American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)

ISSN (Print) 2313-4410, ISSN (Online) 2313-4402

http://asrjetsjournal.org/

Determination of Some Trace Elements in Air Samples from the Study Environment of Alasala National Colleges and Study of Irradiated Poly (Vinyl Alcohol) Film: Electrical Properties and Determination of Some Trace Elements

Hassan Aldagham[a], Ahmad Aljishi[b], Mustafa Talag[c], Mohana Attia[d*]

[a,b,c,d]Alasala National Colleges, Dammam, PO. BOX 12666 Dammam code 31483, Saudi Arabia

[d]Email: mohana.attia@alasala.edu.sa

Abstract

This study included two objectives, firstly determination of some trace elements in air samples from the study environment of Alasala National Colleges and secondly study of Irradiated Poly (vinyl alcohol) Film: Electrical Properties and Determination of Some Trace Elements, in the same Environment. The investigate the level of trace elements including Lead [Pb], Copper [Cu], Zinc [Zn] in air samples collected from Alasala National Colleges in Dammam, KSA. The samples were analyzed by X-Ray Fluorescence (XRF). The enrichment factors relative to average soil and crustal rock were done of these trace elements to predict the possible sources of these elements in air. The study revealed that the analysis that is scholarly is wholly free from Pb. The ratio that is average of Zn is 0.0006 and Cu is 0.0003 ng/m^3. Also the determination of some trace elements by thin film x-ray fluorescence and study of electrical properties of Poly (vinyl alcohol) using ion/electron beam. After preparing of the PVA films the trace elements are determined on thin-film samples by x-ray fluorescence spectrometry. The limits of detection on the thin film are 0.05-0.7 μg, depending on the element being measured. This study reports on the effect of nitrogen and electron beam irradiation on the electrical properties of films. Films of 3 mm were exposed to a charged (ion/electron) beam for different treatment times; the beam was produced from a dual beam source using nitrogen gas with the other ion/electron source parameters optimized. The real ($\boldsymbol{\varepsilon}'$) and imaginary ($\boldsymbol{\varepsilon}''$) parts of the dielectric constant decreased with frequency for all irradiated and non-irradiated samples.

----

* Corresponding author.

The AC conductivity showed an increase with frequency for all samples under the influence of both ion and electron irradiation for different times.

Keywords: Alasala National Colleges; Enrichment factor; Trace elements; PVA; XRF; Electrical conductivity; Irradiation; Ion/Electron beam.

1. Introduction

Air is a mechanical mixture of a variety of individual gases enveloping the terrestrial globe to form the earth's atmosphere [1] Air pollution is the presence in the outdoor atmosphere of one or more contaminants, such as dust, fumes, gas, mist, smoke, or vapour, in quantities, of characteristics, and of duration such as to be injurious to human, plant, or animal life or to property, or to interfere unreasonably with the comfortable enjoyment of life and property. Air pollution by solid particles includes both actual deposition and suspension of dust in the air. The bigger particles are trapped in the outer breathing passage (nose, throat) and at least partly expelled from there. The effect of these particles are therefore mainly confined to upper part of the respiratory system, where they may set up irritation. In addition of these medical consequences of particles in suspension, those deposited particles cause fouling of houses, furnishings, plants, garden equipment, and anything else that is exposed to air [2]. In this study the level of trace elements including Pb, Cu, Zn were investigated.

1.1. Trace elements

Trace elements are chemical elements that are present in low concentration, usually in the range of milligram per kilogram (mg/kg) or in part per million(ppm). The term is also used to designate a number of chemical elements contained in soil, minerals, rock, water and organisms [2]. In geochemistry, the frequently used definition for, trace elements, also known as microelements, are chemical elements whose concentration in the earth's crust is less than 0.1 per cent by weight [3]. At present, trace elements analysis is defined as the determination of trace elements below about 100 mg/g in a sample [4]. Trace elements can be classified into major and minor or alternatively as nutrient and pollutants. Nutrient trace elements are essential elements absorbed from soil by plants and they are needed in relatively large amounts (macronutrients) such as N, P, Ca, K and Na.

Deficiency of these elements in the [5] soil retards the growth of the plants. Other nutrient elements called (micronutrients) such as Fe, Mn, Cu, Zn, Co are used by higher plants in very small amounts. They are less essential than macronutrients, but they are needed in small quantity [6]. The environmental harmful effects of pollutant trace element arise from urban industrial and agricultural pollutants. Although some of these effects are associated with traditional processes, most are of fairly recent origin. Cd, Pb, Hg, and Ni are considered as major pollutant heavy elements, while Ba, B and V are considered as minor pollutants, a fact depending on their abundance30. The term heavy metals refer to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations. Some heavy metals, e.g. Cu, Se and Zn, are essential to maintain the metabolism of the human body [7]. Heavy metals are dangerous because they tend to bioaccumulates. Bioaccumulation means an increase in the concentration of a chemical in a biological organism over time, compared to the chemicals concentration in the environment [8].

1.2. Poly (vinyl alcohol) (PVOH, PVA, or PVAl)

Poly (vinyl alcohol) (PVOH, PVA, or PVAl) is a water-soluble synthetic polymer. It has the idealized formula [CH2CH(OH)] n. It is used in papermaking, textiles, and a variety of coatings. It is white (colorless) and odorless. It is sometimes supplied as beads or as solutions in water [9]. Pollution by solid particles includes both actual deposition and suspension of dust in the air. The bigger particles are trapped in the outer breathing passage (nose, throat) and at least partly expelled from there. The effect of these particles are therefore mainly confined to upper part of the respiratory system, where they may set up irritation. In addition of these medical consequences of particles in suspension, those deposited particles cause fouling of houses, furnishings, plants, garden equipment, and anything else that is exposed to air [2]. Radiation treatment of polymer materials include subjecting polymers to irradiation, ordinarily in a continuous mode, to change the polymers to progress their properties for industrial objective. Radiation treatment of polymers is a non-power application and mainly consists of cross linking, curing, grafting, and degradation [10]. Electron beam irradiation is a based tool for change the chemical structure and physical characteristic of a polymer's surface [11]. Polyvinyl alcohol (PVA) can be applied as dielectric material in thin-film transistors. PVA is hydrophilic in nature and thus can be utilized as a polyelectrolyte-based resistive sensor [12]. In this study the level of trace elements investigated. Also, Films of 3 mm were exposed to a charged (ion/electron) beam for different treatment times (20, 40, and 80 minutes). The dielectric loss tangent $\tan \delta$, electrical conductivity σ, and dielectric constant ε' in the frequency range 100 Hz–100 kHz were measured at room temperature. The variation of dielectric constant and loss tangent as a function of frequency was also studied at room temperature.

2. Materials and Methods

2.1. Study location

Alasala National Colleges is located north of Dammam city in Saudi Arabia and it is about 20 km from the down town. It covers an area of 64.155 square meters, with 35,000 square meters of buildings.

2.2. section A: determination of some trace elements in air samples from the study environment

2.2.1. Data collection and limitation of the study

The air was drawn through the filter by a Millivac vacuum pump Fig 1, and gas meter fig 2, was used to measure the volume of the air samples in each time. Twenty air samples were collected from the area. The collection time per sample was one and half hours, and the samples were taken nearly discrete from ^{5}th to ^{20}th April 2018.

2.2.2. Air samples analysis

All air samples were collected on Nuclepore Membrane Filter, fig 3, were presented directly to x- ray florescence [for metal analysis and sorting, compliance screening, environmental analysis and mining applications], fig 4, after the calibration of the instrument.

Figure 1: Millivac Vacuum pump

Figure 2: Digital Gas meter, model MF5706-N-200

Figure3: Nuclepore membrane filter [Whatman: diam. 13mm, pore size 0.1 micrometer

Figure 4: SPECTRO xSORT handheld XRF

Each sample was irradiated. The time of collection was 2000 second. samples were prepared on Nuclepore Polycarbonate membrane filter. The main part of XRF spectrometer, source in this case 109 cd with energy 22.1 Kev. The detection system detector (ORTEC) with 6.4 Kev, Amulbi channel analyzer to process the spectra. Computer was used for the collection of the spectra and their analysis.

2.3. section B: study of Irradiated Poly (vinyl alcohol) Film: Electrical Properties and Determination of Some Trace Elements

In this section, the researchers used the same model of local designing a modified saddle-field ion source at the Egyptian Atomic Energy Authority, Egypt. for M. M. Abdelrahman and F. W. Abdelsalam [16].

2.3.1. PVA film preparation

Different concentrations (2, 4, and 6 g) were dissolved in 70 ml distilled water and heated until complete dissolution at 800 C for 4 h, then cast on a glass plate and left to dry for 4 days to obtain uniform and homogenous surfaces. It was found that, the best films are 0.03 and 0.05 g/ml ones. After preparing the film, it was exposed to different treatment times (10, 25, and 40 minutes) from a dual ion/electron beam source with low energy using nitrogen gas.

The electrical properties of the polymer samples were investigated at room temperature by using a system [13]. DSP Dual Phase Lock-In Amplifier (SR830) is used to measure the voltage difference (VR) between the two ends of known resistance R in an equivalent RC circuit.

Measurements were carried out at frequency range (1mHz–102.4 kHz) over the temperature range (200–400 K) in vacuum of about mbar. Data logger software is used for controlling and gathering the data through IEEE-488 GPIB and 332 serial interfaces with different tools. The two surfaces of each polymer sample were coated with silver paint, checked for good conduction, and then kept in between the two cell electrodes for making measurements. The 3 mm thin films were exposed to a charged (ion/electron) beam for various treating times (0, 20, 40, and 80 minutes); the radiation was generated from a dual radiation source using nitrogen gas with the other ion/electron source factors optimized. The experimental framework used for dual beam treating is a local built system, shown in Figs. 5(a) and (b) [14].

The source consists of two copper anode rods surrounded by a cylindrical cathode. A blank Perspex cylinder was put inside the cylindrical cathode, relative to it. The Perspex cylinder had two opposite holes with a diameter of 5 mm, to output the highest ion and or electron beam current. The film samples were put on a Faraday cup at both sides 1.5 cm from the cylindrical cathode. A saddle-field ion source was used to obtain the dual beam with nitrogen and consequently irradiate the film surface. In case of the ion source, the anode was connected to the positive polarity of the power supply, while, in case of the electron source, the anode was connected to the negative polarity and the cathode was earthed. The system was evacuated up to about 5×10^{-5} mbar to remove the residual gases before gas injection into the source. The ion/electron fluence was estimated by time of irradiation and beam current as [15]:

$$I = Q / t = Dqe / t = \varphi\ Aqe / t \quad (1)$$

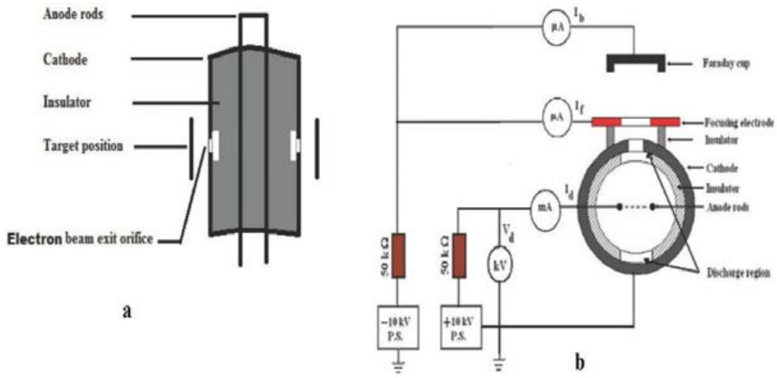

Figure 5: Schematic of the double beam source, a. Electron source and b Ion source [16]

Where ***I*** is the ion current (A), ***Q*** the total charge, D the dose (ion fluence in ion/cm^2 × area) of irradiation in ***cm^2***, ***q*** the charge state, e the electron charge (1.6×10^{-19} C), and ***t*** the irradiation time in ***s***.

The conductivity can be expressed according to [17]:

$$\sigma(\omega) = \sigma_{dc}(0) + \sigma_{ac}(\omega) \quad (2)$$

Where ***σ_{dc} (0)*** is the DC conductivity, ***$\sigma_{ac}(\omega)$*** is the AC conductivity, and ***ω*** is the frequency. The dielectric constant ***(έ)*** measurements were carried out in a frequency range from 100 Hz to 100 kHz at room temperature. The dielectric constant was determined from the formula:

$$\sigma = I \cos\theta\ (d/A),\ \acute{\varepsilon} = \frac{cd}{\varepsilon_0 A},\ \varepsilon'' = \tan\delta\,\varepsilon' \text{ and } \tan\delta = \frac{1}{\tan\theta} \quad (3)$$

where ***c*** is the capacitance in Farad, ***d*** is the thickness of the sample in m, ***A*** is the cross-sectional area, ***ε_0*** is the constant of permittivity of free space, and ***θ*** is the phase angle.

Electrical measurements were carried out on the film samples in the form of a disc with polished surfaces covered by silver paste and with dimensions of 1 cm in diameter and 3 mm in thickness:

$$\tan\theta = \frac{1}{2\pi f R_p C_p} \quad (4)$$

Where ***δ*** is the loss angle, ***f*** is the frequency, ***Rp*** is the equivalent parallel resistance, and ***Cp*** is the equivalent parallel capacitance.

The dielectric loss ***ε''*** was also measured in terms of the tangent loss factor (***tan δ***) , defined by the relation:

$$\varepsilon'' = \varepsilon' \tan\delta \quad (5)$$

2.3.2. Direct determination of trace elements

After prepared of the PVA film, the eluate containing the impurity elements was evaporated to about 0.7 ml and weighed. The mass of which was determined by difference, 0.1 ml was then pipetted on to a Whatman No. 41 filter-paper, which had a diameter of 16 mm and was propped using a film of Mylar. The mass rather than the volume of the specimen was used in order to progress the accuracy and precision of the analysis. It had prior been determined that, on the Siemens SRS200 spectrometer used in this study, a sample with a diameter of 16 mm gave best results for this type of sample than the normal specimen of 40 mm diameter. Samples prepared by the use of filter-papers are usually inhomogeneous owing to chromatographic spreading of the constituents during drying. The use of a smaller specimen results in improved precision and sensitivity. When the solutions had dried, the filter-papers were insert between films of Mylar 5μm thick and clamped in a sample holder normally used for solutions. Calibration specimens were prepared in the same way as the samples.

3. Results and Analysis

3.1. section A: determination of some trace elements in air samples from the study environment

Precis of statistical result for trace elements concentration in air samples from each site of the study in ng\ m^3 by XRF are in table [1].

Table 1: summary of statistical results for trace elements concentration in air

Trace element	Pb [ng/m^3]	Cu [ng/m^3]	Zn [ng/m^3]
First reading	0.000	0.000	0.000
Second reading	0.000	0.001	0.000
Third reading	0.000	0.000	0.002
Mean	0.000	0.0003	0.0006
Maximum	0.000	0.001	0.002
Minimum	0.000	0.000	0.000

Table [2] refer to compare between certified values (referred to the International Atomic Energy Agency [IAEA] standard reference material, IAEA 336) and Experimental values.

Table 2: Compare between certified value

Certified [mg/kg]	Certified [ppm: part per million]	Experimental [ppm: part per million]
Pb: 4.9	4.9	0.000
Cu: 3.600	3.600	3×10^{-15}
Zn: 30.4	30.4	6×10^{-15}

3.1.1. Enrichment factor for air samples

Enrichment factor (EF) has been used for the rating of contamination in several, environmental media by several researchers [18]. The enrichment factor is the enrichment of the elements in airborne particles compared to that of earth's crust by Fe as a reference element. An enrichment of unity Indicates soil, derived element. Where elements derived from high temperature combustion operations will be more unsteady and enrichment factors significantly above one. Enrichment factors are calculated using the overall mean concentrations of different elements.

3.2. section B: study of Irradiated Poly (vinyl alcohol) Film: Electrical Properties and Determination of Some Trace Elements

3.2.1. Electrical properties of irradiated film

The films samples were treated by N_2 ions for various handling times (20, 40, 80 minutes), and the fluence of N_2 ions was in the range from 3×10^{17} ion/cm^2 up to 1.9×10^{18} ion/cm^2, while the fluence of electrons was in the range from 5×10^{17} electron/cm^2 to 2.3×10^{18} electron/cm^2 (Table 3). Electron beams are a shape of ionizing radiation, that means the accelerated electrons have sufficient energy to shatter chemical bonds in organic materials, including polymers. The common effect of the breaking of chemical bonds is the formation of free radicals. Electron beams applications take a worth of processes resulting from the formation of these radicals.

Table 3: Irradiation parameters of film

Time (minute)	N_2 ion beam fluence (ion/cm^2)
20	3×10^{17}
40	6×10^{17}
80	1.9×10^{18}
Time (minute)	Electron beam fluence (electron/cm^2)
20	5×10^{17}
40	9×10^{17}
80	2.3×10^{18}

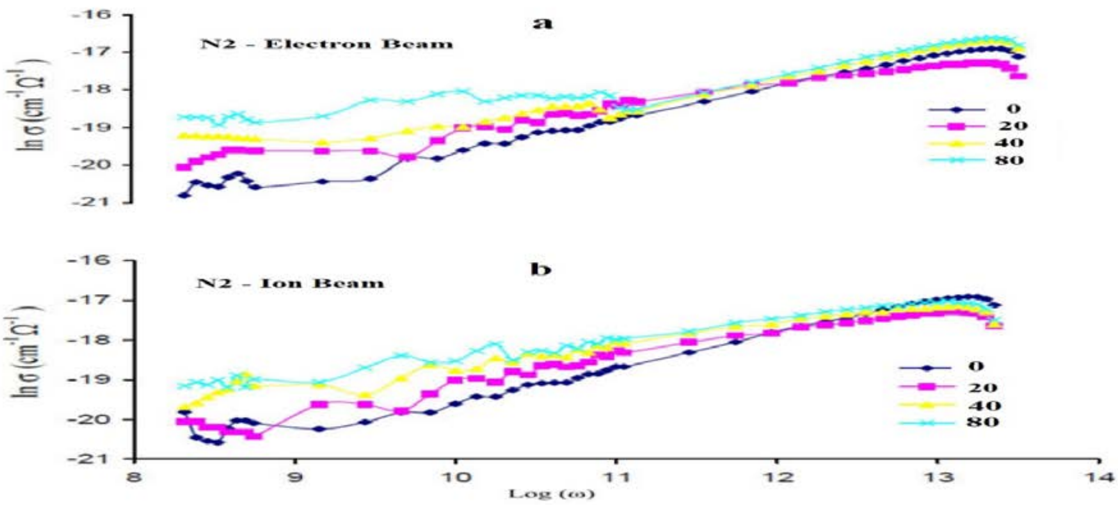

Figure 6: Variation in AC for all irradiated and non-irradiated samples with electron and ion beams at room temperature

Figure 6 (a) shows the variation of log ω versus ln σ for all irradiated and non-irradiated film specimen with electron beam at room temperature for different treatment times (0, 20,40, and 80 minutes). The conductivity increases approximately with increasing frequency, where the change of conductivity with frequency is better as ln σ versus log ω (ω = 2 π f) [16]. Figure 5 (b) shows the same behavior, but for ion beam irradiation on film samples of different doses at room temperature. It is shown that conductivity increases approximately with increasing frequency, as seen for ion beam irradiation (Fig. 6(b)), but with a higher effect than for the electron beam.

Figure 7(a) shows the variation of the dielectric constant ($\boldsymbol{\varepsilon}'$) of films samples before and after electron and ion beam irradiation with different treatment times (20, 40, and 80 minutes) as a function of the frequency at room temperature.

All samples show normal dielectric dispersion behavior, where the dielectric constant, ε, decreases with increasing frequency. Figure 3(b) also shows the variation of the dielectric constant ($\boldsymbol{\varepsilon}'$) of film samples before and after ion beam irradiation with different doses (0, 20, 40, and 80 minutes) as a function of frequency at room temperature. All samples also show normal dielectric dispersion behavior, where the dielectric constant decreases with increasing frequency.

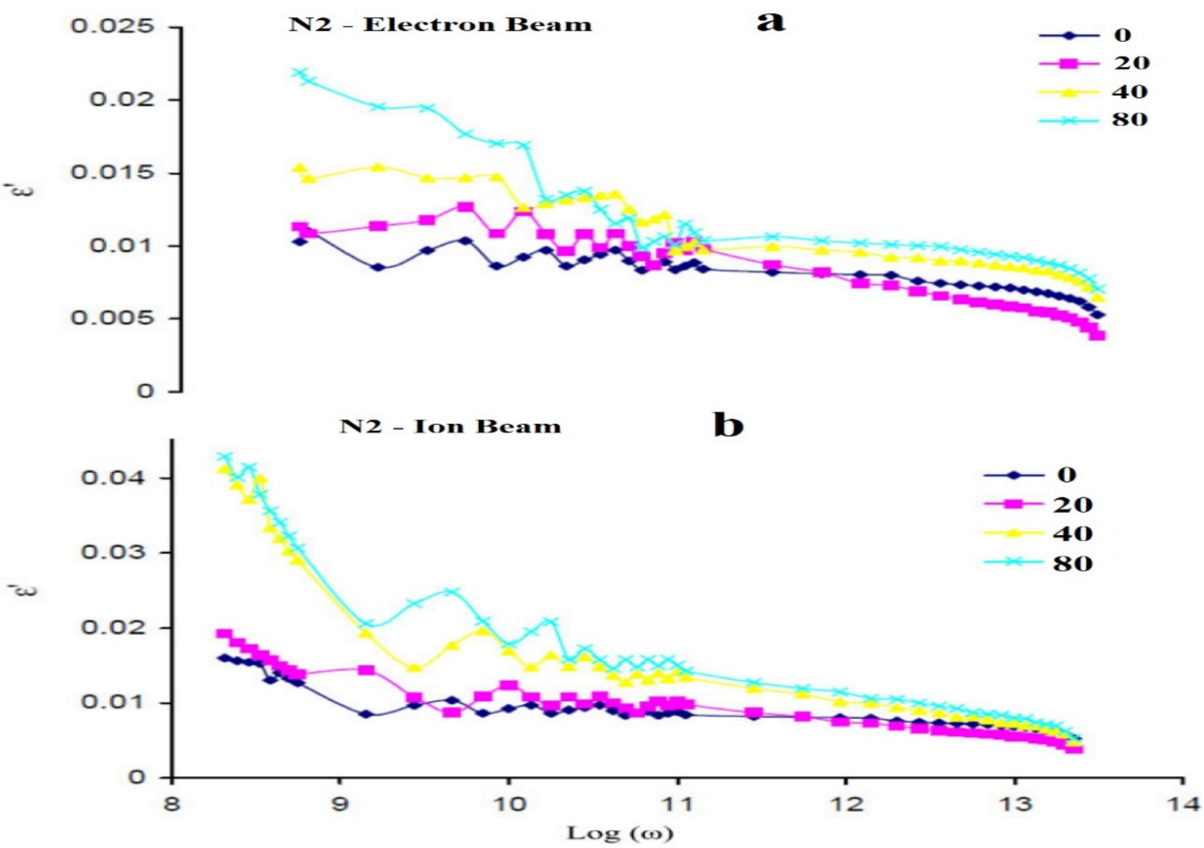

Figure 7: Variation of dielectric of film for all irradiated and non-irradiated samples with electron and ion beams at room temperature

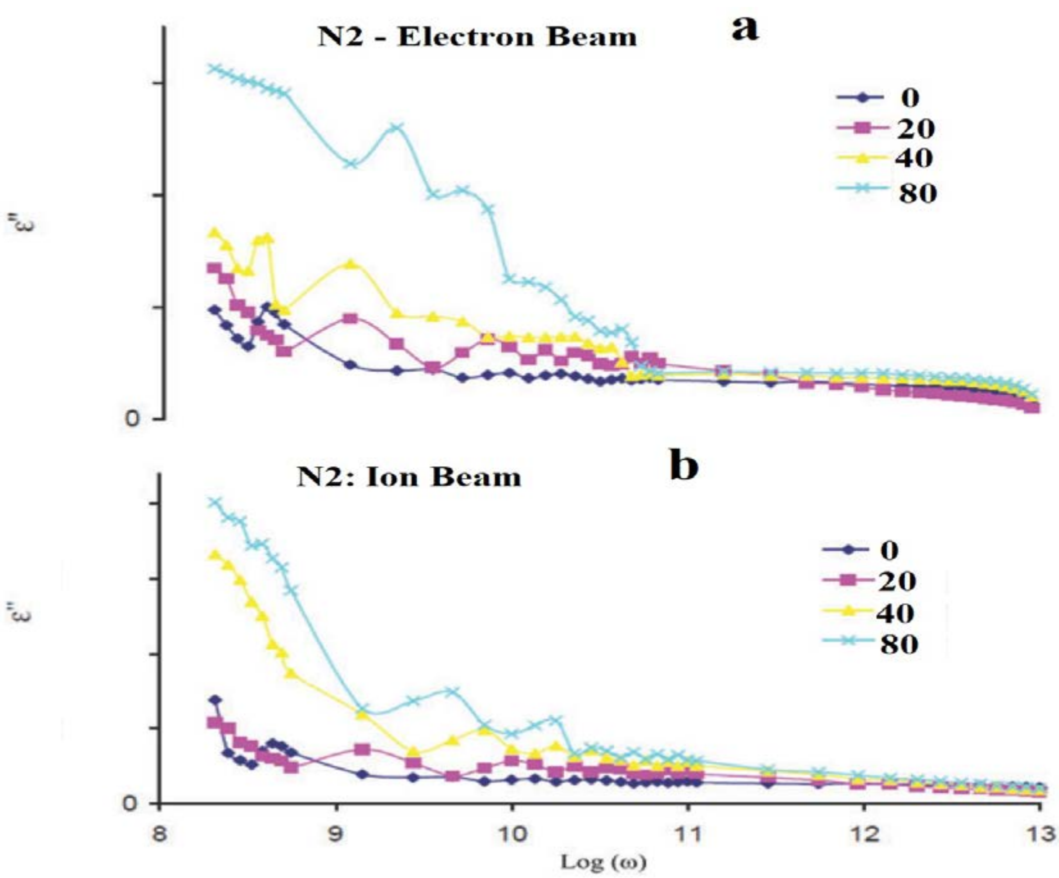

Figure 8: Variation of the imaginary part of the impedance ε" with frequency for film at room temperature, irradiated and non-irradiated with electron and ion beams

Figure 8 (a) shows the variation of the dielectric constant (ε'') of film samples before and after electron beam irradiation with different treatment times (0, 20, 40, and 80 minutes) as a function of the frequency at room temperature.

Figure 8 (a) shows the variation of the dielectric constant (ε'') of PVA samples before and after electron beam irradiation with different doses (0, 20, 40, and 80 minutes) as a function of frequency at room temperature. The dielectric constant (ε'') can be evaluated as a function of frequency, where the curves indicate a considerable decrease with a frequency side. A large influence for the ion beam effect on film samples with different doses more than for electron beam (Fig. 8 (b)).

The dielectric loss tangent (tan δ) as a function of frequency was studied at room temperature (Figs. 9 (a), (b)) for ion/electron beam irradiation on film samples with different treatment times (20, 40, and 80 minutes).

The dielectric loss tangent decreases with increasing frequency for all irradiated and non-irradiated samples [19,20].

The values of tan ε' depend upon a number of factors, such as film content and structural homogeneity. From this figure, it can be seen that the dielectric loss tangent has a sudden decrease at low frequency in comparison to the high frequency region (Figs. 9 (a), (b)). The influence of ion beam irradiation on films was found to be less than the electron beam effect.

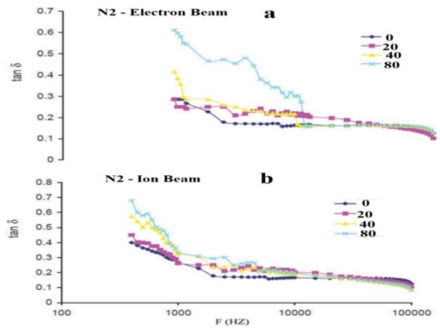

Figure 9: Variation in the dielectric loss tangent tan δ with frequency of film irradiated and non-irradiated with electron and beams at room temperature.

3.2.2. XRFS measurement of the thin-film samples

The intensities for all element lines were studied. The measured background intensity was modifying for the constant slope of the background. In the direct process, the net intensity was associated directly to the concentration of the analyses. To normalize the count rate, the analyses intensities for samples prepared by the Coprecipitation method were divided by the intensity of the (In Kα) line. The normalization step corrects for tiny errors in the positioning of the specimen in the sample holder and for minor mechanical losses during the preparation process. The ratio of the intensities measured for the samples was then associated to the concentration of the analyses in the calibration standards prepared using the Coprecipitation method. The standardization graphs for the direct method, which are shown in Fig.10, lid the range 0 -500 μg of analyses on the thin film. The concentrations of all the elements in a particular standard were the same. The standardization graphs shown in Fig.11 were obtained when the Coprecipitation method was used, and extend from 0 to 100 μg.

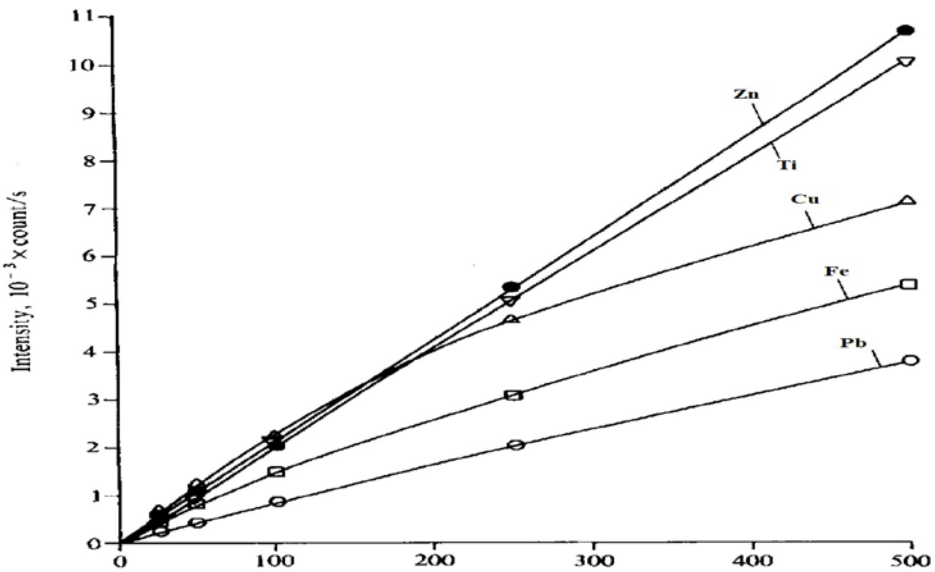

Figure 10: Calibration for the determination of lead, iron, copper and zinc by the direct filter- paper method.

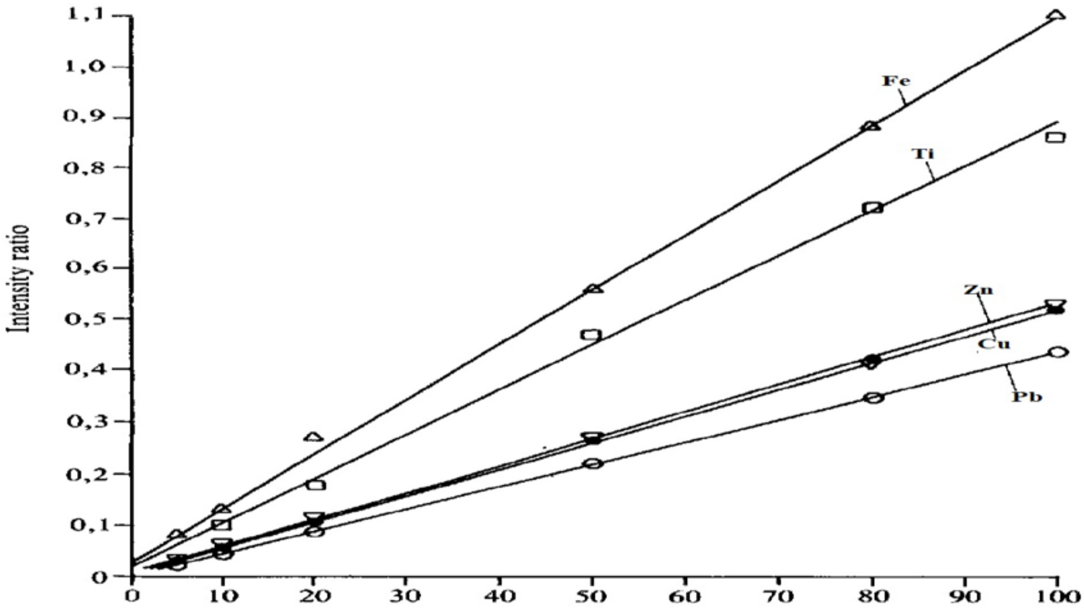

Figure 11: Calibration for the determination of lead, iron, copper, titanium and zinc by the Coprecipitation method

4. Conclusion

One of the more significant findings to emerge from this study is that the study area is completely free of Pb, the average ratio Cu is 0.0003 ng/m^3. The average ratio of Zn it was 0.0006 ng/m^3 and This value is less than the certified value so it is also considered not dangerous. In general, the study observed that the Study Environment of Alasala Colleges wholly free from Lead [Pb], Copper [Cu] and Zinc [Zn]. The influence of an electron/ion beam on film samples with different treatment times (20, 40, and 80 minutes) has been systematically investigated in detail from the viewpoint of the electrical properties. It was found that the dielectric permittivity, and tan δ are found to increase with the irradiation time. There was an increased effect for ion beam compared to electron beam irradiation. The decrease in surface conductivity on (ion /electron) irradiation in film samples is attributed to a decrease in the mobility of macromolecular charged species due to an increase in the degree of crystallinity. Electric conductivity increases approximately linearly with increasing frequency, as seen for both electron and ion beam irradiation with different doses, but with a higher effect for ions than for electrons. For trace elements, the limits of detection of both methods are good and below the usual requirements of 20-50 μg g^{-1} impurities.

5. Significance Statement

This study found that the level of trace elements including Lead [Pb], Copper [Cu], Zinc [Zn] in air samples collected from Alasala Colleges in Dammam, KSA indicates that it is wholly free from Pb. The ratio that is average of Zn is 0.0006 and Cu is 0.0003 ng/m^3 and it would be helpful for the researchers in examining the level of trace element in different institutions. Also, study found that the limits of detection of both methods are good and below the usual requirements of 20-50 μg g-1 impurities. Also, Electric conductivity increases approximately linearly with increasing frequency, as seen for both electron and ion beam irradiation with different doses, but with a higher effect for ions than for electrons and it would be helpful for the researchers in examining the level of trace element in different institutions.

6. Recommendations

The researcher attendees identified a range of areas for attention and the following main recommendations for research are based on the study findings:

1. Limited and variable access to investigate in the wider trace elements in air samples and soil system is a significant barrier to reducing the increased rate of its presence. More research is needed to identify effective ways of improving the current study. Research should address structural and salt soil and how these might be overcome.
2. Research to explore the impact of different aspects of safety culture on Student and staff.
3. Examining the level of trace element processing should be identified as a component program of the Administration Initiative.
4. A coordinated program supported to generate basic data and simulation of surface processes, Electric conductivity and ion and electron irradiation.

Acknowledgements

The authors would like to thank the academic support from Alasala National Colleges, especially Prof. Jamal Nazzal.

Author's Contribution

Mohana Faroug Attia, Hassan Ali Aldagham, Ahmad Fouad Aljishi and Mustafa Hassan Talag conceived of the presented idea. Mohana Attia developed the theory and performed the computations. Hassan Ali verified the analytical methods. All authors discussed the results and contributed to the final manuscript. All authors carried out the experiment and wrote the manuscript with academic support from Alasala National Colleges.

Competing Interests

The authors declare that there are no personal, organizational or financial conflicts of interest.

References

[1] Young, Patricia A. Instructional Design Frameworks and Intercultural Models. Information Sciences References, 2009, p161.

[2] Arthur Stern. Air Pollution. Academic Press 1978. p250.

[3]. Nyle C. Brady., The Nature and Properties of soil, 8th ed. USA (1974). https://trove.nla.gov.au/work/7794592.

[4]. Paul B Tchounwou, Clement G Yedjou, Anita K Patlolla, and Dwayne J Sutton. "Heavy Metals Toxicity and the Environment". Molecular, Clinical and Environmental Toxicology.101. pp 133-164. 2012.

[5]. Adrian McDonald. A perspective of environmental pollution. Cambridge University Press 1981. P 381.

[6]. Allen, Stewart E. "Chemical analysis of ecological materials". Oxford, England: Blackwell Scientific, 1974. P 95.

[7]. Lenntech BV. "Heavy Metals". https://www.lenntech.com/processes/heavy/heavy-metals/heavy-metals.htm. 2018.

[8]. Brown, H. J. M., "In Environmental Chemistry of the Element". Academic, Press. London 1979. p 150.

[9]. Manfred L. Hallensleben "Polyvinyl Compounds, Others". Ullmann's Encyclopedia of Industrial Chemistry, 2000, Wiley-VCH, Weinheim. https://doi.org/10.1002/14356007.a21_743.

[10]. M. Ramakrishna Murthy, and E. Venkateshwar Rao. "Ion-beam modifications of the surface morphology and conductivity in some polymer thin films". Bull. Mater. Sci. 25, pp 403–406. 2002. https://link.springer.com/article/10.1007/BF02708018.

[11]. A. A. El-Saftawy, A. Elfalaky, M. S. Ragheb, and S. G. Zakhary. "Electron beam induced surface modifications of PET film". Radiation Phys. Chem. 102, pp 96 – 102. 2014. https://doi.org/10.1016/j.radphyschem.2014.04.025.

[12]. Mohammed Ahmed Ali Omer, Emadeldin AbdeljabarAli Bashir. "Synthesis of polyvinyl alcohol and cuprous oxide (PVA/Cu2O) films for radiation detection and personal dosimeter based on optical properties". Journal of Radiation Research and Applied Sciences. 11. Pages 237-241. 2018. https://doi.org/10.1016/j.jrras.2018.03.001.

[13]. S. S. Ata-Allah and M. Kaiser, J. Alloys Compounds 471, 303 (2009). http://10.1016/j.jallcom.2008.03.117

[14]. R. Isabey, E. Duverger, C. Darraud-Taupiac, V. Binsangou, L. Makovicka, J.L. Decossas, J.C. Vareille. "Theoretical and experimental study of the CR-39 behavior under electron beam". Radiation Measurements. 31. Pages 85-88. 1999. https://doi.org/10.1016/S1350-4487(99)00095-5.

[15]. A. Ahmed. "Synthesis and Physical characterization of nano-scale materials containing iron

Methods: Mossbauer Spectroscopy, X-Ray Powder Diffraction, SEM-EDS". Ph.D. Thesis. Egypt. Al-Azhar University Department of Physics .2011.

[16]. M. M. Abdelrahman and F. W. Abdelsalam. "Modified Saddle Field Ion Source Using a Ring

Focusing Electrode". Journal of Nuclear and Particle Physics. 2, pp 26 – 30. 2012. https://doi.org/10.5923/j.jnpp.20120203.01

[17]. Abdo Mohd Meftah, Elham Gharibshahi, Nayereh Soltani, W. Mahmooud Mat Yunus and Elias Saion. "Structural, Optical and Electrical Properties of PVA/PANI/Nickel Nanocomposites Synthesized by Gamma Radiolytic Method". Polymers. 6. pp 2435-2450. 2014. https://doi.org/10.3390/polym6092435.

[18]. M. A. Addo, E.O. Darko, C. Gordon, B. J. B. Nyarko, J. K. Gbadage, E. "Evaluation of Heavy Metals Contamination of Soil and Vegetation in the Vicinity of a Cement Factory in the Volta Region, Ghana" International Journal of Science and Technology, 2. P :40-50. 2012. https://www.researchgate.net/publication/233739911_Evaluation_of_Heavy_Metals_Contamination_of_Soil_and_Vegetation_in_the_Vicinity_of_a_Cement_Factory_in_the_Volta_Region_Ghana.

[19]. A. Maher Wahba and M. Bakr Mohamed. "Structural, magnetic, and dielectric properties of Nanocrystalline Cr-substituted Co0.8Ni0.2Fe2O4 ferrite". Ceramics International. 40. pp 6127-6135. 2014. https://www.researchgate.net/publication/259973290_Structural_magnetic_and_dielectric_properties_of_nanocrystalline_Cr-substituted_Co08Ni02Fe2O4_ferrite

[20]. Moustafa Mohamed Abdelrahman, Mukit Osman, A. Hashhash. "Electrical properties of irradiated PVA film by using ion/electron beam". Progress of Theoretical and Experimental Physics. 2016. 023G01. 2016. https://doi.org/10.1093/ptep/ptv178.