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ARTICLE

Study of Elements, Functional Groups and UV Characteristics of Trapped Dust in the Filters of Air Conditioners for the Purpose of Air Quality Awareness

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Abstract: The current study on air quality awareness at Bowen University was undertaken to determine elements, functional groups, and UV characteristics of air conditioning (AC) filter dust collected from various buildings on campus. Atomic absorption spectroscopy (AAS), Fourier transform infrared spectroscopy (FTIR), and ultraviolet (UV) analysis were performed on the samples to raise community awareness. AAS revealed the presence of eleven elements in the samples: Na, K, Ca, Mg, Fe, Cd, Zn, Mn, Cu, and Cr. FTIR analysis identified thirteen functional groups with origin = N – H, C – N, N – H, SiO_3, C – S, C – H, -NCS, = N – H, -O-C≡N, C = C – C, -C=N-, P – O – C, and C≡C, with maximum wavenumber peaks ranging from 3350 to 3320 cm^{-1}. The transmittance ray's visibility showed the presence of the orange-to-red spectrum at wavelengths between 650 and 750 nm. The study concludes that the presence of these elements, functional groups, and UV rays in the dust accumulated on AC filters underscores the importance of regular cleaning and maintenance. Proper upkeep of AC filters can help prevent dust inhalation, reducing the risk of nasal and respiratory diseases within the community.

Keywords: Dust sample, Elements, Functional groups, Air quality, Location.

Introduction

Indoor dust composition varies depending on location and is influenced by outdoor activities that occur in any area. Textile fibers, decomposing organisms, animal and human skin, rusted food, polyester bags, roadway and sand dust, and other factors all add to the number of tiny particles in interior dust. Pollutants such as zinc, nickel, lead, copper, and cadmium are commonly associated with automobile emissions in all parts of the world [1-4]. Fossil fuel use, as a result of waste material generated from various stations such as refineries, industries, brick-laying activity, and mining, may also contribute to harmful components found in the atmosphere that penetrate various residential and commercial locations [5, 6].

Most people spend the majority of their lives indoors, either at home or at work, where air quality reflects their health efficiency [5, 7, 8]. This is in contrast to outdoor air quality, where different particles are inhaled in varying quantities, most of which may be toxic [3]. indoor air quality is determined by the condition of air filters in the interior unit of an air conditioner (AC) in residential and commercial buildings [5]. Dealing with the issue of critical indoor dust knowledge has a significant impact on the composition of air quality [9-11].

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According to many authors, heavy metal composition and other harmful pollutants are researched in various locations around the world [12, 13], particularly roadway dust, soil dust, and air quality within and outside residential areas [10, 14-22].

It is a well-known truth that interior dust in the vicinity of any busy roadway has a substantial impact on settlers due to the huge or tiny amount of dust inhaled by them [5, 23, 24]. Large metropolitan characteristics and air quality of roadside dust are known to be one of the ecological contaminations in the environment, according to authors such as Sezgin *et al*. [16], Pagotto *et al*. [25], and Elik [26]. According to research, harmattan dust at the height of about 300 m above ground level, which is above the stratospheric region of the atmosphere, contributes to dust accumulation in air conditioning (AC) units at Bowen University. However, the transportation and deposit of this Saharan dust have a significant impact on the Earth's radiation budget [27-29]), with both beneficial and detrimental effects on human health [15, 30-33]. Dust particles contribute to the nasal congestion experienced by humans [34, 35]. Reports indicate that dust accumulation is widespread in both residential and commercial areas [8, 27, 29, 35-47]. Sunnu *et al*. [35] discovered that the impacts of dust are related to climate-related effects rather than the physical properties of the dust. This demonstrates that dust has been identified as a significant contributor to the global radiation balance [41-46]. It has been noted that some commercial districts in Nigeria have a significantly higher number of air conditioners (ACs) than residential areas. However, in business areas, most of these air conditioners are in operation from January to April which is Nigeria's hot season, and dust is particularly noticeable at this time of year. It has been stated that during this time of year, AC filters capture more dust, providing greater information on the indoor air quality. Because of the activities that take place in these locations, a study conducted in Lahore, Pakistan's second-largest city, revealed that the dust content of AC filters in commercial areas is substantially higher than in residential areas [48, 49]. Nigeria is a country with a unique perspective on cleaning its surroundings, in which environmental dust settles into homes [50], potentially causing health problems owing to poor cleaning and poor air quality all over the country. Bowen University is no exception. Therefore, the goal of this study is to determine the elemental composition and functional groups present in AC filter dust within Bowen University's indoor environments. The findings will help raise awareness about the importance of cleaning AC filters for the benefit of the community's residents' health.

Sampling City Site

Bowen University, located in the ancient city of Iwo, was used for the collection of the samples (7.6401°N, 4.1770°E). The city is located in the western portion of Nigeria, and the vegetation is rainforest. The land area of the city is 7,543km^2. The city's highest temperature is 24°C, with a relative humidity of 92%. Bowen University features a variety of structures, including administrative buildings, classrooms, dormitories, offices, cafeterias, a worship center, and other facilities. To ensure comfort for staff and students, most of these buildings are equipped with different brands of air conditioners (ACs). The sampling locations are shown in Fig. 1.

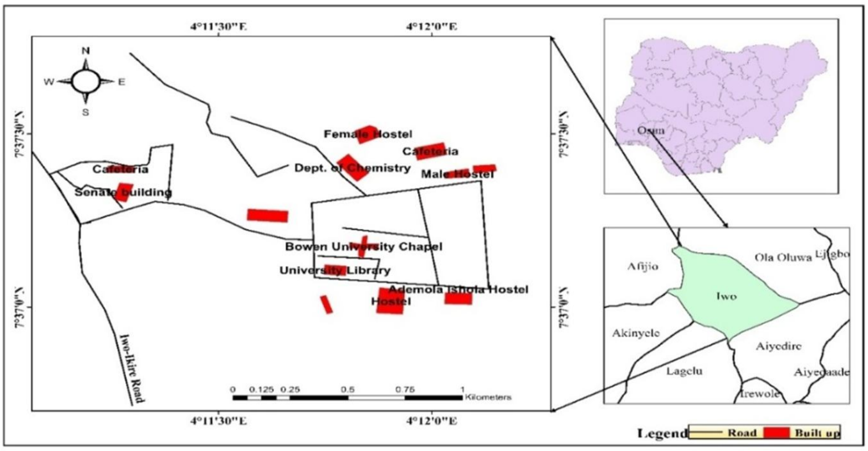


FIG. 1. Map of Bowen University showing the sampling location.

Materials and Methodology

Sample Collection

Dust particles were collected from the air filters of indoor air conditioning units installed in various buildings at Bowen University. The collection sites included the Senate building (administrative), university library, worship center (chapel), offices, classrooms, student hostels, and the cafeteria. Samples were obtained using a direct collection method in which dust particles were suspended in distilled water and subsequently extracted for analysis. This approach aligns with previous studies by Aweda et al. [2] and Falaiye et al. [31], who used a direct deposition method involving distilled water.

To avoid contamination from external sources, the collected samples were sealed in polythene polyamide bags and stored in a refrigerator until analysis. For accuracy, both dust samples from AC filters and a controlled AC filter dust sample were collected to ensure meaningful results.

Sample Preparation and Analysis

- Method for Preparing AAS Samples

The collected dust samples were analyzed in the laboratory using Atomic Absorption Spectroscopy (AAS). The AAS instrument used was an Agilent Technologies PG990 model (Buck Scientific). Before analysis, the dust samples were digested to extract trace elements. The digestion process involved transferring the sample quantitatively into a beaker, followed by the addition of hydrochloric acid (HCl) and heating on a hot plate. For safety, digestion was performed inside a fume cupboard.

Each liquid sample (six samples in total) was prepared by adding 50 ml of solution, which was then heated until reduced to 20 ml by adding 5 ml of hydrochloric acid. The filtered samples and filtrates were chemically analyzed to determine the trace element composition. This procedure follows the methodology reported by Aweda *et al*. [15] and Chineke and Chiemeka [51].

- Standard Solution for AAS

The standard solution used in this study was prepared from a stock solution of 1000 mg/L. Dilutions were performed in stages, with nitric acid (>1%) added to prevent precipitation. The sensitivity or characteristic concentration was defined as the analyte concentration yielding an absorbance signal of 0.0044 units. The detection limit was determined as three times the standard deviation of a blank solution.

Table 1 presents the standard values used in analyzing the AAS data. It also includes the working range of the samples, along with the instrument parameters, alternative wavelengths, standard solutions, and potential interferences identified using the PG990 series instrument.

TABLE 1. Elements and their calibration and detection limits.

Elements	Analytical Line (nm)	Bandwidth (nm)	Filter Factor	Lamp Current (ma)	Integration Time (sec)	Sensitivity (mg/l)	Detection Limit (mg/l)	Working Range (mg/l)
Na	589.0	0.2	1.0	5.0	3.0	0.003	0.002	0.02-1.0
K	766.5	0.4	1.0	5.0	3.0	0.008	0.001	0.008-1.2
Ca	422.7	0.4	1.0	5.0	3.0	0.01	0.0042	0.02-2.00
Fe	248.3	0.2	1.0	5.0	3.0	0.05	0.0046	0.03-8.0
Cd	228.8	0.4	1.0	5.0	3.0	0.012	0.0028	0.02-2.20
Zn	213.9	0.4	1.0	5.0	3.0	0.01	0.003	0.01-3.0
Mn	279.5	0.4	1.0	5.0	3.0	0.002	0.002	0.01-3.5
Cu	324.7	0.4	1.0	5.0	3.0	0.03	0.004	0.018-4.0
Cr	357.9	0.4	1.0	5.0	3.0	0.05	0.005	0.04-8.0

Sample Preparation for Fourier-Transform Infrared Spectroscopy (FT-IR)

The samples were taken to the laboratory for analysis utilizing an FTIR instrument installed in the Bowen University's central laboratory for this study. The equipment, manufactured by Agilent Technologies, is the CARY 630 FT-IR model. To prevent the liquid sample from settling in the container, it was vigorously agitated with a magnetic stirrer. A 0.2 ml portion of the sample was dropped on the machine's sensor. The sample was then exposed to radiation to determine the spectrum it contained. The FT-IR machine was calibrated using polystyrene film, which was coupled with an ATR (attenuated total reflectance) with a diamond crystal surface. Table 2 shows the resolution and wavenumber values used for the analysis of the samples. The interferometer is permanently designed using Michelson 45^0 mechanical flexures to enhance the machine's sensitivity.

TABLE 2. The resolution of the FTIR machine used for the analysis.

Resolution (cm^{-1})	Wave number Accuracy (cm^{-1})	Wave number reproducibility (cm^{-1})	Interferometer (mm)	Spectral Range (cm^{-1})
4.00	0.05	0.005	25	4000-650

UV Sample Preparation

Dust samples were collected from several locations across Bowen University and evaluated using a UV-1800 spectrophotometer with serial number A114550 made by USA Inc. 50196 in absorbance measurement mode. The spectra were obtained by exposing the samples to a standard wavelength range of 200 to 800 nm at a speed of 0.5 m/s. The peaks in the spectra were determined accordingly. The settled samples were stirred using a magnetic stirrer, and then 5 ml of each sample was dropped into the machine sample analyzer for examination. A spectrum-generating machine was used to create the spectrum for each sample.

Additionally, the resulting spectrum was standardized by identifying the peaks in the spectrum using the standard waveband. The UV-1800 spectrophotometer used is a double-beam UV-visible spectrometer, incorporating a tungsten lamp to supply radiation in the visible region and a deuterium lamp to supply radiation in the ultraviolet region. The detector used for measurements is a photocell.

Results and Discussions

AAS Analysis of Air Conditioner Dust at Different Locations

The AAS results, as shown in Table 3, reveal the presence of ten elements: Na, K, Ca, Mg, Fe, Cd, Zn, Mn, Cu, and Cr. The concentrations of these elements vary by location at Bowen University. The elemental compositions and their concentrations (in mg/m³) are summarized in the table. The AAS analysis revealed that these elements are present in different concentrations across the locations.

As demonstrated by the AAS data, dust directly influences the climate by scattering or absorbing incoming solar radiation. Additionally, dust indirectly affects the climate by acting as nuclei on which clouds can form, as discussed by researchers including Chineke and Chiemeka [51], Temmerman et al. [52], Gupta and Mandariya [53], and the World Health Organization [54]. The direct influence of dust on climate is largely due to human activities, such as fossil fuel combustion (including from vehicles), metal processing industries, and waste incineration near the university, which contribute to the presence of dust particles in the environment.

TABLE 3. AAS results of the selected locations in Bowen University

Stations	Na	K	Ca	Mg	Fe	Cd	Zn	Mn	Cu	Cr
Senate	25.97	4.12	2.93	7.51	7.53	0.158	0.079	0.076	0.046	1.822
Library	22.65	4.78	1.99	7.44	7.00	0.168	0.089	0.095	0.056	1.833
Chapel	19.42	3.98	2.55	7.01	7.67	0.254	0.098	0.085	0.067	1.755
Offices	24.67	2.99	2.79	6.99	7.56	0.169	0.075	0.075	0.047	1.835
Cafeteria	23.50	4.56	3.00	7.43	7.45	0.211	0.057	0.055	0.672	1.834
Hostel	25.33	4.15	2.58	7.23	7.78	0.155	0.097	0.072	0.045	1.847
WHO [54]	0.005	8.7	0.4	0.4	0.4	5.0	0.4	0.01	0.03	0.5

Atomic Absorption Spectroscopy (AAS). Unit: mg/m^3.

The acceptable levels for Fe, Ca, Mg, and Zn in air for human respiration are set at 0.4 mg/m^3 for twenty-four hours, according to Gupta and Mandariya [53] and the World Health Organization [54]. Meanwhile, according to the AAS machine, the average concentrations of these elements in this study were found to be: Fe 7.50 mg/m^3, Ca 2.64 mg/m^3, Mg 7.27 mg/m^3, and Zn 0.08 mg/m^3. This demonstrates that the dust levels at various locations on the Bowen University campus are both above and below the WHO's recommended standard values for human health. The variation in these values could be attributed to activities occurring in the surrounding environment, such as vehicular movement, abattoir operations, and industrial activities at the university.

Although there is a slight increase in iron content across the area, the air at Bowen University may not be entirely clean. Iron, however, is essential for the survival of plants and animals, as it plays a crucial role in the production of chlorophyll during photosynthesis. Additionally, iron is a vital component of hemoglobin, the substance responsible for oxygen transport in red blood cells. The WHO [54] warns that excessive iron in the body can lead to liver and heart diseases.

The results also show that the concentration of magnesium in the air across all studied locations averaged 7.27 mg/m³, which exceeds the WHO's recommended standard for air quality. Furthermore, the average Ca concentration of 2.64 mg/m³ was found to be higher than the WHO's acceptable level for air quality.

Manganese, a metal used in the production of battery cells and as an oxidizing agent in chemical industries, has a tolerable average value of 0.01 mg/m³, according to the WHO. However, in this study, the average concentration of manganese in the air at Bowen University was observed to be 0.076 mg/m³, which is significantly higher than the recommended value [54].

Zinc (Zn) is an essential component of dust because it is essential for human health and all living organisms. According to research, Zn can be toxic to human health if the concentration is much higher than the World Health Organization's recommendations [54]. The average value observed for this research was 0.08 mg/m^3, indicating that the Zn level in the air is below the World Health Organization's recommended acceptable level [54]. This is potentially due to lower population density in Iwo metropolis and the university itself.

The average potassium (K) concentration in Iwo was found to be 4.10 mg/m³, which is below the WHO's recommended acceptable level of 8.7 mg/m³ [54]. Potassium is a pent borate white, odorless, powerful substance that is flammable, combustible, or explosive and has a high dermal toxicity, as indicated by research from various sources, including Chineke and Chiemeka [51], WHO [54], Zdrowia [55], and Harrison et al. [56].

Figure 2 illustrates the average elemental variations, where Na was found to have the highest concentration, while Mg and Fe showed nearly equal values. Mn had the lowest concentration in the air samples collected.

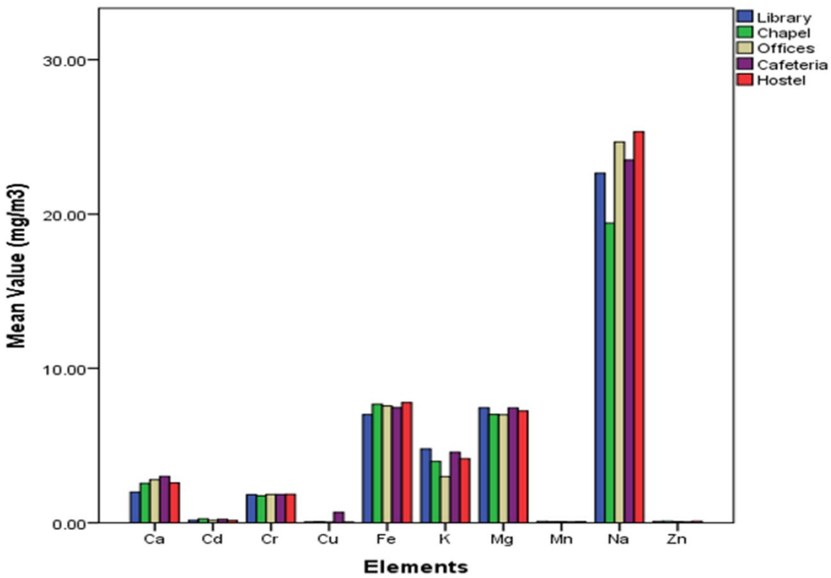


FIG. 2. Average value of each element at different locations.

FTIR Spectral Analysis of Air Conditioner Dust at Different Wavebands

The results of the FTIR spectrum analysis of dust collected from air conditioner filters at Bowen University, as shown in Figs. 3-8, reveal that the spectral waveband peaks and transmittance vary from location to location. The observed corresponding wavebands are

3322.9cm^{-1}, 3317.3cm^{-1}, 3322.9cm^{-1}, 3289.4cm^{-1}, 3267.0cm^{-1}, and 3268.9cm^{-1}, which appear across all study locations. These wavebands are associated with the hydroxyl group, the H single bond of OH stretch observed in the out-of-plane, and are likely present due to the distilled water used to extract the dust sample from the air conditioner.

The bands observed in the spectrum could be attributed to both in-plane and out-of-plane stretches of N-H and O-H single bonds. Additionally, the stretches at 1638.2 cm^{-1} and 1636.3 cm^{-1} indicate the presence of an olefinic/alkene group with a stretch band of C=C present in all of the samples collected. The stretch at 1981.1 cm^{-1}, as shown in Figures 5 and 7, suggests the presence of a C-C single bond in the samples.

Similarly, the stretch values at 1006.4 cm^{-1} and 1028.7 cm^{-1} indicate the presence of phosphate groups in the dust samples from specific locations. Furthermore, based on studies by Cameron [57], Coates [58], and Workman and Springsteen [59], the peak at 1015.7 cm^{-1}, observed at the University Worship Centre and Offices, may be attributed to a P-O-C stretch (aliphatic phosphate) that could result from road construction activities in these areas.

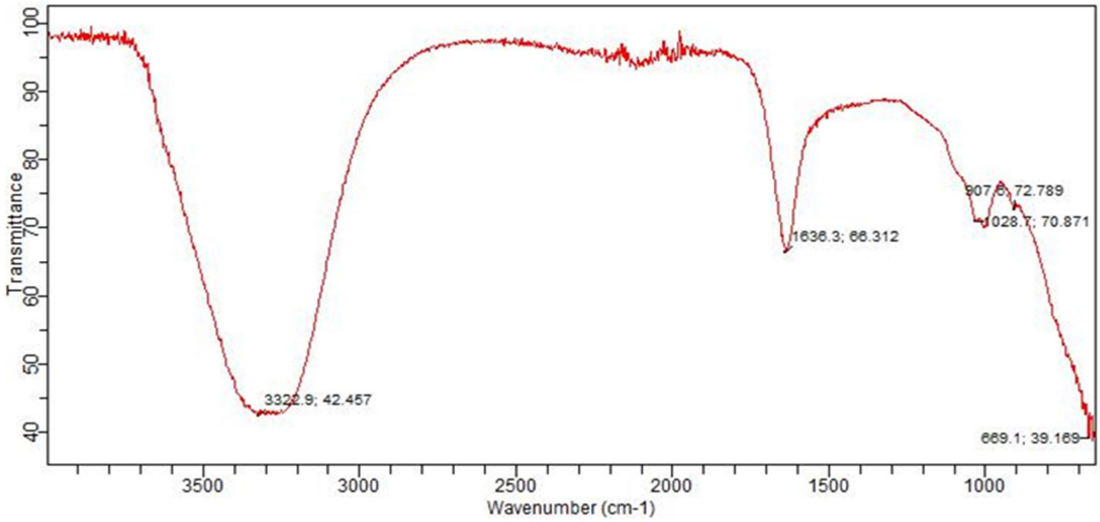


FIG. 3. FT-IR spectrum of samples from the Senate building at Bowen University.

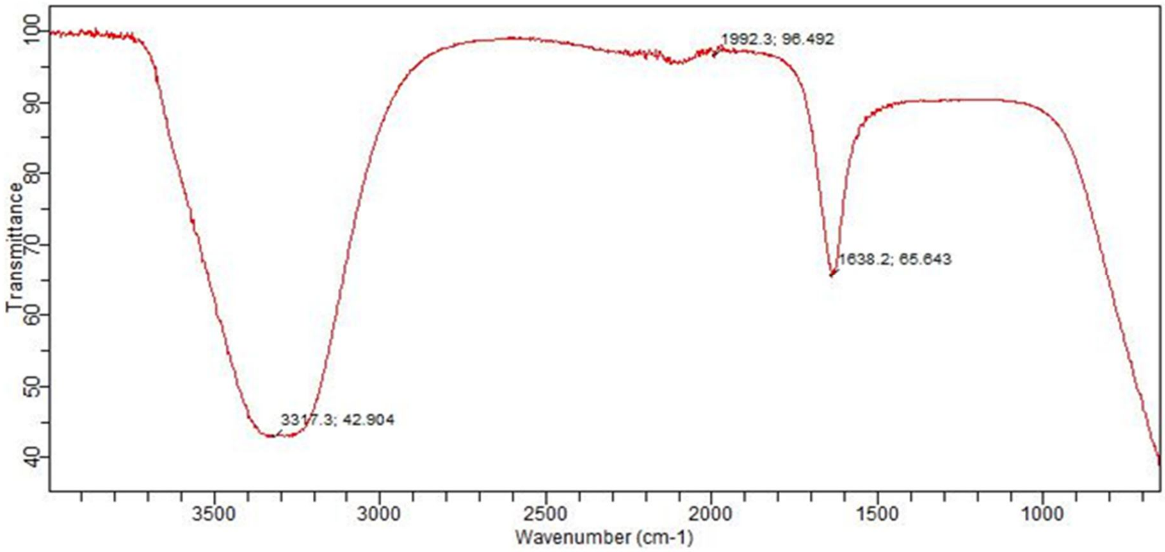


FIG. 4. FT-IR spectrum of samples from the library at Bowen University.

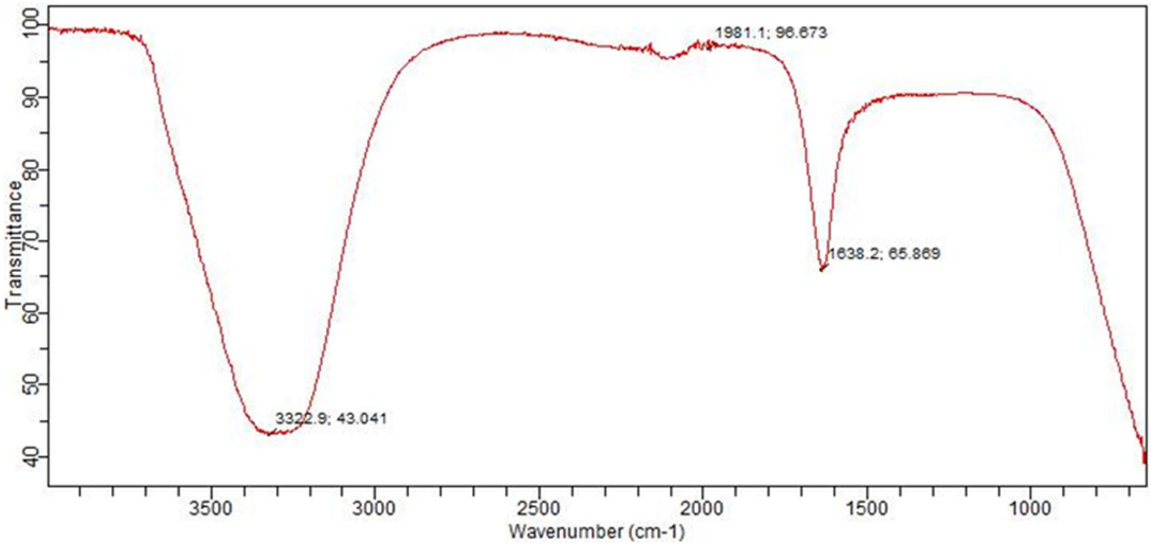


FIG. 5. FT-IR spectrum of samples from worship center at Bowen University.

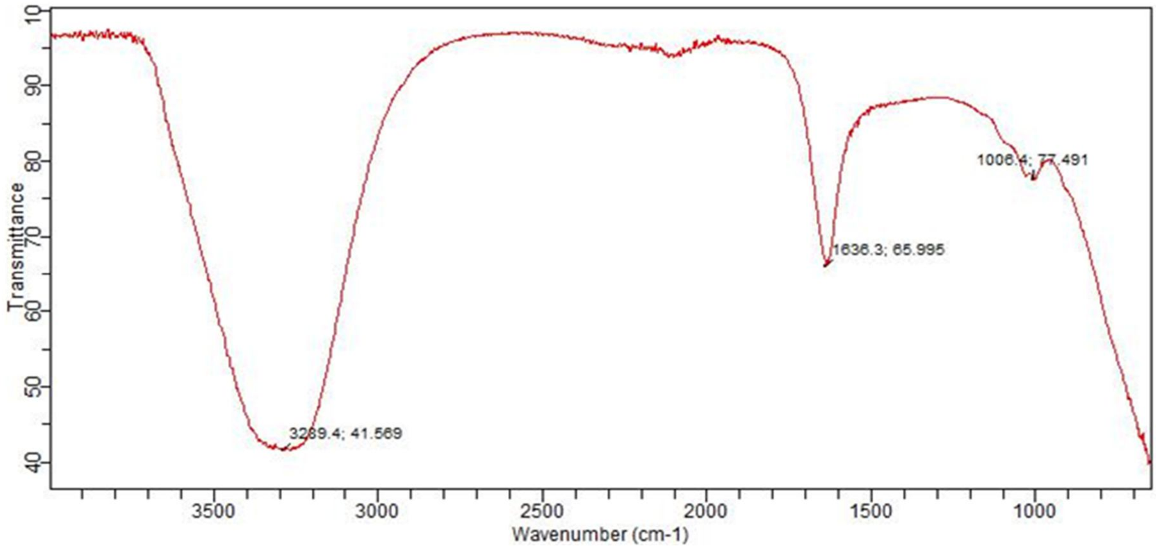


FIG. 6. FT-IR spectrum of samples from selected offices at Bowen University.

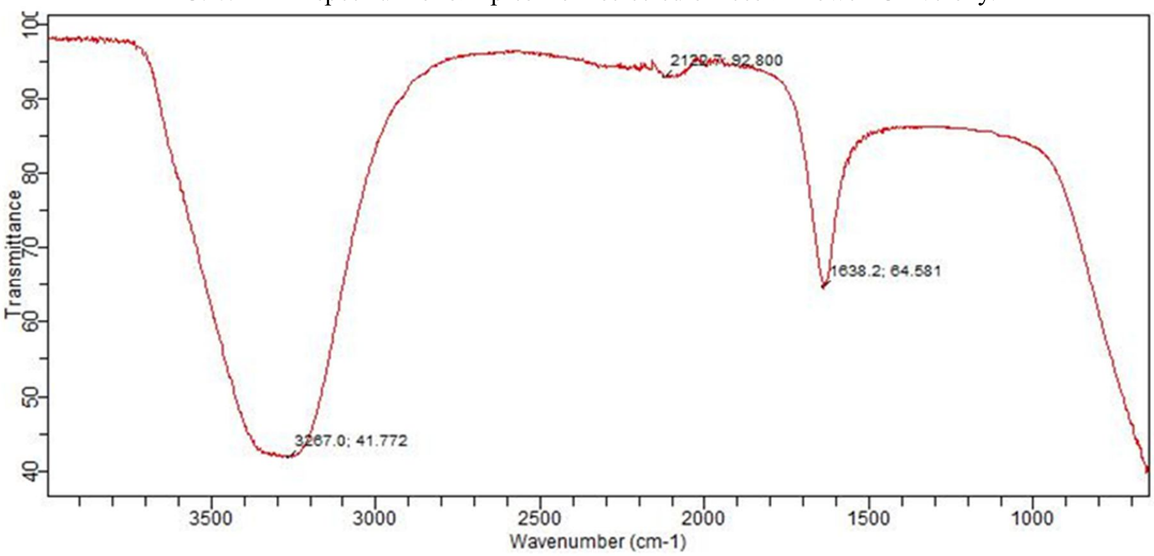


FIG. 7. FT-IR spectrum of samples from the cafeteria at Bowen University.

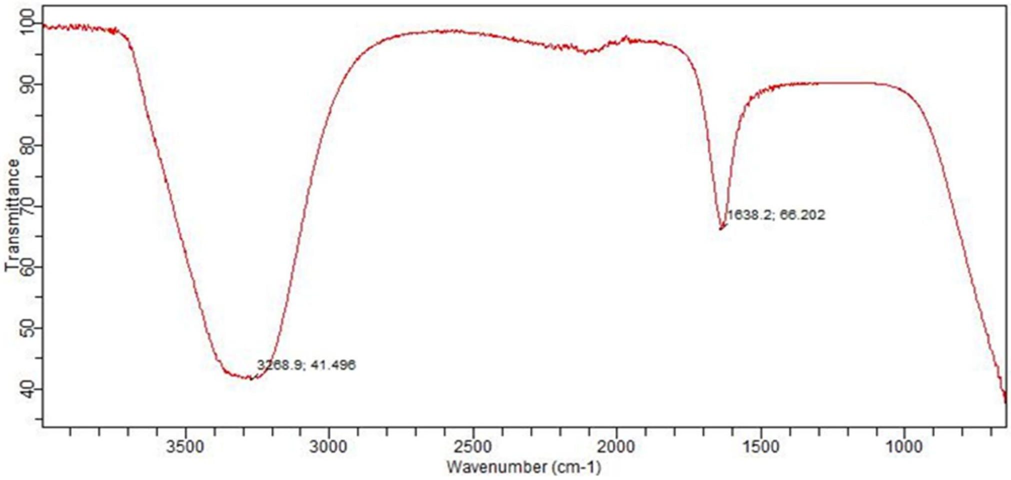


FIG. 8. FT-IR spectrum of samples from the Bowen University hotel.

The broadband in the 3700-3000cm^{-1} range may be attributed to the O-H stretch, which corresponds to hydroxyl groups that are completely removed when the sample is sintered at temperatures above 973 K, as reported by Dey and Ghose [60] and Alpert *et al*. [61]. Thus, the FTIR analysis confirms the presence of harmattan dust in the country's atmosphere.

The results in Table 4 show = N-H with a wavenumber of 3322.9cm^{-1} and a transmittance of 42.457. This value corresponds to imino compounds, characterized by an NH stretch with both double and single bonds. The nitrogen double-bonded groups, including imino and azo groups, exhibit absorption bands similar to the N-H single bond. The Bowen University Senate building appears to contain examples of these frequency bands, observed in a few multiple single bonds and accumulated in the double-bonded region of the spectrum. However, these groups are not as prevalent in other locations due to dust transportation.

The sample exhibits a frequency range of 1680–1630 cm^{-1}, corresponding to the amide functional group, with C-N and N-H single bonds detected at a wavenumber of 1636.3 cm^{-1} and a transmittance of 66.312. This suggests that compounds such as anhydrides and acid halides may react with water, potentially forming amides and esters in the presence of amines and alcohols. Furthermore, infrared spectroscopy provides insightful information on the formation of these compounds. However, these compounds were not detected in samples collected from cafeterias and student hostels, possibly due to differences in activities occurring in these areas.

TABLE 4. The FTIR spectral result analysis of the functional groups

Location	Origin	Group Frequency Wavenumber (cm^{-1})	Functional Groups
Senate Building	= N – H	3350 – 3320	Imino Compound (NH Stretch)
	C – N and N – H	1680 – 1630	Amide
	SiO_3	1100 – 900	Silicate ion
	C – N	1090 – 1020	Primary amino (Primary amide, CN Stretch)
	C – S	715 – 670	Aryl thioethers, Ø - S (C – S Stretch)
Library	C – H	3320 – 3310	Alkyne (C – H Stretch)
	-NCS	2150 – 1990	Isothiocyanate (-NCS)
	C – N and N – H	1680 – 1630	Amide
Worship Centre	= N – H	3350 – 3320	Imino Compound (NH Stretch)
	-O-C≡N	2285 - 1990	Cyanates, isocyanates, thiocyanates
	C – N and N – H	1680 – 1630	Amide
Offices	C – H and C = C – C	1355 – 1320	Aromatic nitro compounds
	-C=N-	1690 – 1590	Open – chain imino
	P – O – C	1100 – 1000	Aliphatic Phosphate
Cafeteria	C – H and C = C – C	1355 – 1320	Aromatic nitro compounds
	C≡C	2260 – 2100	Terminal Alkyne (mono substituted)
	-C = N -	1690 – 1590	Open – chain imino
Hostel	C – H and C = C – C	1355 – 1320	Aromatic nitro compounds
	-C = N -	1690 – 1590	Open – chain imino

The presence of silicate ions in the 1100–900 cm^{-1} region was also revealed by the results shown in Fig. 3. This has a wavenumber of 907.6 cm^{-1} and a transmittance of 72.789. This group demonstrates that silicates are saline in nature and contain silicon (Si) and oxygen anions, resulting in SiO_3. This was not noticed in other places. The presence of SiO_3 in the Senate building indicates that salty activities are occurring there.

Furthermore, according to several writers, silicates constitute approximately 95% of the Earth's crust and upper mantle, making them the primary component of igneous rock. Silicates are also a major source of dust in Nigeria. Additionally, Fig. 3 shows evidence of primary amines in the sample. The C–N single bond stretch, which falls within the 1090–1020 cm^{-1} range, was detected at 1028.7 cm^{-1} with a transmittance of 70.871. However, tertiary amines were found to be more prevalent in the sample. The diagnostic data further reveal that only a single bond C–N vibration is present, and these amides were not detected in all studied locations.

The results also indicate the presence of aryl thioethers, identified by a wavenumber of 669.1 cm^{-1} with a transmittance of 39.169. This suggests the presence of aliphatic or aromatic (aryl) molecular fragments in the sample. Interestingly, aryl thioethers were not found in any other location, which could be attributed to activities specific to the Senate building, such as higher tourist traffic and increased environmental interactions in the surrounding area.

The results of the sample collected at the University library, as shown in Table 4, show that the group frequency ranges from 1680 to 1630 cm^{-1}, with the presence of the amide functional group, along with C-N and N-H single bonds. A wavenumber of 1638.2 cm^{-1} and a transmittance of 66.643 were detected. These findings suggest that compounds such as anhydrides and acid halides can react with water. Additionally, when these compounds interact with amines and alcohols, they may form amides and esters. Infrared spectroscopy further confirmed the presence of these compounds, indicating their significance in chemical processes. However, these compounds were not found in samples from the cafeteria and student hostels, which could be attributed to differences in activities occurring in these locations.

Table 4 also shows the presence of amide in the sample. The C–N single bond stretch, occurring within the 1680–1630 cm^{-1} range, was observed at 1638.2 cm^{-1} with a transmittance of 66.643. Various researchers have noted that tertiary amines tend to be more significant than primary or secondary amines. However, the diagnostic data in this study indicate that the sample contains only a single bond C–N vibration. Notably, these amides were not detected in all the locations investigated.

Additionally, the results reveal the presence of isothiocyanate (-NCS) in the university library sample, identified at a wavenumber of 1992.3 cm^{-1} with a transmittance of 96.492. This suggests the presence of aliphatic molecular fragments. Isothiocyanate was absent in samples from other locations, which may be due to specific environmental activities and increased tourist presence around the university library.

Furthermore, the results in Table 4 for the worship center show the presence of =N–H at a wavenumber of 3322.9 cm^{-1} with a transmittance of 43.041, similar to what was observed in the Senate building. This corresponds to imino compounds, characterized by NH stretching in both single and double bonds. Imino and azo groups, which belong to the nitrogen double bond category, exhibit absorption similar to N–H single bonds. The Bowen University Senate building and worship center appear to contain examples of these frequency patterns, reflected in multiple single bonds and accumulated double-bonded sections. However, these compounds were not detected in other locations, likely due to dust transportation. This was not observed in any other study locations, while the sample's group frequency 1680 –1630 cm^{-1} and amide functional group with C-N and N-H single bonds are said to be present in all locations. It does, however, show that compounds like anhydrides and acid halides react with water. When these compounds react with amines and alcohols, they can produce amides and esters. Furthermore, infrared spectroscopy revealed that the manufacturing of these chemicals is instructive. These compounds were not found in the cafeteria and student hostel samples, which could be attributed to the activities that take place there.

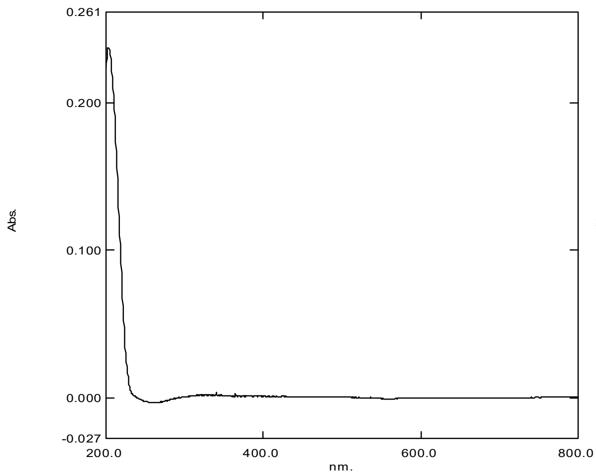
Additionally, the origin of the -O–C≡N broadband signal was observed only in the worship center, with a broadband range of 2285–1990 cm^{-1}. This confirms the presence of cyanates, isocyanates, and thiocyanates in the sample, which were absent from all other locations.

Table 4 further highlights the presence of aromatic compounds containing C=C and C≡C bonds. The samples from offices and the cafeteria exhibited both double and triple bonds. According to Cameron [57], Coates [58], and Coates [62], the triple bond carbon-to-carbon (C≡C) observed at 2120.7 cm^{-1} corresponds to a terminal alkyne of a mono-substituted compound. Additionally, saturated and unsaturated aromatic compounds exhibiting C≡C bonds were found in the cafeteria sample. Similarly, aromatic compounds with carbon-to-carbon double bonds (C=C) were identified in samples from offices and hostels. These observations confirm the presence of aromatic molecular structures in the studied locations.

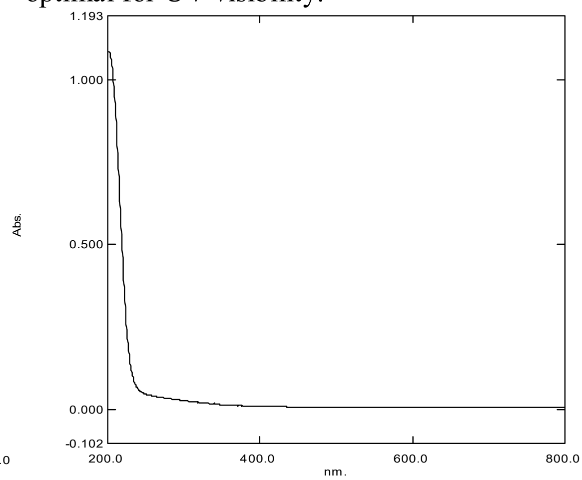
UV Characteristics of Bowen University

The ultraviolet (UV) characteristics of air conditioning (AC) dust collected at Bowen University were analyzed based on its exposure to the electromagnetic spectrum. The wavelength of the dust was found to be between 200 and 800 nm. However, according to Kealey and Haines [63], the visibility region of the spectrum is between 400 and 800 nm.

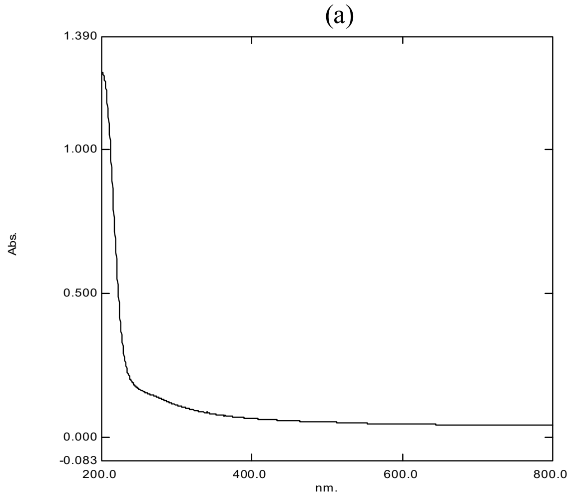
As shown in Figs. 9(a)-9(f), the absorption rate of UV light by the dust samples was weak, as revealed by the results. The absorbance spectra presented in Figs. 9(a)-9(f) indicate that the absorbance values ranged from 1.00 to 0.25 across all locations. Figure 9(a) has a value of 0.25, Fig. 9(b) has a value of 1.10, Fig. 9(c) has a value of 1.2, Fig. 9(d) has a value of 2.3, Fig. 9(e) has a value of 0.85, and Fig. 9(f) has a value of 1.0. According to Falaiye and Aweda [4], an absorbance value below 1.00 is considered optimal for UV visibility.



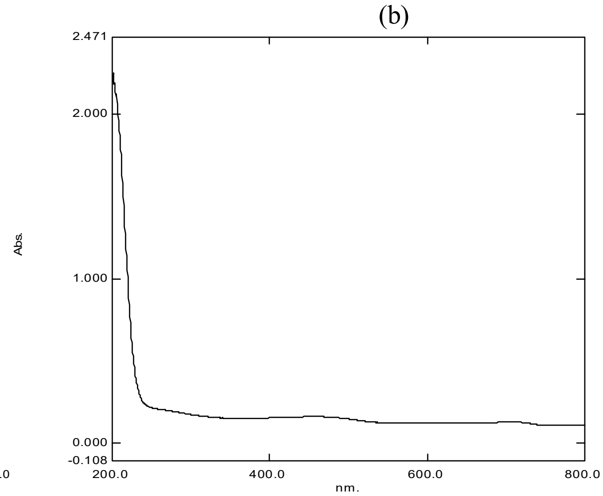
(a)



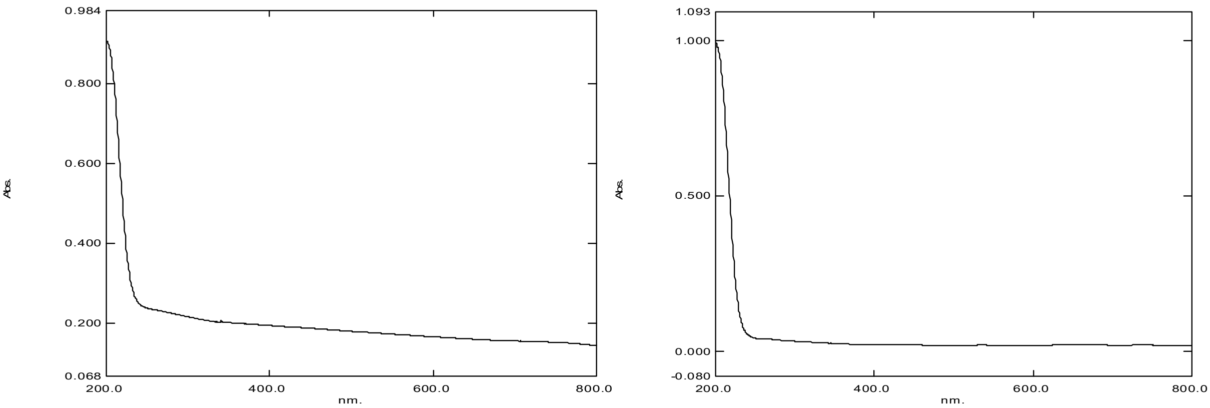
(b)



(c)



(d)



(e) (f)

FIG. 9. UV characteristics of the samples collected at Bowen University

According to Aweda *et al.* [2] and Hemwech *et al.* [64], the visible spectrum for orange ranges between 600 and 700 nm, extending into the red region. Furthermore, the dust sample collected at Bowen University may have both minimum and maximum advantages in terms of the UV relationship. However, the orange to red spectrum indicates that dust may be trapped in the light visibility from solar radiation, which may have an effect on greenhouse radiation. Furthermore, this confirms the presence of greenhouse gases, which may have an effect on some of the chemicals present in the sample.

For each of the locations studied, it was discovered that the higher the incoming absorption in the ultraviolet (320 nm) absorption in the ultraviolet region (320 nm) corresponded with increased infrared wavelength emissions. This demonstrates that the particle has a lower UV concentration when compared to the dust collected at Bowen University. Furthermore, aerosol plays a significant role in the interaction of UV on dust particles across the spectrum transmittance. Furthermore, aerosol is primarily a dust particle that can transport trace metals and particulate matter, such as $PM_{2.5}$ or PM_{10}, throughout the Nigerian zone.

Conclusion

The dust samples collected from the AC filter at Bowen University contained ten elements: Na, K, Ca, Mg, Fe, Cd, Zn, Mn, Cu, and Cr. However, the elements present in the sample followed what was reported by [65, 66]. The functional group present in the sample identified that there are thirteen functional groups with origin (=N – H, C – N, N – H, SiO_3, C – S, C – H, -NCS, = N – H, -O-C≡N, C = C – C, -C=N-, P – O – C, C≡C). Maximum wavenumber peaks ranging from 3350 to 3320 cm^{-1} were observed. The transmittance ray's visibility showed the presence of orange to red within the 650-750 nm wavelength range. As a result, the study concludes that the presence of elements, functional groups, and UV rays in the dust collected from the air filter of the indoor air conditioning unit suggests that air conditioner filters should be cleaned and maintained regularly. Proper maintenance is essential to prevent the accumulation and inhalation of dust, which could lead to various nasal diseases in the community.

Recommendation

The authors wish to recommend to the management of Bowen University that adequate precautionary measures and policies should be made to help mitigate the effects of high elemental concentrations present in the filter of the air conditioner placed in different offices, classrooms, cafeterias, hostels, and other relaxation places in the University. However, for proper verification of air quality at the University, effect of dust on human health, both advantages and disadvantages as well as daily collection of the dust, is also recommended.

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References

[1] Ferreira-Baptista, L. and De Miguel, E., Atmos. Environ., 39 (25) (2005) 4501.

[2] Aweda, F.O., Falaiye, O.A., and Oyewole, J.A., Jordan J. Phys., 14 (1) (2021) 1.

[3] Falaiye, O. and Aweda, F., J. Appl. Sci. Envir. Manag., 22 (2) (2018) 281.

[4] Falaiye, O.A. and Aweda, F.O., Jordan J. Phys., 13 (1) (2020) 17.

[5] Siddique, N., Majid, A., and Tufail, M., J. Radioanal. Nucl. Chem., 290 (3) (2011) 691.

[6] Abiye, O. et al., Ife J. Sci., 16 (1) (2014) 107.

[7] Ezeh, G.C. et al., Hum. Ecol. Risk Assess., 24 (4) (2018) 925.

[8] Abiye, O.E. et al., Environ. Sci. Pollut. Res., 27 (2020) 39317.

[9] Falaiye, O.A. and Aweda, F.O., arXiv preprint arXiv:1806.11557, (2018).

[10] Colbeck, I., Nasir, Z.A., and Ali, Z., Environ. Sci. Pollut. Res., 17 (6) (2010) 1187.

[11] Wasim, M., Nucleus, 47 (2) (2010) 149.

[12] Manoli, E., Voutsa, D., and Samara, C., Atmos. Environ., 36 (6) (2002) 949.

[13] Kothai, P. et al., Aerosol Air Qual. Res., 11 (5) (2011) 560.

[14] Salim A.M. and Madany, I.M., Water Air Soil Pollut., 66 (1) (1993) 111.

[15] Aweda, F.O., Falaiye, O.A., and Babatunde, G.J., J. Appl. Sci. Environ. Manag., 21 (7) (2017) 1313.

[16] Sezgin, N. et al., Environ. Int., 29 (7) (2004) 979.

[17] Han, L. et al., Atmos. Environ., 41 (35) (2007) 7485.

[18] Martinez, T. et al., J. Radioanal. Nucl. Chem., 276 (3) (2008) 799.

[19] Jabeen, N. et al., J. Radioanal. Nucl. Chem., 247 (1) (2001) 145.

[20] Chung, Y.-S. et al., J. Radioanal. Nucl. Chem., 278 (2) (2008) 441.

[21] Waheed, S. et al., J. Radioanal. Nucl. Chem., 285 (3) (2010) 723.

[22] Okhravi, R., J. Sci., 10 (1999) 706.

[23] Zaidi, J. et al., J. Radioanal. Nucl. Chem., 196 (1) (1995) 125.

[24] Waheed, S. et al., Toxicol. Environ. Chem., 83 (1-4) (2002) 13.

[25] Pagotto, C. et al., Environ. Technol., 22 (3) (2001) 307.

[26] Elik, A., Commun. Soil Sci. Plant Anal., 34 (1-2) (2003) 145.

[27] Bryant, A.C., Painter, T.H., Deems, J.S., and Bender, S.M., Geophys. Res. Lett., 40 (2013) 3945.

[28] Su, J., Huang, J., Fu, Q., Minnis, P., Ge, J., and Bi, J., Atmos. Chem. Phys., 8 (10) (2008) 2763.

[29] Tegen, I., Heinold, B., Todd, M., Helmert, J., Washington, R., and Dubovik, O., Atmos. Chem. Phys., 6 (2006) 4345.

[30] Kalu, A. E., “The African dust plume: Its characteristics and propagation across West–Africa in winter”. In: Ed. Morales, C., “Saharan Dust Mobilization Transport Deposit”, SCOPE 14, (John Wiley, 1979), p. 95.

[31] Falaiye, O.A., Yakubu, A.T., Aweda, F.O., and Abimbola, O.J., Ife J. Sci., 15 (2013) 175.

[32] Adimula, I.A., Falaiye, O.A., and Adindu, C.L., Centrepoint Sci. Ed., 16 (2008) 15.

[33] Falaiye, O.A., Aweda, F.O., Yakubu, A.T., FUTA J. Res. Sci., 13 (1) (2017) 158.

[34] Resch, F., Sunnu, A., and Afeti, G., Tellus B, 60 (1) (2008) 98.

[35] Sunnu, A., Afeti, G., and Resch, F., Atmos. Res., 87 (1) (2008) 13.

[36] Sunnu, A., Resch, F., and Afeti, G., Aeolian Res., 9 (2013) 125.

[37] Goudie, A.S., Environ. Int., 63 (2014) 101.

[38] de Longueville, F., Ozer, P., Doumbia, S., and Henry, S., Int. J. Biometeorol., 57 (1) (2013) 1.

[39] Sunnu, A.K., J. Environ. Sci. Eng. A, 1 (10A) (2012) 1203.

[40] Ginoux, P., Prospero, J.M., Gill, T.E., Hsu, N.C., and Zhao, M., Rev. Geophys., 50 (3) (2012) RG3005.

[41] Rodríguez, S., Alastuey, A., and Querol, X., Aeolian Res., 6 (2012) 55.

[42] Ravi, S. et al., Rev. Geophys., 49 (3) (2011) RG3001.

[43] Okin, G.S. et al., Eos Trans. Am. Geophys. Union, 92 (29) (2011) 241.

[44] Prospero, J.M., Welcome to Bremen, 10 (2011) 17.

[45] He, C., Breuning-Madsen, H., and Awadzi, T.W., Geogr. Tidsskr.-Danish J. Geogr., 107 (1) (2007) 9.

[46] McFiggans, G. et al., Atmos. Chem. Phys., 6 (9) (2006) 2593.

[47] Breuning-Madsen, H. and Awadzi, T.W., Catena, 63 (1) (2005) 23.

[48] von Schneidemesser, E. et al., Sci. Total Environ., 408 (7) (2010) 1640.

[49] Dybczynski, R. and Suschny, O., Final Report on the Intercomparison Run SL-1 for the Determination of Trace Elements in a Lake Sediment Sample, (IAEA Vienna, 1979).

[50] Alaiyemola, S.R., Abbass, M., and Aweda, F.O., Iran. J. Energy Environ., 15 (1) (2024) 38.

[51] Chineke, T. and Chiemeka, I., Afr. Rev. Phys., 3 (1) (2010) 125.

[52] Temmerman, S. et al., Nature, 504 (7478) (2013) 79.

[53] Gupta, T. and Mandariya, A., Environ. Sci. Pollut. Res., 20 (8) (2013) 5615.

[54] World Health Organization (WHO), The World Health Report 2002: Reducing Risks, (Promoting healthy life, 2002).

[55] Zdrowia, Ĺ.O., "Guidelines for Drinking-water Quality: Health Criteria and Other Supporting Information", (World Health Organization, 1996).

[56] Harrison, R.M. et al., Atmos. Environ., 262 (2021) 118592.

[57] Cameron, E.M., Geochim. Cosmochim. Acta, 45 (6) (1981) 997.

[58] Coates, J., "Interpretation of Infrared Spectra, a Practical Approach", (Citeseer 2000).

[59] Workman J, Jr. and Springsteen, A., "Applied Spectroscopy: A Compact Reference for Practitioners", (Academic Press, 1998).

[60] Dey, S. and Ghose, J., Mater. Res. Bull., 38 (11-12) (2003) 1653.

[61] Alpert, N.L., Keiser, W.E., and Szymanski, H.A., "IR: Theory and Practice of Infrared Spectroscopy", (Springer Science & Business Media, 2012).

[62] Coates, J.P., Appl. Spectrosc. Rev., 31 (1-2) (1996) 179.

[63] Kealey, D. and Haines, P.J., "BIOS Instant Notes in Analytical Chemistry", (Taylor & Francis, 2002).

[64] Hemwech, P. et al., SN Appl. Sci., 3 (12) (2021) 1.

[65] Falaiye, O.A., Abiye, O.E., and Nwabachili, S.C., Proc. Int. Acad. Ecol. Environ. Sci., 11 (1) (2021) 15.

[66] Aweda, F.O., Falaiye, O.A., and Samson, T.K., Jordan J. Phys., 16 (4) (2023) 413.