	693-695	Quartz	U3, KA3,	K.M Murthuza *et.al* [11]
693	693-695	Quartz	PH3, BAH3, SH3, SO3, HO3, BHA3, BA3, SH2, HO2	K.M Murthuza *et.al* [11]
692	690-692	Quartz	SVD3, SO2, K2, S2, SA2, MAU2, D2, SVD2, BA2, M2,	N. Oumabady Alias Cannane *et .al* [14]
691	690-692	Quartz	D3, P2, C2	N. Oumabady Alias Cannane *et .al* [14]
690	690-692	Quartz	M3, K3, BAH2, KO2, MN2.M2	N. Oumabady Alias Cannane *et .al* [14]

689	688-689	Quartz	KAU2, BHA2, KA2	K.M Murthuza *et.al* [11]
688	688-689	Quartz	BHA1, BA1, U1, P1, KA1	K.M Murthuza *et.al* [11]
646	641-649	Orthoclase feldspar	SO3	K.M Murthuza *et.al* [11]
645	641-649	Orthoclase feldspar	U3	K.M Murthuza *et.al* [11]
644	641-649	Orthoclase feldspar	HO3	K.M Murthuza *et.al* [11]
584	585-588	Microline feldspar	MAU3	Paramasivam *et.al* [13]
538	533-538	Orthoclase feldspar	BAH3	K.M Murthuza *et.al* [11]
534	533-538	Orthoclase feldspar	K3, HO1	K.M Murthuza *et.al* [11]
533	533-538	Orthoclase feldspar	KAU3, MAU3,	K.M Murthuza *et.al* [11]
529	520-530	Hematite	H1	N. Oumabady Alias Cannane *et .al* [14]
527	520-530	Hematite	C1, U1	N. Oumabady Alias Cannane *et .al* [14]
526	520-530	Hematite	BA1	N. Oumabady Alias Cannane *et .al* [14]
525	520-530	Hematite	S1, J1, MAU1	N. Oumabady Alias Cannane *et .al* [14]
524	520-530	Hematite	SO1, BAH1, P1, KAU1, SA1	N. Oumabady Alias Cannane *et .al* [14]
523	520-530	Hematite	K1	N. Oumabady Alias Cannane *et .al* [14]
522	520-530	Hematite	MN1	N. Oumabady Alias Cannane *et .al* [14]
521	520-530	Hematite	SVD1	N. Oumabady Alias Cannane *et .al* [14]
518	515-520	Quartz	SH1, KO1, KA1, D1	S. Sivakumar *et.al* [12]
517	515-520	Quartz	M1, PH1	S. Sivakumar *et.al* [12]
469	465-470	Orthoclase feldspar	KAU1	S. Sivakumar *et.al* [12]
468	465-470	Orthoclase feldspar	SA1, KA1, M1, SH1, BAH1, PH1, S1	S. Sivakumar *et.al* [12]
467	465-470	Orthoclase feldspar	P1, D1, MAU1	S. Sivakumar *et.al* [12]
466	465-470	Orthoclase feldspar	K1, C1	S. Sivakumar *et.al* [12]
465	465-470	Orthoclase feldspar	H1	S. Sivakumar *et.al* [12]
459	455-460	Quartz	KO1, KAU1	S. Sivakumar *et.al* [12]
458	455-460	Quartz	S1, M1, P1, KA1, U1	S. Sivakumar *et.al* [12]
457	455-460	Quartz	PH1, BAH1	S. Sivakumar *et.al* [12]
456	455-460	Quartz	MN1, HO1, MAU1	S. Sivakumar *et.al* [12]
455	455-460	Quartz	SA1	S. Sivakumar *et.al* [12]
432	430-435	Orthoclase feldspar	C1	S. Sivakumar *et.al* [12]
430	425-430	Microcline feldspar	MN1	S. Sivakumar *et.al* [12]
427	425-430	Microcline feldspar	HO1, SH1, P1, KO1, KAU1, SA1, U1	S. Sivakumar *et.al* [12]
426	425-430	Microcline feldspar	BAH1, MAU1, D1, M1, KA1	S. Sivakumar *et.al* [12]
425	425-430	Microcline feldspar	K1, PH1	S. Sivakumar *et.al* [12]
408	405-410	Albite	SA	S. Sivakumar *et.al* [12]

Fourier transform infrared (ATR-FTIR) spectroscopy combined with chemometrics**. Morrissson *et al. (*2009)** used ATR-FTIR as part of a wider soil examination process to examine the soil organic matter and the mineral composition for the discrimination of soil from urban areas around Scotland. The research to date shows that IR examination can provide information on both the organic and inorganic components of a soil sample. As both the KBr and DRIFTS FTIR examination have limitation in a forensic context and ATR-FTIR is a technique commonly available in forensic trace evidence laboratories which requires no sample preparation. ATR-FTIR method was used in the present study to qualitatively detect the minerals in the collected soil samples from different location of Prayagraj. From the study the minerals which were detected are as follow Quartz, Feldspar Minerals (Microcline, Orthoclase, Albite), Clay minerals (kaolinite, montmorillonite and illite) and Metal oxides minerals (Hematite). The presence of quartz minerals was indicated by the IR absorption bands at 455-460 cm^{-1}, 515-520 cm^{-1},688-689 cm^{-1},690-692 cm^{-1},693-695 cm^{-1},770-777 cm^{-1}, and 775-780 cm^{-1}. The IR absorption peaks appearing at 405-410 cm^{-1}, 425-430 cm^{-1},430-435 cm^{-1}, 465-470 cm^{-1},533-538 cm^{-1}, 585-588 cm^{-1}, 641-649 cm^{-1}, 740-745 cm^{-1}, 765-770 cm^{-1}, 990-995 cm^{-1}, and 1744-1745 cm^{-1}, was referred to Feldspar mineral. The IR absorption peak at 991-1000 cm^{-1}, 1000-1009 cm^{-1}, 1031-1034 cm^{-1}, and 3614-3620 cm^{-1}, in the soil sample indicates the presence of the kaolinite clay mineral. IR absorption peak at 1640–1645 cm^{-1}, in the soil sample indicates the presence of the montmorillonite clay mineral and the IR absorption peak found at the range of 1645–1650 cm^{-1} in the soil samples indicate the presence of illite and are belongs to Al-O-H stretching vibrations. Hematite is one of the most common types of iron oxide found in soil sample. We can observe that the IR absorption peak at 520-530 cm^{-1}, in the soil sample indicates the presence of the Hematite.

CONCLUSION

ART-FTIR spectroscopic techniques that provide qualitative and semi-quantitative data of soil organic/inorganic (aliphatic, carboxyl, and aromatic) and mineral composition (kaolin, clays, and quartz) from fractions of samples. These instrumentation techniques can be combined with multivariate analysis and can be used for the prediction of soil properties, their respective groups/class, and the geographical locations of unknown soil samples. The non–destructive application of the ATR–FTIR technique for characterization of soil samples could be helpful to give forensic aid in resolving criminal cases. The proposed method can characterize, and classify the soil samples accurately. The low cost of analysis, handy operation, non–destructive, reliable, and high resolution make the ATR–FTIR spectroscopy best choice of instrument for forensic soil examination. These newly developed approaches can be utilized in the database formation and this will help to specify and restrict possible origin of the sample which is in questioned. Thus, present research confirms that soil examination will be highly useful in forensic examination work in criminal cases, where the investigation of soil is required.

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