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COMPARATIVE ANALYSIS OF HUMIC AND FULVIC ACIDS EXTRACTION AND CHARACTERIZATION FROM DIFFERENT ORGANIC SOURCES

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ABSTRACT

There is a scarcity of information on the chemical and spectral properties of humic substances obtained from various organic sources. For this purpose, a laboratory experiment was carried out to extract humic and fulvic acids from vermicompost, compost, farmyard manure, and sheep manure. Humic and fulvic acids have the following chemical properties: electrical conductivity (E.C), pH, organic carbon, total nitrogen, total acidity, the level of humiliation and aroma activity of humic substances (E_4/E_6 ratio), and spectral characterization methods using spectroscopic methods such as UV- Vis and Fourier transform infrared spectra (FTIR). The results showed that the highest value of pH was 3.25 for humic acid extracted from sheep manure. The highest EC was 6.68 dSm^{-1} of fulvic acid extracted from sheep manure. The C/N ratio of humic was less than fulvic acid extracted from all organic sources. In comparison to humic acid, fulvic acid had a higher total acidity. Also, Fulvic acid contained more functional groups than humic acid extracted from all organic sources, including carboxyl and phenolic-OH groups. According to the results, humic acid has lower E_4/E_6 ratio values than fulvic acid. Analysis of UV-Vis spectra revealed that humic substances contained aromatic components. According to Fourier transform infrared spectra, humic and fulvic acids contain aliphatic CH, hydroxyl, and carboxyl groups with varying values depending on the organic sources.

INTRODUCTION

Since organic wastes contain a significant amount of nutrients required for plant growth in addition to maintaining soil health, there is a need to increase soil fertility in a sustainable way by using these wastes. Utilizing organic wastes as a source of nutrients minimizes the need for chemical fertilizers, and these wastes also contain a significant amount of humus, which helps to improve the soil physical, chemical, and biological properties. However, many management techniques have been used to increase the organic matter content of soils, including crop rotation, plowing techniques, green manuring, the application of animal residues, and the usage of humic acids and humates (**Awwad *et al.*, 2015**). Farmers consider the use of bulky organic manures as a burden because it necessitates many agricultural labourers for transportation and application. Furthermore, the use of bulky organic manures results in the spread of weed seeds in crop land and weed control would be a major concern. In this regard, the extraction and use of humic substances from bulky organic manures may assist in the resolving of many challenges associated with the use of bulky farmyard manure (**Gayathri *et al.*, 2020**).

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Humic compounds are formed because of the degradation, oxidation, and transformation of plant and animal organic debris. These organic matter modifications are carried out indefinitely by soil enzymes and microorganisms in soil microcosms, yielding humic substances with chemical and biological properties. Humic substances are currently regarded as one of the most promising trends in green chemistry as renewable, economically advantageous, and eco-friendly sources of raw materials to produce chemical products (**Khil'ko *et al.*, 2011; Fuentes *et al.*, 2018**). Humification is the transformation of fresh organic matter into humic matter that occurs in soil. Based on their solubility in aqueous solution, humic substances can be divided into three fractions: humic acid (HA), which is soluble at alkaline pH values; fulvic acid (FA), which is soluble at all pH levels; and humin, which is insoluble at all pH levels (**Sutton and Sposito, 2005**). Humic acids are thought to be aromatic ring macromolecules containing amino acids, amino sugars, peptides, and aliphatic compounds that participate in aromatic group linkages. The hypothetical structure of humic acid includes quinone structures, free and bound phenolic OH groups, nitrogen and oxygen serving as bridge units, and COOH groups arranged on aromatic rings in various configurations (**Shamia *et al.*, 2017**).

Many characterization methods, such as ultraviolet-visible (UV-VIS), Fourier transform infrared (FTIR), and elementary analysis, have been used to identify important features of this structural complexity (**Rodrguez *et al.*, 2014**). UV-VIS spectroscopy can be used to determine the absorbance of aromatic structures and the ratio E4/E6, which are associated with the degree of humification of HS and, thus, the quality of the soil or organic materials (**Rodríguez and Núñez, 2011**). FTIR spectroscopy is an extremely beneficial technique for identifying complex organic compounds. FTIR spectra are a qualitative tool for evaluating chemical groups and humic acid bands (**Helal *et al.*, 2011**). FTIR spectroscopy provides more information about the structural changes that occur during the transformation of humic acid. Although a specific band may sometimes correspond to the overlap of the absorption of two different functional groups, this technique allows the identification of functional groups that compose the humic macromolecule (**Wang *et al.*, 2014**). The purpose of the current study was to characterize humic and fulvic acids that were extracted from various organic sources such as vermicompost, compost, farmyard manure, and sheep manure by determining some chemical characteristics, total acidity, and spectroscopic methods like UV- Vis and FTIR.

MATERIALS AND METHODS

Four samples were collected from different organic sources to extract humic and fulvic acids as follows: 1) vermicompost, 2) compost, 3) farmyard manure, 4) sheep manure. These sources were obtained from commercial companies and farms in Ismailia Governorate.

Extraction of Humic Substances

Organic samples were air dried, and 0.1 N sodium hydroxide (NaOH) was added, and the mixture was shaken for 24 hours. Centrifugation was used to collect the dark-colored supernatant solution. The separation procedure was repeated three times, each time using extractant to ensure complete humic acid extraction. Supernatants were pooled in a volumetric flask, and the resulting colored separated by centrifugation was centrifuged at 15,000 rpm for 15 minutes. To precipitate humic acid, the pH electrode was dipped into the colored supernatant solution and 2 N HCl was added until the pH was lowered to 2. After giving it a thorough stir, it was left to stand for 24 hours at room temperature. Humic acid (coagulate) and fulvic acid (supernatant) samples were taken separately. The collected coagulate was dried on a hot waterbath (**Stevenson, 1994**).

Characterizations of Humic Substances

By utilizing both the traditional Kjeldahl method and a modified version of Walkely Black's wet digestion method, the carbon and nitrogen contents of the humic and fulvic acids were determined as that reported by **Bremner and Mulvaney (1982)**. PH of the humic substances was determined in 1:50 humic acid to water ratio by bench type Beckman glass electrode pH meter, (**Sparks *et al.*, 2020**). Electrical conductivity of humic substances was determined in 1:100 humic acid to water ratio by conductivity meter (**Sparks *et al.*, 2020**). Total acidity was estimated by barium hydroxide method according to **Schnitzer and Gupta (1964)**. Calcium acetate was used to determine the carboxylic groups of humic and fulvic acids (**Schnitzer and Khan, 1972**). The phenolic-OH groups were estimated by subtracting total acidity from carboxylic group acidity (**Kononova, 1966**). The level of humiliation and aroma activity of humic substances were determined using UV-visible spectrophotometer. The absorbance at 465 and 665 nm was measured and expressed as E_4/E_6 ratio **(Kononova, 1966).** Spectral characteristics of humic substances were evaluated by UV- visible spectrophotometer. The absorbance was measured in UV- range in the wavelength range of 200-300 nm (**Rajashekhar *et al.*, 2017)**. Fourier transform infrared spectroscopy (FTIR) analysis was identified by FTIR spectrometer using KBr. Humic fraction sample were further dried for 72 hours at 105ºC. Each sample was broken up into 1.5 mg pieces, mixed with 300 mg of KBr, and then compressed for 10 minutes at high pressure and vacuum into a tiny disc that was 10 mm in diameter and 1-2 mm thick. Since KBr does not absorb light in the IR region (4000-500 cm^{-1}), a complete spectrum of each humic and fulvic sample could be obtained (**Omar *et al.*, 2018; Helal *et al.*, 2011**).

RESULTS AND DISCUSSION

Some Chemical Properties of Extracted Humic and Fulvic Acids

The results shown in Table 1 illustrates some of the chemical characteristics of humic and fulvic acids that were extracted from various organic sources. Humic acid pH values were 2.35, 3.0, 3.22 and 3.25, when extracted from vermicompost, compost, farmyard, and sheep manure, respectively. Additionally, the amounts of fulvic acid extracted from vermicompost, compost, farmyard, and sheep manure were 3.0, 3.17, 2.67, and 2.8, respectively. These findings indicated that humic and fulvic acids are acidic. These results could be explained by the presence of phenolic-OH and carboxyl groups. These results were in accordance with **Kinniburgh *et al.* (1998)** who reported that humic and fulvic acids exhibit negative charge increase with increasing pH due to protons dissociation. Carboxylic-type groups are responsible for this behavior, while phenolic-type groups contribute more at higher pH values.

The electrical conductivity (EC) (1:100) of extracted humic acid were 0.50, 0.41, 0.34 and 0.32 dSm^{-1} of vermicompost, compost, farmyard, and sheep manure, respectively. Also, EC of extracted fulvic acid from different organic sources were 0.65, 0.45, 0.58 and 0.67 dSm^{-1} of vermicompost, compost, farmyard, and sheep manure, respectively. The results showed that EC of extracted fulvic acid from different organic sources was higher than humic acid extracted from the same organic sources. These findings could be the result of higher salt concentrations

Table 1. Some chemical properties of humic and fulvic acids extracted from different organic sources

Source	Humic Acid							Fulvic Acid						
	EC dSm^{-1} 1:100	pH 1:50	O.C	T. N	P	K	C/N ratio	EC dSm^{-1} 1:100	pH 1:50	O.C	T.N	P	K	C/N ratio
			gkg^{-1}							gkg^{-1}				
Vermicompost	0.50^{a}	2.35	540^{a}	41.0^{a}	0.40^{ab}	1.80^{c}	$13.2:1^{a}$	0.65^{a}	3.00	480^{a}	47.0^{a}	0.70^{a}	2.70^{c}	$10.2:1^{c}$
Compost	0.41^{ab}	3.00	340^{b}	27.0^{c}	0.10^{c}	1.20^{d}	$12.6:1^{a}$	0.45^{b}	3.17	510^{a}	28.0^{b}	0.30^{b}	1.20^{d}	$18.2:1^{a}$
Farmyard Manure	0.34^{b}	3.22	280^{c}	35.0^{b}	0.30^{b}	3.90^{a}	$8.00:1^{b}$	0.58^{ab}	2.67	220^{c}	30.0^{b}	0.10^{c}	4.50^{a}	$7.40:1^{d}$
Sheep Manure	0.32^{b}	3.25	163^{d}	42.0^{a}	0.50^{a}	3.30^{b}	$4.00:1^{c}$	0.67^{a}	2.80	420^{b}	35.0^{b}	0.30^{b}	3.60^{b}	$12.0:1^{b}$

accumulating because of the decomposition of organic matter or higher levels of organic carbon (**Chaitra *et al.*, 2018**). Additionally, **Anielak and Majewski (2003)** found a relationship between fulvic acid pH and electrical conductivity (EC), with decreased pH causing increase in EC. This was due to the use of a higher concentration of HCl to lower the pH of the solution.

Humic acid that had been extracted from various organic sources ranged in organic carbon content from 540gkg^{-1} to 163 gkg^{-1}. For fulvic acid, the same organic sources of carbon ranged from 420 gkg^{-1} to 480 gkg^{-1}. The results also revealed that, except for fulvic acid extracted from compost and sheep manure, humic acid had higher levels of organic carbon than fulvic acid. These results agreed with those of **Omar *et al.* (2018).** This might be because of the loss of carbon and nitrogen that occurred concurrently with the formation of fulvic acid (**Schnitzer, 1999; Reddy *et al.*, 2014**).

The nitrogen content in humic acid ranged from 4.1% to 2.7% (Table 1). For fulvic acid, nitrogen content varied between 28 gkg^{-1} to 47 gkg^{-1}. The results indicated that humic acid nitrogen content was marginally higher than nitrogen content in fulvic acid. These findings concur with those found by **Omar *et al.*(2018)**. The C/N ratios of humic and fulvic acids that were extracted from various organic materials were also shown in the results at Table 1. Humic acid had C/N ratios between 4:1 and 13.2:1 in its composition. However, fulvic acid C/N ratios varied from 7.40:1 to 18.2:1.

Total Acidity

Total acidity of extracted humic acid ranged from 5 to 24 meq g $^{-1}$. According to the results in Table 2, humic acid extracted from farmyard manure had the highest total acidity. The amount of humic acid extracted from compost has the minimum amount of total acidity. The total acidity of fulvic acid extracted from vermicompost, compost, farmyard manure, and sheep manure, however, ranged from 16 to 23 meq g $^{-1}$. The highest value was 23 meqg^{-1} obtained from compost and the minimum value was 16 meg^{-1} obtained from vermicompost. In general, total acidity of fulvic acid was higher at different organic materials such as vermicompost and compost than the total acidity in humic acid in the same organic materials. These results were confirmed with those of **Omar *et al.* (2018)** who found that fulvic acid had a higher total acidity than humic acid. Additionally, **Eshwar *et al.* (2017)** reported that the total acidity of humic acid was 7.2 meqg^{-1} less than fulvic acid. **Reddy and Rao (2000)** found that increasing total acidity with decreasing molecular weight corresponded to increased degree of oxidation of low molecular weight components.

Carboxyl Groups

Results presented in Table 2 show the carboxyl groups in the humic and fulvic acids that were extracted from compost, vermicompost, farmyard manure, and sheep manure. According to the results, humic acid degradation caused the carboxyl groups to have the highest value at 7.60 meqg^{-1} in humic acid extracted from farmyard manure. The fulvic acid extracted from sheep manure had a maximum value of 7.4 meqg $^{-1}$. This result was in agreement with **Rajashekhar *et al.* (2017)** who found that the carboxylic groups in fulvic acid were higher than humic acid. This could be due to decarboxylation did not occur before polymerization, resulting in the low particle weight of fulvic acid extracted from sheep manure (**Srilatha *et al.*, 2013**). Furthermore, it may be because the fulvic acid from sheep manure is more mature than that from vermicompost, compost, and farmyard manure (**Omar *et al.*, 2018**).

Phenolic- OH Groups

The phenolic-OH group analysis of humic and fulvic acids extracted from vermicompost, compost, farmyard manure, and sheep manure is a measure of their acidity. Table 2 shows that the phenolic-OH group content of humic acid was 3.6, 1.5, 16.4, 15.4 meg^{-1} in vermicompost, compost, farmyard manure, and sheep manure, respectively. Fulvic acid contained more phenolic -OH groups than humic acid in all extracts. These findings were incompatible with **Rajashekhar *et al.* (2017)** who observed that fulvic acid had more carboxylic and phenolic -OH groups than humic acid derived from farmyard manure and vermicompost. Furthermore, the phenolic-OH group content of humic acid obtained from vermicompost, and compost was higher than that of farmyard manure. **Kar *et al.* (2012)** found that humic acid extracted from farmyard manure had higher carboxylic and phenolic-OH contents than humic acid extracted from vermicompost. According to **Ukalska-Jaruga *et al.* (2021)**, the alcoholic and phenolic-OH groups are the most important functionalities for the chemical behaviour of humic substances. According to **Allen King *et al.* (2002)**, phenolic-OH and carboxylic groups provide the capacity for humic substance interaction reactions because they are the major contributors to the cation exchange capacity of soil organic matter.

These results were used to calculate the percent contributions of phenolic-OH groups and carboxylic groups (Table 3). Humic acid extracted from vermicompost, compost, farmyard, and sheep manure contributed 64, 70, 31.7 and 30% of its carboxylic groups, respectively. In contrast, sheep and farmyard manure had higher phenolic-OH group contributions to total acidity than vermicompost and compost, at 68.3 and 70%, respectively. For fulvic acid, the contribution of carboxylic groups extracted from vermicompost was 42.5% higher than that of compost, farmyard, and sheep manure. Whereas fulvic acid extracted from compost had the highest contribution of phenolic-OH groups to total acidity (71.30%). According to **Eshwar *et al.* (2017)**, the percent contribution of carboxylic groups in humic acid was lower than that of fulvic acid. Furthermore, **Rajashekhar *et al.* (2017)** found that the percent contribution of phenolic-OH groups to total acidity was greater in humic acid than in fulvic acid.

The Level of Humiliation and Aroma Activity of Humic Substances (E_4/E_6 ratio)

The E_4/E_6 ratio is related to the humic substances' molecular weight and oxygen content. It is also expected to decrease as the molecular weight and content of condensed aromatic rings increase (**Helal, 2011**). The optical density ratio at 465 and 665nm is frequently used to characterize humic and fulvic acids. This ratio is independent of humic and fulvic acid concentrations, but it also differs with humic substances extracted from different organic materials (**Srilatha *et al.*, 2013**).

Table 2. Total acidity, carboxyl, phenolic- OH and E_4/E_6 content of humic and fulvic acids extracted from different organic sources

Source	Humic Acid (meqg^{-1})				Fulvic Acid (meqg^{-1})			
	Total Acidity	Carboxyl Groups	Phenolic -OH Groups	E4/E6 Ratio	Total Acidity	Carboxyl Groups	Phenolic -OH Groups	E_4/E_6 Ratio
Vermicompost	10.0	6.40	3.60	4.64	16.0	6.80	9.20	7.38
Compost	5.00	3.50	1.50	5.00	23.0	6.60	16.4	7.50
Farmyard Manure	24.0	7.60	16.4	6.25	21.0	6.20	14.8	18.75
Sheep Manure	22.0	6.60	15.4	2.95	18.0	7.40	10.6	55.6

Table 3. Content of carboxyl and phenolic-OH groups in humic and fulvic acids, expressed as a percentage of total acidity

Source	Humic Acid		Fulvic Acid	
	The percentage of total acidity (Content)		The percentage of total acidity (Content)	
	Carboxyl Groups	Phenolic -OH Groups	Carboxyl Groups	Phenolic -OH Groups
Vermicompost	64.0	36.0	42.5	57.5
Compost	70.0	30.0	28.7	71.30
Farmyard Manure	31.7	68.3	29.5	70.5
Sheep Manure	30.0	70.0	41.1	58.9

Humic acid extracted from vermicompost, compost, farmyard manure, and sheep manure had E_4/E_6 ratios of 4.64, 5.00, 6.25, and 2.95, respectively (Table 2). The E_4/E_6 ratio of fulvic acid extracted from vermicompost, compost, farmyard, and sheep manure were 7.38, 7.5, 18.75, and 55.6, respectively. The results showed that fulvic acid had higher E_4/E_6 values than humic acid. It could be caused by the greater degree of aromaticity in carbon atoms of humic acids. This finding contradicted the findings of **Srilatha *et al.* (2013) and Eshwar *et al.* (2017)**, who found that fulvic acid had a relatively increased E_4/E_6 ratio than humic acid. A high degree of condensation of aromatic humic components is indicated by a low ratio of E_4/E_6. While high ratios indicate the presence of numerous aliphatic structures and few condensed aromatic structures (**Petrus *at al.*, 2009; Rajashekhar *et al.*, 2017**). Fulvic acid has a higher E_4/E_6 humification index than humic acid. These results are in line with the results that obtained by **Eshwar *et al.* (2017)**.

UV Spectra

The UV spectra of humic and fulvic acid extracted from various organic materials ranged from 200 to 300 nm, with reducing optical density and increasing wavelength. Humic acid extracted from sheep manure had the highest absorbance in the visible spectral range. Humic acid extracted from compost had the lowest absorbance in the visible spectral range, as shown in Fig. 1. The samples had a slight hump near 260-280nm, which is common in humic substances. This hump may be attributed to radiation absorption by the aromatic components of humic substances' double bands C═C, C═O and N═N. Fulvic acid extracted from farmyard manure had the highest absorbance, while fulvic acid extracted from sheep manure had the lowest absorbance (Fig. 2). In general, humic and fulvic acid UV spectra were featureless and repetitively decreased with increasing wavelength. According to **Rajashekhar *et al.* (2017)**, the lack of UV absorbance could be due to humic substances being in a middle state of development between lignin and coal. **Agarwal *et al.* (2010)** also reported that the difference in the hump observed with the different samples could be attributed to differences in the concentrations of the aromatic compounds, which are properties of the difference in the humification process.

Fourier Transform Infrared Spectroscopy (FTIR)

The infrared spectroscopy analysis of humic and fulvic acids extracted from various organic materials revealed a limited number of broad bands. All fulvic acid samples showed broad bands at approximately 3500, 1725, 1260, and 1040 cm^{-1} (Figs. 3-4).

All of the humic acid samples had broad bands at 1040, 1730, and 2900 cm^{-1}. Furthermore, the spectra revealed a strong broad band from 3500-3000 cm^{-1}. This demonstrates that H-bonded OH groups predominate in all humic acids extracted from various organic materials. The most stretched peak of humic acid extracted from compost was 1040 cm^{-1}. Also, the most stretched peak of humic acid extracted from vermicompost at 1730 cm^{-1}. This demonstrates that COOH stretching was present in humic acid extracted from vermicompost. Furthermore, humic acid extracted from sheep manure contained the broad band 2900 cm^{-1}. This indicated that all humic acid extracted from compost, vermicompost, farmyard manure, and sheep manure had aliphatic CH stretching.

The spectra clearly show the dominance of H bonding OH, COOH, C−O stretching and OH deformation of COOH, as well as the weak band 1050 due to C−O stretching of fulvic acid polysaccharide. The spectra revealed that the highest stretching peak of fulvic acid extracted from farmyard manure was 1725 cm^{-1}. This is due to C═O stretching of COOH. The spectra also revealed that farmyard manure has more C−O stretching of polysaccharide than sheep manure, vermicompost, and compost. The absorption at 1400 cm (OH- deformation and C−O stretching of phenolic OH) also characterizes the fulvic acid spectrum. The FTIR findings are consistent with the other characterization findings. These results are in agree with the results that obtained by **Helal *et al.* (2011), Reddy *et al.* (2018), Agarwal *et al.* (2010), Omar *et al.* (2018) and Niu *et al.* (2019)**.

Conclusion

The characterization of humic and fulvic acids that were extracted from various organic sources such as vermicompost, compost, Farmyard manure, and sheep manure by determining some chemical characteristics, total acidity, and spectroscopic methods. The results indicated that the humic and fulvic acids are acidic and electrical conductivity in fulvic acid more than humic acid that extracted from various organic sources. In addition, the nitrogen content of humic acid was slightly higher than nitrogen content of fulvic acid extracted from different organic sources. Humic acid had C/N ratios between 4:1 and 13.2:1 in its composition. However, fulvic acid C/N ratios varied from 7.40:1 to 18.2:1. The total acidity of fulvic acid was higher than humic acid. Also, carboxyl and phenolic-OH groups of humic and fulvic acids varied depending on the sources of organic materials. The findings reported that E_4/E_6 ratio values of fulvic acid were higher than humic acid. FTIR spectra indicated that aliphatic compounds, carboxyl, and hydroxyl groups in humic substances structures.

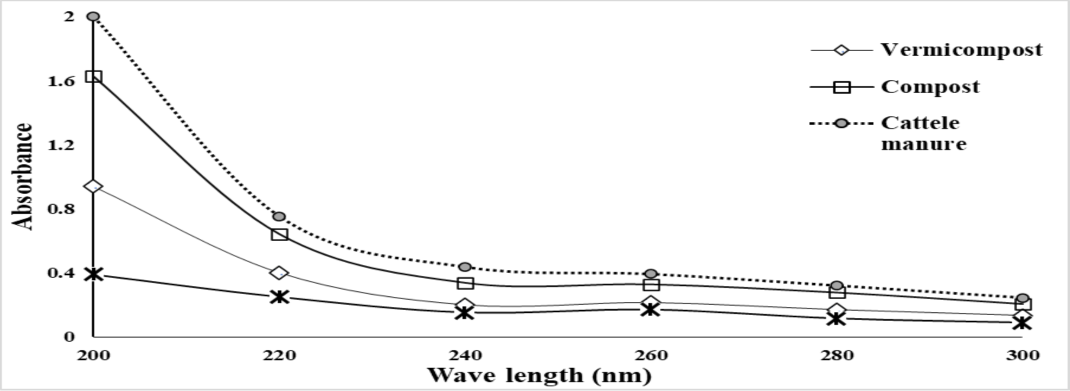

Fig. 1. UV- vis spectra of humic acid extracted from different organic sources

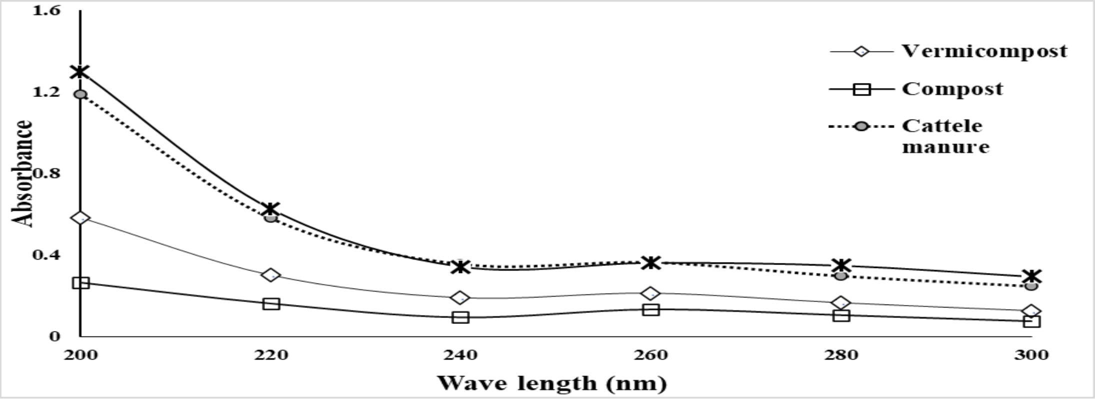

Fig. 2. UV- vis spectra of fulvic acid extracted from different organic sources

Table 4. Proposed attributions for wavelengths (cm^{-1}) of FTIR spectra

Wavelengths cm^{-1}	Proposed attribution
3700-3620	Free OH stretch
3400-3200	OH stretch, inter- and intra-molecular N-H, amine NH and phenol OH
1660–1630	Amide C=O stretch; quinone C=O and/or C=O bonded to H in paired ketones; C=C aromatic
1600–1580	C = C aromatic group stretching
~1430	Stretching of methyl and methylene C-H bonds
1400–1380	Aliphatic C-H stretch
<1000	C-O stretches; aromatic C-H corresponding to polysaccharides and carbohydrates

Stevenson (1994)

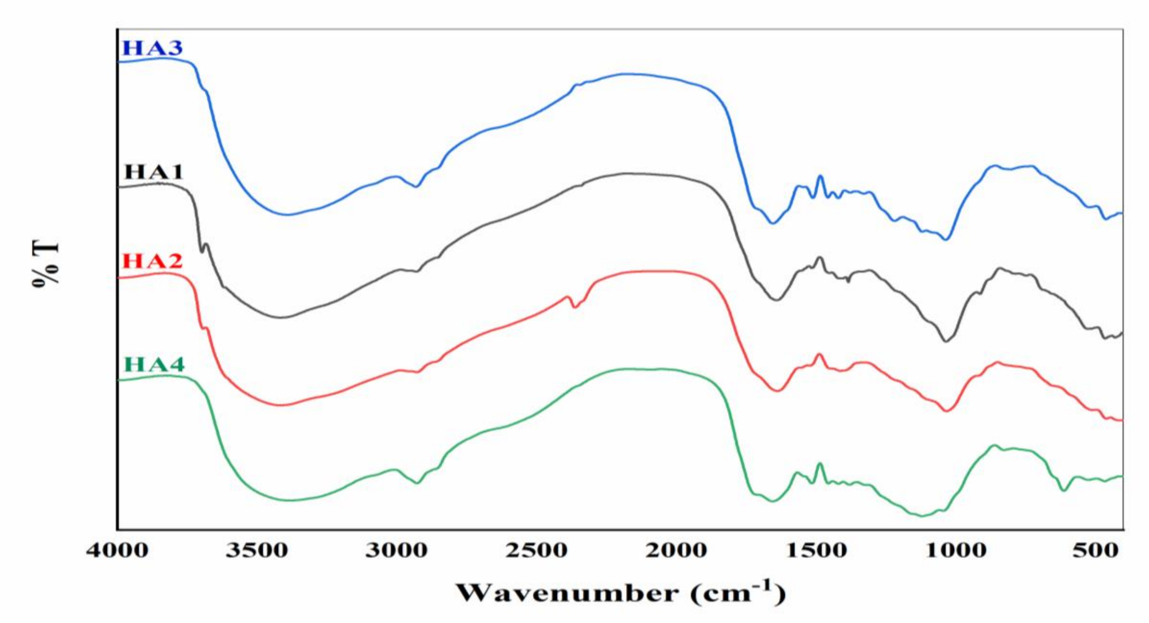

Fig. 3. FTIR spectroscopy of humic acid extracted from different organic sources as HA1 is humic acid extracted from vermicompost, HA2 is humic acid extracted from compost, HA3 is humic acid extracted from farmyard manure and HA4 is humic acid extracted from sheep manure

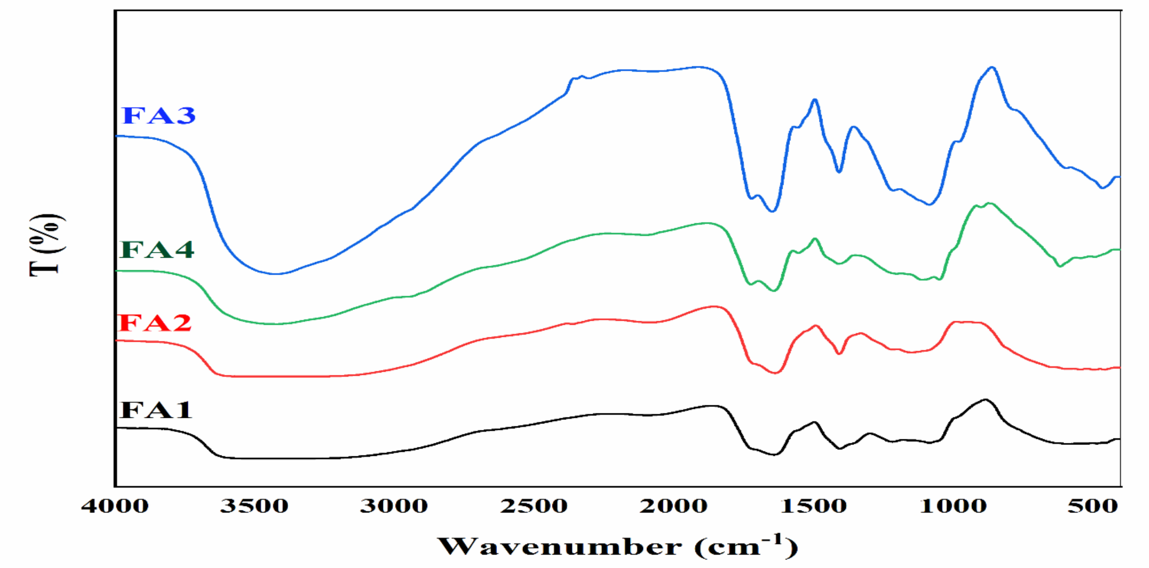

Fig. 4. FTIR spectroscopy of fulvic acid extracted from different organic sources as FA1 is fulvic acid extracted from vermicompost, FA2 is fulvic acid extracted from compost, FA3 is fulvic acid extracted from farmyard manure and FA4 is fulvic acid extracted from sheep manure

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الملخص العربي

تحليل مقارن لاستخلاص وتوصيف أحماض الهيوميك والفالفيك من مصادر عضوية مختلفة

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يوجد ندرة في المعلومات حول الخصائص الكيميائية والطيفية لمركبات الهيومبك المستخلصة من مواد عضوية مختلفة. ولهذا الغرض تم اجراء تجربة معملية لاستخلاص أحماض الهيوميك والفالفيك من الفيرميكمبوست، الكمبوست، السماد البلدي وسماد الأغنام. وقد تم تقدير الخصائص الآتية وهي: الملوحة الكلية (EC)، رقم الحموضة (pH)، الكربون العضوي، النيتروجين ، الحموضة الكلية و E_4/E_6 بالإضافة الى الخصائص الطيفية باستخدام UV-Vis spectroscopy وFTIR. وقد أوضحت النتائج أن أعلى درجة الحموضة كانت 3.25 لحمض الهيوميك المستخلص من سماد الأغنام. وأيضا أعلى ملوحة كلية كانت 6.68 ديسمينز/متر لحمض الفالفيك المستخلص من سماد الأغنام. أيضاً أظهرت النتائج أن نسبة النيتروجين/الكربون لحمض الهيوميك أقل منها لحمض الفالفيك وذلك من كل المصادر العضوية المستخدمة. وبالمقارنة مع حمض الهيوميك كان حمض الفالفيك له حموضة كلية عالية بالإضافة الى احتواء حمض الفالفيك على المجاميع الكربوكسيلية والفينولية بكمية أعلى من حمض الهيوميك المستخلص من كل المصادر العضوية المستخدمة. وأوضح تحليل UV-Vis spectra على احتواء أحماض الهيوميك المستخلصة على المركبات الأروماتية. وأوضحت نتائج الأشعة التحت حمراء على احتواء أحماض الهيوميك والفالفيك على المجاميع الأليفاتية والكربوكسيلية والهيدروكسيل وتختلف كمياتهم باختلاف المصدر العضوي المستخدم.

الكلمات الإسترشادية: حمض الهيوميك، حمض الفالفيك، المجاميع الوظيفية، الأطياف فوق البنفسجية، الأشعة التحت حمراء.

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