



School of Applied Science & Engineering

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Attenuation Caused by Dust

Storms at 6-7 GHZ

In (El-Jabal Al akhdar) Area

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الإهداء

إلى خاتم النبيين وإمام المرسلين وأستاذ المتعلمين.
إلى سيدنا محمد عليه أفضل الصلاة وأزكى التسليم.
إلى التي أنجبتني على هذه الدنيا.
إلى أمي الغالية
إلى الذي دفعني حتى وصلت إلى هذه اللحظة
إلى أبي العز
إلى رفيقة دربي في مشوار حياتي
إلى زوجتي الحبيبة
إلى فـلـذات كبـدي
إلى أبنائي وبـنـاتي
إلى من تقاسمت معهم حلو الحياة ومرّها
إلى إخوتي وأخواتي

ABSTRACT

The aim of this thesis is to study the effect of dust storms on microwave links and apply the results of this study to the microwave link of (El-Jabal Al akhdar).

The first step is the collection of dust and sand samples from twenty one sites from (El-Jabal Al akhdar) area along the microwave link and analyze them to find the chemical composition, microscopic images for the samples, Relative Humidity for the Samples in laboratory and Particle-Size-Distribution(PSD).

The second step is collecting data for the relative humidity and wind speed.

The third step is to calculate the effect of height and humidity thus giving the final evaluation of the effect on the link.

The aim of this thesis is to evaluate the effect of dust and sand storms on microwave signals in El-jabal Alakhdar at frequency 6- 7GHZ and for that this work follow these steps:-

1-collecting samples for the suspended dust and samples

2-Making chemical and dimension analysis .

3-Using the chemical results to estimate the attenuation and phase constants.

4-find the effect of height and humidity.

5- give the final evaluation of the links

المـلـخـص

الهدف من هذه الأطروحة هو دراسة تأثير العواصف الغبارية على وصلات الميكروويف، وتطبيق هذه الدراسة على منظومة الميكروويف الرابطة لمنطقة الجبل الأخضر.

الخطوة الأولى تتمثل في تجميع عينات الغبار من واحد وعشرون موقع وإيجاد التركيب الكيميائي وتوزيع الحجم الجزيئي والصور المجهرية للعينات وكذلك الرطوبة النسبية لكل عينة. الخطوة الثانية جمع معلومات عن الرطوبة النسبية وبيانات عن سرعة الرياح في منطقة الدراسة.

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List of Abbreviations

RF - Radio Frequency

GPS - Geographical Positioning System

PSD - Particle- Size Distribution

MEPA - Meteorological and Environmental Protection Administration

XPD - Cross- Polar Discrimination

CW - Cumulative Weight

CHAPTER 1

1-1 Introduction

Radio communication plays a vital role in any country's social and economical development, many applications require radio frequency (RF) or microwave propagation from point to point very near the earth's surface examples of such applications include cellular telephones, public service radio, pagers, broadcast television, radio stations, and differential GPS transmitters. The performance of service depends on many factors such as area of coverage, and climate conditions.

The millimeter waves bands are in the short wavelengths range; unfortunately, the shorter the wavelength the more attenuation will be induced by absorption and scattering due to rain drops, dust and sand particles in the radio path . The attenuation caused by sand and dust particles is one of the major problems in the utilization of microwave and millimeter wave bands for terrestrial and space communication . When microwave and millimeter waves pass through a medium containing precipitations like sand and dust particles, the signals gets attenuated through two phenomena:

1- Absorption of energy by sand and dust particles, which depends on the loss tangent of the sand and the dust contents, the more contents of sand and dust material attenuation to the signal, will be move.

2- Scattering of energy out of beam by sand and dust particles.

In desert and semi-desert, the effects of dust particles on microwave propagation have received some interest, and the knowledge of the complex permittivity of particles suspending or precipitating in the atmosphere is of importance in radio communication and radio meteorology.

The attenuation and phase shift constants for a medium with dust or/and sand particles depends on the frequency, visibility, maximum particles-size, complex permittivity,

shape of the scattering particles, concentration, and their orientation relative to the wave polarization, also the attenuation of electromagnetic waves due to dust is predominantly a function of the moisture content of the particles.

Dust or/and sand storms are frequently encountered at eastern of Libya, such storms may last for days, [El-jabal Alakhdar] region which is located at the east of Libya has high wind speed . The effect of the dust and sand on the microwave links in this area has not been studied, neither the effect of the humidity on the complex permittivity whereby its effect on both attenuation and cross-polarization constants, also the effect of the height of towers, and the height of area due to the importance of this region for the Libyan microwave communication Network. Beside the expectation of different chemical analysis of the dust and sand, we have chosen this region for study.

1.2 Previous Work.

The effects of sand and/or dust storms on the propagation have been considered by only few investigators in some parts of Sudan, Iraq, Saudi Arabia and recently in Libya. This is because most of the developed countries do not face problems of this type, and they have completely different but parallel problems due to rain and snow, and the countries that gets affected by it focused little attention because most of it are under developed.

1.2.1 In Libya

The first study was carried out by **Hassan Aldeeb** under the supervision of **Dr.Sayeh Elhabash** ,and covered the east part of Libya along the microwave link from Agedabia to Jalo between longitude (20.13 to 21.40N) and latitude (30.45 to 29.10 E) in spring of 2006 . The analysis of sand and dust samples showed that the average of the complex permittivity for the studied area is $\epsilon_r = 4.71965 - j0.08195$. He classified the samples as sand if it has diameter 150 micrometer and higher, and it is dust if the diameter is lower than 150 micrometer. And from this study the following points can be deduced:[1] **1-** The average measured density of the samples collected in the studied area

is 1.5067 gm/cm³.

2 -The measurements have shown that an average attenuation constant for dry samples is 0.00597dB/km at 3GHz, so the attenuation of the signal that results from the dust and/or sand storms is negligible, this is based on the average attenuation per unit length and the maximum distance between stations which was 55km (total attenuation 0.328dB).

A following study carried out by **Nafati Abasallam** covered the north part of Libya along the microwave link Abo-Njeem between longitude (15.15 to 15.56N) and latitude (31.7 to 29.07E) in spring of 2008 . The analysis of the samples showed that the average of the complex permittivity for the studied area is $\epsilon_r = 5.6344 - j0.1060$ and the other conclusions are :-

- 1- The average of density of samples in Abo-Njeem region is equal to 2.478gm/cm³.
- 2- About 87% of the samples have diameter between (125-150 μ m), therefore the dominant grain size is a fine sand size.
- 3- The attenuation of signal due dust storms with visibility equal 5m (worst case) at a humidity of 0 % is negligible at any height, this is based on the attenuation per unit length and the maximum distance between stations which is 51 km (total attenuation 0.3978 dB).
- 4- The attenuation of signal due dust storms in study area in Libya with visibility equal 5m (worst case) at a humidity of 58.3 % and 100% is serious at any height, this is based on the attenuation per unit length and the maximum distance between stations which is 51 km (total attenuation 1.718 dB and 2.8254 respectively).

another study was carried out by **Jumaa.O.A.Mesbh** under the supervision of **Dr.Sayeh Elhabash** ,and covered the south part of Libya along the microwave link from Wadi-Alshati between longitude (27.26 to 27.44N) and

latitude (14.31 to 13.05 E) in fall of 2008 . The analysis of sand and dust samples showed

that the average of the complex permittivity for the studied area is $\epsilon_r = 5.6309 - j0.2033$. He classified the samples as sand if it has diameter 125 micrometer and higher, and it is dust if the radius is lower than 125 micrometer. And from this study the following points can be deduced:

1-The average measured density of the samples collected in the studied area is 1.442 g/ml.

2 -The measurements have shown that an average attenuation constant for dry samples is 0.00834db/km .[12]

There are other works which of each from: **Ismail Abohdima , Briek and Mustafa Agha**

1.2.2 - In Sudan

A study was carried out by S. I. Ghobrial and S. M. Sharief for the area located between longitude (10 to 20N) and latitude (30 to 35 E) in Sudan. The particle-size distribution (PSD) of dust samples collected in Sudan is carried by Hydrometer using Pipette method, it was indicated that dust particles have an equivalent diameter in the range of 0.1 to 300 micron and with mean diameter less than 50 micron, also microscopic investigation revealed that the average axes ratios for the best fit ellipsoid are 1:0.71:0.53, and the average measured density of samples collected in Khartoum, is $\rho = 2.44 \text{ gm/cm}^3$. The measurements have shown that an average dielectric constant of dry dust samples is $5.5 - j0.16$ at 8.5GHz, while it is $8.1 - j0.90$ for samples with approximately 4.8% moisture content by weight at 8.3 GHz. This results in an attenuation of 0.328 db for a path of 55 km.[5]

1.2.3- Saudi Arabia

A. Ali presented a procedure for obtaining the optimum hop length for millimeter wave radio links operating in arid and semi-arid regions, the procedure is based on long-term meteorological data for Saudi Arabia, a typical arid land, and a set of actual field measurements from a millimeter-wave radio network, his results were based on a

study of the meteorological data obtained include a 25-year rain and sand storm record from 137 recording stations in Saudi Arabia. The study involved the operation and monitoring of radio links in the millimeter wave and infrared parts of the spectrum. Meteorological stations and related test equipment were also operated and monitored. The experimental system comprised of:

- 1- A set of three radio links: two millimeter waves (40 GHz) and one near infrared (0.88 m) with path distances of 14 km and 0.75 m. respectively.
- 2- Meteorological instrumentation including dust passive collectors, high volume samplers and a dust particle-size analyzer.

Predicting attenuation and phase shift caused by sand or dust storms requires knowledge of pertinent storm parameters affecting propagation. Such parameters include particle shape, size distribution, refractive index, concentration and composition. A record of all sand and dust storm events which occurred in Saudi Arabia over 20 years from 1968 was obtained from the Meteorological & Environmental Protection Administration (MEPA). It includes the dates and durations when the optical visibility was reduced due to storm events. An analysis of propagation reliability for millimeter wave radio links operating in an arid climate has been presented. Using the results of actual measurements of excess attenuation due to rain, sandstorms and fading at 40 GHz in Riyadh. The results are presented in the form of design charts depicting link reliability against fade margin at various hop lengths. The frequency band from 30 to 70 GHz was covered in 10 GHz increments. Sand particle sizes diameter of 0.07 and 0.15 mm were considered with moisture contents of 0%, 5% and 10%. Different design charts were given for various geographical regions of Saudi Arabia. It is believed that the analysis will be used by radio engineers designing radio links operating at Millimeter wavelengths in an arid climate”.

[1]

1.2.4 - Iraq

Shakir and H . M. Al-Rizzo in their work several wind blown and

dust fall samples were collected in the spring, summer and autumn of 1984 at a height of 20 m above the ground surface during severe sand and dust storms over the city of Baghdad. The particle-size distribution (PSD) of the samples was determined using five different measurement techniques (hydrometer, pipette, sedimentation balance, optical microscope and coulter counter). The results showed that the cumulative weight techniques yield almost identical results for all the samples tested. The mode number distribution was found to occur at around 2 and 3.5 μm for the blowing and falling dust samples, respectively. A computer program was developed to describe the measured distributions by some analytical functions. It was found that the cumulative distributions can be well described by a third degree polynomial and log-normal functions for particle diameters ranging from 1 to 100 μm . An attempt has been made to estimate the attenuation α and phase shift β for a microwave signal for up to 37 GHz utilizing the measured particle size distribution and for different particle moisture contents. It was concluded that at 37 GHz and for 10 m visibility, the upper bound for α and β were 0.7 dB/km and 26.5 degree/km for 20 percent particle moisture content.[13]

1.3 Scope of Thesis.

The aim of this thesis is to evaluate the effect of dust and sand storms on microwave signals in El-jabal Alakhdar at frequency 6- 7GHZ and for that thi work follow these steps:-

- 1-collecting samples for the suspended dust and samples
- 2-Making chemical and dimension analysis .
- 3-Using the chemical results to estimate the attenuation and phase constants.
- 4-find the effect of height and humidity.
- 5-give the final evaluation of the links.

1.4 Layout of the Thesis:

This thesis consists of four chapters in addition to the introductory chapter:

1- Chapter two: Radio Wave propagation, Dust and Sand Properties, Variation of Visibility with Height and Attenuation Due to Sand and Dust Particles.

2- Chapter three: Microwave link, Metrological Data, Samples of Dust and Sand and Analysis of the Samples.

3- Chapter four : In this chapter analyze the results which presented in chapter three from path Calculation of the Complex Permittivity of Samples, particle size distribution Analysis, Estimation of Air Relative Humidity effect and Estimating the Wave Attenuation and evaluate the link.

4-Chapter five: we give the final concluding remarks.

CHAPTER 2

Radio Wave Propagation

2.1 Radio Wave Propagation

Radio propagation is the behavior of radio waves when they are transmitted, or propagated from one point on the Earth to another, or into various parts of the atmosphere.[15]

Propagation mechanisms are very complex and diverse. because of the separation between the receiver and the transmitter, attenuation (reduction or loss) of the signal strength occurs,in addition, the signal propagates in different manners, known as diffraction, scattering, reflection, and refraction.[2]

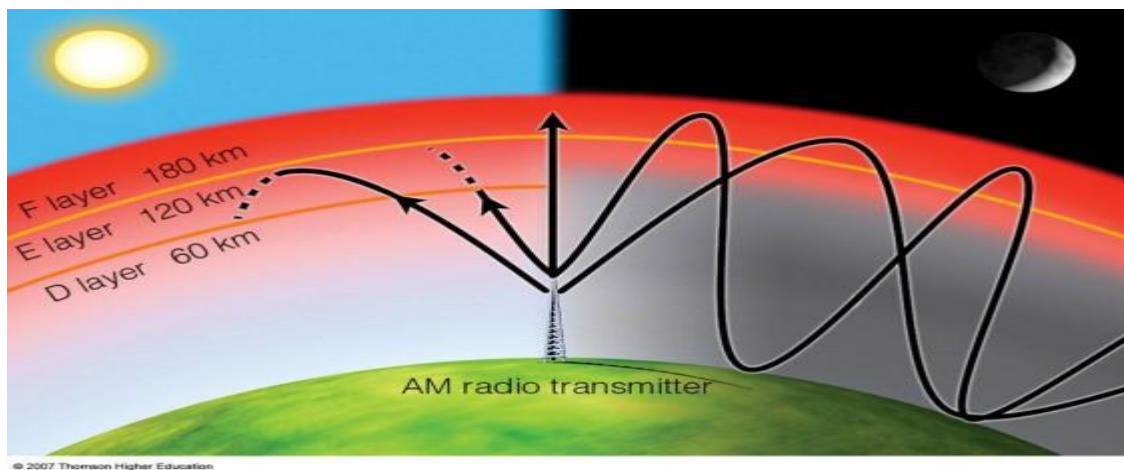
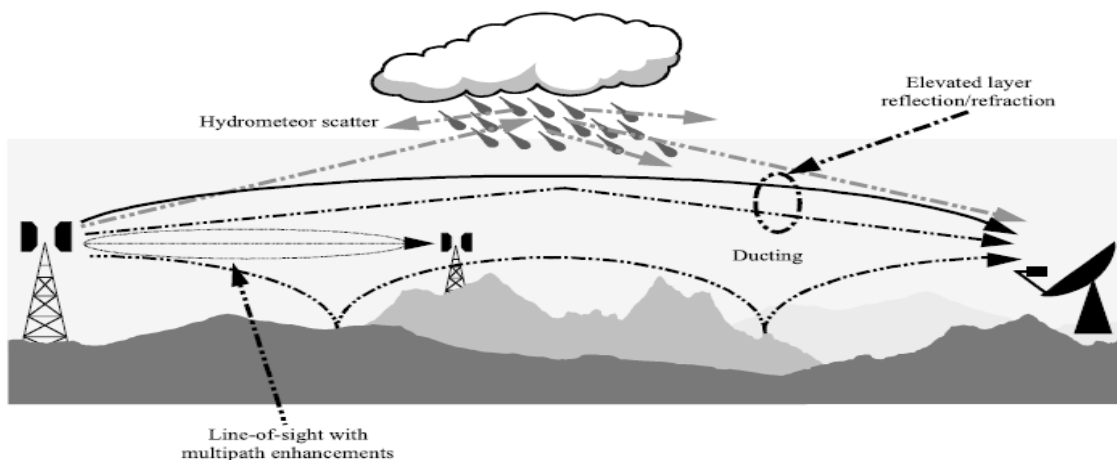


Figure 2- 1 Radio Wave Diffraction, Refraction and Transmitter over obstacles.[15]

2.2 Dust and Sand Properties

To study the effect of sand and dust storms on microwave links we must review some important properties of particles, complex permittivity, shape of the scattering particles, concentration, visibility, particles-size distribution, and their orientation relative to the wave polarization.

2.2.1 Definition of Sand and Dust Storms

A dust storm or sand storm is a meteorological phenomenon common in desert and semi-desert regions and arises when a gust front passes or when the wind force exceeds the threshold value where loose sand and dust are removed from the dry surface. Particles are transported by saltation and suspension, causing soil erosion from one place and deposition in another. In soil mechanics, particles with radii less than 60 micron are termed clay or silt, depending on their size. Particles with radii greater than 60 micron are called sand [5].

2.2.2 Dielectric Constant of Dust and Sand

Knowledge of the dielectric constant of particles suspending or precipitating in the atmosphere is of importance in radio communication and radio meteorology. In desert and semi-desert regions dust and sand storms are frequently encountered and it is therefore of interest to investigate the dielectric constant properties of these particles [8].

Dust and sand particles are soil particles removed from the earth surface as a result of wind erosion under certain climatic, meteorological and soil conditions. It is well known that the earth surface is composed of a large number of minerals inhomogeneous mixture form. The dust and sand particles are expected to have similar composition. The mixture percentage depends on the mineral composition of the parent soil.

In order to predict the dielectric constant for dust and sand particles from its mineral and /or chemical composition values, the following points should be considered:

- 1- The chemical and mineral composition of the dust and the sand.

2- The dielectric properties of each constituent.

3- Model for the mixture dielectric constant.

The chemical composition of a sand sample may or may not come close to that of a dust samples. This depends on the origin of sand and dust samples. One should not expect a change in the dielectric constant with particle size. The chemical analysis carried out in Sudan[11] showed that the major constituents of dust are SiO_2 , Al_2O_3 and Fe_2O_3 . where SiO_2 has the greatest effect on the real part and Al_2O_3 has the greatest effect on the imaginary part[9].

The results from samples in Libya showed that main parts of the samples are

i) The chemical analysis carried from Agedabia to Jalo are:

The main metals in samples are Aluminum oxide and ferrite oxide they have percentage that average to about 7 % .

ii) The chemical analysis carried from Abo-Njeem:

The percentage of silicon oxide (SiO_2) in the samples increases as we move south (far from the sea side).

iii) The major constituents of samples are SiO_2 and CaCO_3 , about 89% by weight of samples.

A number of models are available to estimate the dielectric constant of a sand and dust samples.

$$\epsilon_m^{1/3} = \sum_{i=1}^n v_i \epsilon_i^{1/3} \dots\dots\dots (2-1)$$

Where:

(ϵ_m) dielectric constant of mixture. ϵ_m depends on the complex dielectric of the substance (ϵ_i) and its relative volume(v_i) .

The permittivity of materials at microwave frequencies is $\varepsilon = \varepsilon' - j\varepsilon''$

Where:

ε' is referred to as the dielectric constant and ε'' is the dielectric loss factor.

The complex permittivity also depends on frequency of operation and moisture content. In general, moisture causes increase in both real and imaginary parts of the complex permittivity depending on chemical composition of dry soil samples [9,10].

2.2.3 Particles Geometry

Dust and sand particles are random in shape and can not be classified as spheres, ellipsoid or otherwise. However, since computation of the effects of dust storms on wave propagation can not be easily carried out for the case of random shaped particles one needs to assume some suitable geometry. The nearest geometry that approximate particles are ellipsoid or sphere. There are two important factors to estimate cross polarization discrimination change due to the effect of elliptical particles on microwave links [11].

1- Orientation of the particle relative to the propagation field, determination of the orientation of particles during storms is difficult because this depends on the motion of air surrounding the particle.

2- The axes ratio $a_1: a_2: a_3$, the probability distributions of the a_2/a_1 and a_3/a_2 ratios are of interest and use in estimate attenuation and phase constants for ellipsoid particles.

2.2.4 Visibility and Dust Concentration

The number of particles suspended per unit volume of air (mass concentration), is one of the important parameters needed to compute the medium propagation constants.

A measure of the severity of storm is visibility. As is well known visibility decreases with increasing number of particles in the atmosphere. As we saw previously by Eq. (2.3), the mass of suspending dust per unit volume of air is related to visibility.

From measurements of dust concentration and visibility the following empirical relationship between visibility V (in km) and mass density ρ (in gm/cm³) has been obtained [11]:

$$\rho = \frac{C}{v * V^\gamma} \dots\dots\dots(2.2)$$

Where : C=2.3 X 10⁻⁵

v is the relative volume occupied by particles (m³ of particles /m³ of air).

2.2.5 Particle Size Distribution

Analysis of particulate samples is done to find the particle size and distribution from a representative sample. A particle size distribution can be displayed either in tabular form or graphically, and either as a cumulative distribution or as a differential distribution. For a sphere, the size is the diameter (or radius) of the sphere. For a real particle of arbitrary shape, the commonly acceptable size for 3-dimensional measurement techniques such as laser diffraction and counter principle is defined as the volume equivalent sphere diameter. Because it is impractical to measure every particle in a bulk sample, especially for small particles, correct sampling, to ensure statistical representation of measured particles to the bulk samples, and correct particle dispersion, to ensure all. [12]

2.3 Attenuation Due to Sand and Dust Particles

The atmosphere contains a variety of solid particles in suspension, These particles range in size from aerosols (up to 50 μm) to coarse dust, sometimes known as sand (about 1 mm). The larger the size of the particles, the quicker they fall out of suspension the lower their height. While aerosols can remain suspending for days, and sometimes years, coarse dust will rapidly descend to the ground once the impelling force, such as a violent wind storm, has subsided. In a like manner, aerosols can be carried high up into the stratosphere in even a slight updraft while the larger particles, such as coarse dust, generally remain within a few meters of the surface of the earth. Aerosols and small solid particles do not significantly affect the transmission of electromagnetic waves until the optical frequencies are approached and their extinction cross-section becomes appreciable. The effect of fine dust and coarse dust on radio wave transmissions can be noticeable at much lower frequencies, however, although the impact is often difficult to separate from the meteorological phenomena that often accompany the dust storms.[4]

2.3.1 Dielectric Constant of Air with Suspending Particles

To study the effect of suspending particles on microwave propagation it will be assumed that the medium (air with suspending particle homogeneous and uniform). The dielectric constant of the medium (this will be referred to the term storm) depends on the intensity of dust particles per unit volume of air, the polarization of the wave relative to the particles axes, etc. The dielectric constant of the medium with suspending ellipsoids is given by [4]:-

$$\varepsilon_i = \varepsilon_a \left(1 + \nu \frac{\varepsilon - \varepsilon_a}{\varepsilon_a + A_i (\varepsilon - \varepsilon_a)} \right), i=1, 2, 3 \dots\dots\dots (2.3)$$

Where:

ε_i is the dielectric constant of the medium with suspending ellipsoids.

ε is the dielectric constant of the ellipsoids material,(dust and/or sand particles).

ε_a is the dielectric constant of the medium in which ellipsoids are suspending (in our case air).

v is the relative volume occupied by particles.

A_i is the depolarization factor along the a_i axis.

as explained in Fig. (2.2) and is defined by [4].

$$A_i = \frac{a_1 a_2 a_3}{2} \int_{s=0}^{\infty} \frac{ds}{\left((s + a_i^2) \left[(s + a_1^2)(s + a_2^2)(s + a_3^2) \right] \right)^{1/2}} \quad i=1, 2, 3, \dots \quad (2.4)$$

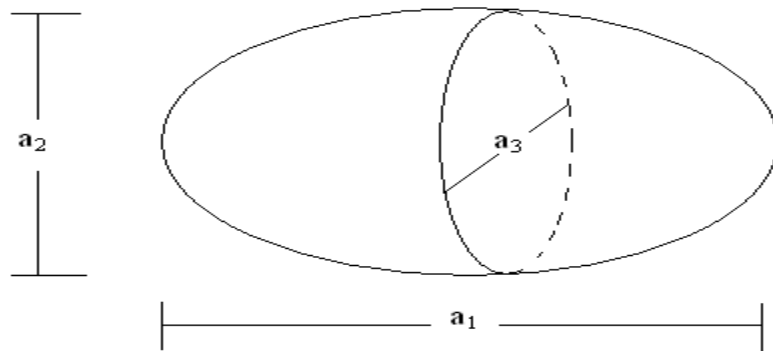


Fig. (2.2) Definition of axes a_1 , a_2 and a_3 for ellipsoid.

For air with suspending dust and/or sand particles, Eq. (2.3) reduces to

$$\varepsilon_i = \left(1 + v \frac{\varepsilon - 1}{1 + A_i(\varepsilon - 1)} \right) \dots \dots \dots (2.5)$$

The propagation constant of the storm is given by [2].

$$\gamma_i = \alpha_i + j\beta_i = j \frac{\omega}{c} \sqrt{\varepsilon_i} = j \frac{2\pi}{\lambda} \sqrt{\varepsilon_i} = j \frac{2\pi}{\lambda} \sqrt{1 + v \frac{\varepsilon - 1}{1 + A_i(\varepsilon - 1)}} \quad \dots \dots \dots (2.6)$$

hence

$$\beta_i \approx \frac{2\pi}{\lambda} \left[1 + \frac{1}{2} \operatorname{Re} \left(\frac{\nu(\varepsilon - 1)}{A_i(\varepsilon - 1)} \right) \right] \dots\dots\dots(2.7)$$

The phase shift per unit length relative to a wave traveling in air is obtained from Eq.(2.8) immediately as

$$8) \dots\dots\dots(2. \quad \phi_i = \frac{\pi}{\lambda} \operatorname{Re} \frac{\nu}{A_i + \frac{1}{\varepsilon - 1}}$$

If particles have random orientations relative to the wave polarization then the attenuation and phase shift constants are obtained as the average of all ϕ_i and α_i , respectively, thus

$$\alpha = -\frac{\pi}{3\lambda} \sum_i \operatorname{Im} \frac{\nu}{A_i + \frac{1}{\varepsilon - 1}} \dots\dots\dots(2.9.a)$$

$$\phi = \frac{\pi}{3\lambda} \sum_i \operatorname{Re} \frac{\nu}{A_i + \frac{1}{\varepsilon - 1}} \dots\dots\dots (2.9.b)$$

Equations (2.8) and (2.10) may be used to determine the attenuation and phase shift when a wave of known polarization propagates through a storm. Evaluation of these equations requires, however; knowledge of the orientation of particles relative to the wave polarization. McEwan and Bashir argued [4] that dust particles fall with the longest dimension vertical. The orientation of particles in the horizontal plane is, however, random with all directions equally likely to be encountered. It should be observed that the above hypothesis is valid only when particles are precipitating under the effect of gravity in the absence of wind. During the storm orientation of particles is expected to be different; the actual orientation depends on many factors including wind direction and its speed etc.

2.3.2 Attenuation and Phase Constants for Vertical Polarization

For a vertically polarized wave, the direction of the electric field is parallel to the shortest axis of the precipitating particle. From Fig.(2-2) and using Eq.(2.7) and Eq.(2.9) the expression for the attenuation and phase shift constants are as follows.

$$\alpha_3 = -\frac{\pi}{\lambda} \text{Im} \frac{\nu}{A_3 + \frac{1}{\epsilon - 1}} \dots\dots\dots (2.10.a)$$

$$\phi_3 = \frac{\pi}{\lambda} \text{Re} \frac{\nu}{A_3 + \frac{1}{\epsilon - 1}} \dots\dots\dots (2.10.b)$$

Since A_3 depends on the ellipsoids' axes ratios and since particles have different ratios, A_3 is not constant and the above equations need to be modified to take into account the variations in the a_2/a_1 and a_3/a_2 ratios. Let the probability of finding particles with a_2/a_1 ratio in the range $R_{l-1} < R < R_{l+1}$ be $P_l(R)$. Also if $P_j(r)$ is the probability of finding particles with a_3/a_2 in the range $r_{j-1} < r < r_{j+1}$ then the probability of finding particles with a_2/a_1 and a_3/a_2 within the indicated range is $P_l(R)P_j(r)$, here R and r stand for the ratios a_2/a_1 and a_3/a_2 , respectively. The above joint probability is valid if the random variables R and r are statistically independent which is assumed, there is no reason to believe otherwise [5].

If the volume occupied by dust per unit volume of air is ν , then the volume occupied by particles with the axes ratios in the selected ranges is $\nu P_l P_j$. Also for these particles the depolarization factor can be designated by A_{3lj} . The attenuation and phase constants due to the presence of these particles can be written as[5]

$$\alpha_{3lj} = -\frac{\pi}{\lambda} \text{Im} \frac{\nu P_l P_j}{A_{3lj} + \frac{1}{\epsilon - 1}} \dots\dots\dots (2.11.a)$$

$$\phi_{3lj} = \frac{\pi}{\lambda} \text{Re} \frac{\nu P_l P_j}{A_{3lj} + \frac{1}{\epsilon - 1}} \dots\dots\dots (2.11.b)$$

The total attenuation α and phase constants ϕ of a vertical polarized wave due to all particles is obtained as[5]:-

$$\alpha_v = -\frac{\pi}{\lambda} \text{Im} \sum_l \sum_j \frac{\nu P_l P_j}{A_{3lj} + \frac{1}{\epsilon - 1}} \dots\dots\dots (2.12.a)$$

$$\phi_v = \frac{\pi}{\lambda} \text{Re} \sum_l \sum_j \frac{\nu P_l P_j}{A_{3lj} + \frac{1}{\epsilon - 1}} \dots\dots\dots (2.12.b)$$

2.3.3 Attenuation and Phase Constants for Horizontal Polarization

The propagation constants for horizontal polarized wave are obtained following the same analysis as for vertical polarization. However, in this case the subscript 3 is replaced by 1 or 2. Since particles have no particular orientation in the horizontal plane the attenuation and phase shift constants are obtained as:-

$$\alpha_h = (\alpha_1 + \alpha_2)/2 \dots\dots\dots(2.13.a)$$

$$\phi_h = (\phi_1 + \phi_2)/2 \dots\dots\dots(2.13.b)$$

Hence, the attenuation and phase shift constants of a horizontally polarized wave is given by[5]:-

$$\alpha_h = -\frac{\pi}{2\lambda} \text{Im} \sum_l \sum_j \nu P_l P_j \left[\frac{1}{A_{2lj} + \frac{1}{\epsilon - 1}} + \frac{1}{A_{1lj} + \frac{1}{\epsilon - 1}} \right] \dots\dots(2.14.a)$$

$$\phi_h = \frac{\pi}{2\lambda} \text{Re} \sum_l \sum_j \nu P_l P_j \left[\frac{1}{A_{2lj} + \frac{1}{\epsilon - 1}} + \frac{1}{A_{1lj} + \frac{1}{\epsilon - 1}} \right] \dots\dots(2.14.b)$$

2.3.4 Attenuation and Cross Polarization of Circular Polarized wave

A circular polarized wave may be resolved into two linearly polarized waves of equal magnitudes but with their polarizations orthogonal and 90° out of phase. Since the attenuation and phase constants for vertical and horizontal polarizations in a storm are not the same, cross polarization is induced. It is known that the cross-polar discrimination (XPD) for a circular polarized wave is given by[5].

$$XPD = 10 \log_{10} \left| \frac{1 + 2m \cos \phi + m^2}{1 - 2m \cos \phi + m^2} \right| \text{ dB} \dots\dots\dots(2.15)$$

Where :

m is the ratio of the amplitudes of the two linearly polarized waves producing circular polarization, and ϕ is the phase difference between them.

If $m = 1$ and $\phi = 90^\circ$, then the wave is truly circularly polarized and XPD becomes infinite. The quantities m and ϕ can be determined for a wave propagating in a storm immediately as follows:

$$m = e^{-|\alpha_h - \alpha_v|D} \dots\dots\dots (2.16.a)$$

$$\phi = (\phi_h - \phi_v)D \dots\dots\dots (2.16.b)$$

Where :

D is the propagation path length in storm.

Attenuation of the circular polarized wave is brought by two mechanisms:

- 1) Absorption of energy in the propagation medium.
- 2) Change in polarization.

The attenuation of a circularly polarized wave due to the above two effects is given by[3]

$$\alpha(dB) = -20 \log_{10} \sqrt{\frac{1 + 2m \cos \phi + m^2}{4}} e^{-\alpha_v D} \dots\dots\dots(2.17)$$

From Eq.(2.18) it can be seen that for constant m the maximum and minimum values of attenuation caused by phase changes are given by:-

$$\alpha_{\min}(dB) = -20 \log_{10} \left(\frac{1-m}{2} \right) e^{-\alpha_v D} \dots\dots\dots (2.18.a)$$

$$\alpha_{\max}(dB) = -20 \log_{10} \left(\frac{1+m}{2} \right) e^{-\alpha_v D} \dots\dots\dots (2.18.b)$$

2.3.5 Attenuation and Phase Shift for Spherical Particles

It has been demonstrated by Chu [6] that the attenuation coefficient from dust or sand storms at centimeter wavelengths may be expressed for a mono dispersive medium (equal particle radii) by:-

$$\alpha = 12.6 \frac{\alpha_o r}{\lambda} \left[\frac{3\epsilon''}{(\epsilon' + 2)^2 + \epsilon''^2} \right] \text{ dB/Km} \dots\dots\dots (2.19)$$

Where :

α_o is the optical attenuation coefficient (dB/Km), r is the particle radius (m)

The total number of particles per unit volume (N_T) is given by:-

$$N_T = 3.67 \times 10^{-5} \frac{\alpha_o}{r^2} \dots\dots\dots (2.20)$$

Solving for α_o in Eq.(2.20) and substituting the resultant expression into Eq. (2.19), we get

$$\alpha = 3.43 \times 10^5 \frac{r^3 N_T}{\lambda} \times \frac{3\epsilon''}{(\epsilon' + 2)^2 + \epsilon''^2} \dots\dots\dots (2.21)$$

If we assume a more realistic condition that a distribution of particle sizes exists (polydispersive case): the Eq.(2-19) may alternately be expressed as:-

$$\alpha = \frac{1.029 \times 10^6 \times \epsilon''}{[(\epsilon' + 2)^2 + \epsilon''^2] \lambda} \sum_i N_i r_i^3 \dots\dots\dots (2.22)$$

where :

N_i is the number of particles with radii between r_i and $r_i + \Delta r_i$ per m^3 . Multiplying and dividing Eq. (2.23) by the total particle density N_T , we arrive at the alternate expression

$$\alpha = \frac{1.029 \times 10^6 \times \varepsilon'' N_T}{[(\varepsilon' + 2)^2 + \varepsilon''^2] \lambda} \sum_i P_i r_i^3 \dots\dots\dots (2.23)$$

Where:

P_i is the probability that r_i lies between r_i and $r_i + \Delta r_i$, and it is given by

$$P_i = \frac{N_i}{N_T} \dots\dots\dots (2.24)$$

2.4 Variation of Visibility with Height

A measure of the severity of storm is visibility. As is well known visibility decreases with increasing number of particles in the atmosphere. It was found that, the mass of suspending dust per unit volume of air is related to visibility by [7]:-

$$M = \frac{C}{V^\gamma} \dots\dots\dots (2.25)$$

Where: M is the dust or sand mass in Kg/cubic meter of air, V is the visibility in Km.

C and γ are constants that depend on the type of land from which the storm originated as well as the climatic conditions.

The visibility during dust and/or sand storms increases as the height is increased. Chepil and Woodruff [7], arrived at the following empirical relation for the variation of dust and/or sand mass concentration (M, kg/m³) with height(h, m).

$$M = \frac{a}{h^b} \dots\dots\dots (2.26)$$

Where: **h** 2m is the reference height

a and **b** are constants that vary a little from one year to another.

They depend on the climatic conditions, meteorological factors and the particle size distribution of the dust and the sand [7].

By substituting for M from Eq. (2.25) into Eq. (2.26), then visibility can be related to height by:-

$$V^\gamma = Ch^{b/a} \dots\dots\dots (2.27)$$

Let the visibility at some reference height h_0 to be V_0 , thus (2.28) yields

$$V^\gamma = V_0^\gamma [h/h_0]^b \dots\dots\dots (2.28)$$

CHAPTER 3

Samples collection and analysis

3 . 1 Site of Study Region

This chapter will be devoted to presenting the collection of samples, the humidity ,the wind speed, and the temperature . Sand and dust samples were collected at heights of 2 meter, 6 meter and 10 meter from positions of the towers station of the microwave link. Weather data are obtained from the national weather center in Tripoli. The samples will be

analysed for the Chemical composition at the petroleum institute center in Tripoli while dimensions analysis is down in the industrial researches center.

3.2 The Microwave Link

The microwave link is an analog system and it is operating at a frequency band 6-7 GHZ.



Figure(3.1) Map Showing the Location of Microwave link

This link has seven stations from Elmarej (station 1) to UM Alrazum (station7) with total distance of 215.1 km.

Table (3-1) height , location of towers and distance between towers

<i>Station Number</i>	<i>Station/ Exchange Name</i>	<i>Latitude N</i>	<i>Longitude E</i>	<i>Tower Height (meter)</i>	<i>Distance Between Towers (km)</i>

1	<i>Elmarej</i>	32 29 37.90	020 49 55.10	80	-
2	<i>Al Garieb</i>	32 33 07.51	021 06 54.81	92	27.37
3	<i>Al Byada</i>	32 37 35.30	021 28 18.60	60	34.48
4	<i>Al Baida</i>	32 45 50.80	021 45 44.10	72	31.22
5	<i>Lamluda</i>	32 47 16.50	022 07 47.30	147	34.54
6	<i>Derna</i>	32 44 06.90	022 40 06.70	122	50.82
7	<i>UM Alrazum</i>	32 32 48.50	022 59 22.80	122	36.67

3-3 The Metrological Data

The metrological data for the exact stations locations are not available but we will use the data for Elmarej, Al Baida and Derna this what has been confirmed to us by the officials of the national metrological center. who gave us the data for the three positions.

Table(3-2) Relative humidity, Temperature and Wind speed forAL Marej monthly averaged over (11) year

Month	Relative Humidity %	Wind speed(knots)	Temperature (C°)
JAN.	72.81	6.17	9.60
FEB.	72.09	6.48	9.44
MAR.	68.09	5.33	11.68
APR.	61.81	6.80	14.62
MAY.	62.72	6.78	20.10
JUN.	63.63	6.66	22.49

JUL.	68.09	6.68	24.46
AUG.	69.18	6.29	25.34
SEP.	66.54	6.12	23.90
OCT.	70.27	5.73	20.86
NOV.	71.81	6.87	16.26
DEC.	78.00	7.65	11.82
Yearly Average	68.75	6.46	17.54

Table(3-3) Relative humidity, Temperature and Wind speed for AL Baida monthly averaged over (17) year

Month	Relative Humidity %	Wind speed(knots)	Temperature (C°)
JAN.	75.74	4.68	10.00
FEB.	68.00	5.59	9.80
MAR.	65.23	5.61	11.82
APR.	55.47	5.73	15.35
MAY.	48.47	4.95	19.04
JUN.	45.46	4.18	20.80
JUL.	55.17	4.86	23.42
AUG.	58.23	4.70	22.60
SEP.	59.58	4.33	21.89
OCT.	60.70	4.31	19.33
NOV.	67.35	4.72	14.96
DEC.	73.35	5.03	11.42
Yearly Average	61.062	4.899	16.702

Table(3-4) Relative humidity, Temperature and Wind speed for Derna monthly averaged over (18) year

Month	Relative Humidity %	Wind speed(knots)	Temperature (C°)
JAN.	71.88	12.27	14.58
FEB.	69.83	12.53	14.25
MAR.	68.27	11.63	15.81
APR.	67.22	11.08	18.05
MAY.	71.77	9.89	21.00
JUN.	72.88	10.67	24.16

JUL.	74.88	13.41	26.29
AUG.	74.22	12.57	27.16
SEP.	71.22	9.87	26.06
OCT.	69.11	9.77	23.50
NOV.	66.16	11.25	19.66
DEC.	67.38	12.63	16.22
Yearly Average	70.401	11.464	20.561

3-4 Samples of Dust and Sand:

The samples were collected from Eljabal- Al akhdar area exact positions as stated in Table (3-1) each sample has three sub-samples, the first from a height of 2 meters the second from a height of 6 meters and the third were collected from a height of 10 meters above the ground.

- sample 1 from Elmarej area. location between latitude (322937.90 N) and longitude (0204955.10 E).
- sample 2 to the east of sample 1 about 27.37km. location between latitude (323307.51 N) and longitude (0210654.81 E).
- sample 3 to the east of sample 2 about 34.48km. location between latitude (323735.30 N) and longitude (0212818.60 E).
- sample 4 to the east of sample 3 about 31.22km. location between latitude (324550.80 N) and longitude (0214544.10 E).
- sample 5 to the east of sample 4 about 34.54km. location between latitude (324716.50 N) and longitude (0220747.30 E).
- sample 6 to the east of sample 5 about 50.82km. location between latitude (324406.90 N) and longitude (0224006.70 E).
- sample 7 to the east of sample 6 about 36.67km. location between latitude (323248.50 N) and longitude (0225922.80 E).

3-5 Analysis of the Samples:

The industrial researches labs . were used for the analysis of the particle - size - distribution (PSD) and the relative humidity. The centre of Petroleum researches in Tripoli was used to carry out the chemical composition analysis their results are given in Appendix (A).

3-5-1 Particle-Size- Distribution (PSD)

When you configure Tables PSD to get the results should use the following laws:

The pass ratio (%) = 100 (%) – Cumulative weight ratio (%)

Weight ratio (%) = (weight/weight of sample)*100

Cumulative weight ratio (%) = (Cumulative weight/ weight of sample)*100

Table (3-5) PSD of Sample(1) at height 2m in ELmarej Weight 113.08g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0	0	0	0	100
425	12.05	10.65	12.05	10.65	89.35
300	21.61	19.11	33.66	29.76	70.24
212	12.63	11.16	46.29	40.93	59.07
150	8.15	7.20	54.44	48.14	51.86
75	12.04	10.64	66.48	58.79	41.21
63	9.11	8.05	75.59	66.84	33.16
pan	37.28	32.96	112.87	99.81	0.19

63.23% of the sample is between(pan-212-300 µm) it is the biggest weight of sample

Table (3-6) PSD of Sample(1) at height 6m in ELMarej Weight 96.92g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0	0	0	0	100
425	3.52	3.63	3.52	3.63	96.37
300	7.30	7.53	10.82	11.16	88.84
212	5.89	6.07	16.71	17.24	82.76
150	3.51	3.62	20.22	20.86	79.14
75	54.55	56.28	74.77	77.14	22.86
63	9.51	9.81	84.28	86.95	13.05
pan	12.60	13.00	96.88	99.95	0.05

79.09% of the sample is between(pan-75 µm) it is the biggest weight of sample

Table (3-7) PSD of Sample(1) at height 10m in ELMarej Weight 46.44g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0	0	0	0	100
425	0	0	0	0	100
300	1.19	2.56	1.19	2.56	97.44
212	0.97	2.08	2.16	4.65	95.35
150	1.48	3.18	3.64	7.83	92.17
75	10.29	22.15	13.93	29.99	70.01
63	6.53	14.06	20.46	44.05	55.95
pan	25.35	54.58	45.81	98.64	1.36

90.79% of the sample is between(pan-75 µm) it is the biggest weight of sample

Table (3-8) PSD of Sample(2) at height 2m in ALGarieb Weight 76.55g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0	0	0	0	100
425	12.17	15.89	12.17	15.89	84.11
300	13.57	17.72	25.74	33.62	66.38
212	10.10	13.19	35.84	46.81	53.19
150	9.75	12.73	45.59	59.55	40.45
75	9.53	12.44	55.12	72.00	28.00
63	3.86	5.04	58.98	77.04	22.96
pan	17.50	22.97	76.48	99.9	0.01

69.77% of the sample is between(pan-212-300-425 µm) it is the biggest weight of sample

Table (3-9) PSD of Sample(2) at height 6m in ALGarieb Weight 66.44g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0	0	0	0	100
425	9.80	14.75	9.80	14.75	85.25
300	12.44	16.25	22.24	33.47	66.53
212	8.96	11.70	31.20	46.95	53.05
150	8.04	10.50	39.24	59.06	40.94
75	8.19	10.69	47.43	71.38	28.62
63	3.63	4.74	51.06	76.85	23.15
pan	15.14	19.77	66.20	99.63	0.37

53.47% of the sample is between(pan -300-425µm) it is the biggest weight of sample

Table (3-10) PSD of Sample(2) at height 10m in ALGarieb Weight 86.30g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0	0	0	0	100
425	0	0	0	0	100
300	9.67	11.20	9.67	11.20	88.80
212	11.97	13.87	21.64	25.07	74.93
150	11.49	13.31	33.13	38.38	61.62
75	15.60	18.07	48.73	56.46	43.54
63	12.70	14.71	61.43	71.18	28.82
pan	24.75	28.67	86.18	99.86	0.14

61.45% of the sample is between(pan-75 µm) it is the biggest weight of sample

Table (3-11) PSD of Sample(3) at height 2m in ALByada Weight 131.18g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	2.15	1.63	2.15	1.63	98.37
425	12.45	9.49	14.60	11.12	88.88
300	15.61	11.89	30.21	23.02	76.98
212	12.92	9.84	43.13	32.87	67.13
150	9.29	7.08	52.42	39.96	60.04
75	46.20	35.21	98.62	75.17	24.83
63	11.77	8.97	110.39	84.15	15.85
pan	20.63	15.72	131.02	99.87	0.13

62.82% of the sample is between(pan-75-300 µm) it is the biggest weight of sample

Table (3-12) PSD of Sample(3) at height 6m in ALByada Weight 93.70g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	1.73	1.84	1.73	1.84	98.16
425	10.68	11.39	12.41	13.24	86.76
300	17.03	18.17	29.44	31.41	68.59
212	12.44	13.27	41.88	44.69	55.31
150	14.26	15.21	56.14	59.91	40.09
75	11.63	12.41	67.77	72.32	27.68
63	5.17	5.51	72.94	77.84	22.16
pan	20.53	21.91	93.47	99.75	0.25

80.97% of the sample is between(pan -300 µm) it is the biggest weight of sample

Table (3-13) PSD of Sample(3) at height 10 m in ALByada Weight 75.65g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0.15	0.19	0.15	0.19	99.81
425	2.28	3.01	2.43	3.21	96.79
300	8.44	11.15	10.87	14.36	85.64
212	11.01	14.55	21.88	28.92	71.08
150	7.03	9.29	28.91	38.21	61.79
75	16.01	21.16	44.92	59.37	40.63
63	11.23	14.84	56.15	74.22	25.78
pan	18.91	24.99	75.06	99.22	0.78

60.99% of the sample is between(pan-75 µm) it is the biggest weight of sample

Table (3-14) PSD of Sample(4) at height 2m in ALBaida Weight 69.58g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	1.08	1.55	1.08	1.55	98.45
425	6.97	10.01	8.05	14.38	85.62
300	9.77	14.04	17.82	25.61	74.39
212	9.98	14.34	27.80	39.95	60.05
150	8.90	12.79	36.70	52.74	47.26
75	15.34	22.04	52.04	74.79	25.21
63	5.58	8.01	57.62	82.81	17.19

pan	11.71	16.82	69.33	99.64	0.36
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80.03% of the sample is between(pan-300 μm) it is the biggest weight of sample

Table (3-15) PSD of Sample(4) at height 6m in ALBaida Weight 90.89g

The sieve size (μm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0.84	0.92	0.84	0.92	99.08
424	9.96	10.95	10.80	11.88	88.12
300	13.18	14.50	23.98	26.38	73.62
212	11.88	13.07	35.86	39.45	60.55
150	10.68	11.75	46.54	51.20	48.80
75	17.08	18.79	63.62	69.99	30.01
63	7.69	8.46	71.31	78.45	21.55
pan	19.34	21.27	90.65	99.73	0.27

79.83% of the sample is between(pan-300 μm) it is the biggest weight of sample

Table (3-16) PSD of Sample(4) at height 10m in ALBaida Weight 78.29g

The sieve size (μm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0.52	0.66	0.52	0.66	99.34
425	4.60	5.87	5.12	6.53	93.47
300	9.87	12.60	14.99	19.14	80.86
212	7.04	8.99	22.03	28.13	71.87
150	9.03	11.53	31.06	39.67	60.33
75	19.32	24.67	50.38	64.35	35.65
63	12.76	16.29	63.14	80.64	19.36
pan	14.31	18.27	77.45	98.92	1.08

59.23% of the sample is between(pan-75 μm) it is the biggest weight of sample

Table (3-17) PSD of Sample(5) at height 2m in Lamluda Weight 82.99g

The sieve size (μm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0.63	0.75	0.63	0.75	99.25
425	5.00	6.02	5.63	6.78	93.22
300	6.88	8.29	12.51	15.07	84.93
212	6.05	7.29	18.56	22.36	77.64

150	7.11	8.56	25.67	30.93	69.07
75	21.48	25.88	47.15	56.81	43.19
63	10.97	13.21	58.12	70.03	29.97
pan	24.53	29.55	82.56	99.59	0.41

68.64% of the sample is between(pan-75 μm) it is the biggest weight of sample

Table (3-18) PSD of Sample(5) at height 6m in Lamluda Weight 72.41g

The sieve size (μm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0.36	0.49	0.36	0.49	99.51
425	2.82	3.89	3.18	4.39	95.61
300	4.01	5.53	7.19	9.92	90.08
212	4.63	6.39	11.82	16.32	83.68
150	6.48	8.94	18.30	25.27	74.73
75	24.39	33.68	42.69	58.95	41.05
63	10.04	13.86	52.73	72.82	27.18
pan	19.27	26.61	72.00	99.43	0.57

74.15% of the sample is between(pan-75 μm) it is the biggest weight of sample

Table (3-19) PSD of Sample(5) at height 10m in Lamluda Weight 102.80g

The sieve size (μm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0	0	0	0	100
425	0.12	0.11	0.12	0.11	99.89
300	4.39	4.27	4.51	4.38	95.62
212	4.92	4.78	9.43	9.17	90.83
150	8.40	8.17	17.83	17.34	82.66
75	41.43	40.30	59.26	57.64	42.36
63	23.55	22.90	82.81	80.55	19.45
pan	19.29	18.76	102.10	99.31	0.69

81.96% of the sample is between(pan-75 μm) it is the biggest weight of sample

Table (3-20) PSD of Sample(6) at height 2m in Derna Weight 126.40g

The sieve size (μm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	3.82	3.02	3.82	3.02	96.98

425	6.27	4.96	10.09	7.98	92.02
300	18.53	14.65	28.62	22.64	77.36
212	11.86	9.38	40.48	32.02	67.98
150	9.69	5.29	47.17	37.31	62.69
75	39.11	30.94	86.28	68.25	31.75
63	13.68	10.82	99.96	79.08	20.92
pan	26.07	20.62	126.03	99.70	0.30

77.03% of the sample is between(pan-300 μm) it is the biggest weight of sample

Table (3-21) PSD of Sample(6) at height 6m in Derna Weight 83.98g

The sieve size (μm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0.60	0.71	0.60	0.71	99.29
425	15.61	18.58	16.21	19.30	80.70
300	11.97	14.25	28.18	33.55	66.45
212	9.19	10.94	37.37	44.49	55.51
150	14.11	16.80	51.48	61.30	38.70
75	11.68	13.90	63.16	75.20	24.80
63	5.57	6.63	68.73	81.84	18.16
pan	14.74	17.55	83.20	99.07	0.93

81.08% of the sample is between(pan-425 μm) it is the biggest weight of sample

Table (3-22) PSD of Sample(6) at height 10m in Derna Weight 84.90g

The sieve size (μm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0.09	0.10	0.09	0.10	99.90
425	2.25	2.56	2.34	2.75	97.25
300	11.87	13.98	14.21	16.73	83.27
212	16.67	19.63	30.88	36.37	63.63
150	20.95	24.67	51.83	61.04	38.96
75	16.60	19.55	68.43	80.60	19.40
63	12.38	14.58	80.81	95.18	4.82
pan	4.00	4.71	84.81	99.88	0.12

78.43% of the sample is between(63-212 μm) it is the biggest weight of sample

Table (3-23) PSD of Sample(7) at height 2m in UM ALrazum Weight 102.70g

The sieve size (μm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	2.72	2.64	2.72	2.64	97.36
425	1.14	1.11	3.86	3.75	96.25
300	4.25	4.13	8.11	7.89	92.11
212	3.83	3.72	11.94	11.62	88.83
150	4.12	4.01	16.06	15.63	84.37
75	28.27	27.52	44.33	43.16	56.84
63	37.21	36.23	81.54	79.39	20.61
pan	20.60	20.05	102.14	99.45	0.55

83.80% of the sample is between(pan-75 μm) it is the biggest weight of sample

Table (3-24) PSD of Sample(7) at height 6m in UM ALrazum Weight 90.80g

The sieve size (μm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	1.07	1.17	1.07	1.17	98.83
425	6.05	6.66	7.12	7.84	92.16
300	9.66	10.63	16.78	18.48	81.16
212	7.67	8.44	24.45	26.92	73.08
150	10.33	11.37	34.78	38.30	61.70
75	18.37	20.23	53.15	58.53	41.47
63	17.30	19.05	70.45	77.58	22.42
pan	19.57	21.55	90.02	99.14	0.86

60.83% of the sample is between(pan-75 μm) it is the biggest weight of sample

Table (3-25) PSD of Sample(7) at height 10m in UM ALrazum Weight 62.64g

The sieve size (μm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0	0	0	0	100
425	0.14	0.22	0.14	0.22	99.78
300	3.00	4.78	3.14	5.01	94.99
212	30.81	49.18	33.95	54.19	45.81
150	8.71	13.90	42.66	68.10	31.90
75	12.86	20.53	55.52	88.63	11.37
63	2.73	4.35	58.25	92.99	7.01
pan	3.88	6.19	62.13	99.18	0.82

83.61% of the sample is between(75-212 μm) it is the biggest weight of sample

3.5.2 Density and Conductivity

The conductivity and density results for the seven samples each sample has three sub-samples, the first taken from a height of 2 meters the second from a height of 6 meters and the third were collected from a height of 10 meters above the ground as in Tables following :-

Table(3-26) Density and Conductivity at height (2-m)

NO.	Samples name	Density (g / ml)	Conductivity (μ s /cm)
1	ALmarej 2m	1.3736	182
2	AL Garieb 2m	1.3274	4030
3	AL Byada 2m	1.3953	788
4	AL Baida 2m	1.3636	489
5	Lamluda 2m	1.4286	754
6	Derna 2m	1.5116	357
7	UM ALrazum 2m	1.4493	258
	Average	1.4070	979.7142

Table(3-27) Density and Conductivity at height (6-m)

NO.	Samples name	Density (g / ml)	Conductivity (μ s /cm)
1	ALmarej 6m	1.4525	730
2	AL Garieb 6m	1.3768	955
3	AL Byada 6m	1.3333	595
4	AL Baida 6m	1.3281	1105
5	Lamluda 6m	1.3559	1812
6	Derna 6m	1.3559	684

7	UM ALrazum 6m	1.3393	314
	Average	1.3631	885

Table(3-28) Density and Conductivity at height (10-m)

NO.	Samples name	Density (g / ml)	Conductivity(μs /cm)
1	ALmarej 10m	1.3514	1255
2	AL Garieb 10m	1.3462	344
3	AL Byada 10m	1.3725	1813
4	AL Baida 10m	1.3393	1006
5	Lamluda 10m	1.4474	1148
6	Derna 10m	1.5217	264
7	UM ALrazum 10m	1.3265	613
	Average	1.3864	920.428

3.5.3 Relative Humidity for the Samples

Table(3-29)The watery content of sample No. (1) **ELmarej**

<i>Height</i>	<i>Weight of Sample humid</i>	<i>Weight of Sample dryish</i>	<i>Weight of Water</i>	<i>Relative Humidity for the Sample%</i>
2m	115.23	113.08	2.15	1.90
6m	98.70	96.92	1.78	1.83
10m	47.00	46.44	0.56	1.20

Table(3-30)The watery content of sample No. (2) **EL Garieb**

<i>Height</i>	<i>Weight of Sample humid</i>	<i>Weight of Sample dryish</i>	<i>Weight of Water</i>	<i>Relative Humidity for the Sample%</i>
2m	80.06	76.55	3.51	4.58
6m	68.79	66.44	2.35	3.53
10m	87.80	86.30	1.50	1.73

Table(3-31)The watery content of sample No. (3) **EL Byada**

<i>Height</i>	<i>Weight of Sample humid</i>	<i>Weight of Sample dryish</i>	<i>Weight of Water</i>	<i>Relative Humidity for the Sample%</i>
2m	134.74	131.18	3.56	4.58
6m	96.19	93.70	2.49	2.65
10m	77.34	75.65	1.69	2.23

Table(3-32)*The watery content of sample No. (4) EL Baida*

<i>Height</i>	<i>Weight of Sample humid</i>	<i>Weight of Sample dryish</i>	<i>Weight of Water</i>	<i>Relative Humidity for the Sample%</i>
2m	70.83	69.58	1.25	1.79
6m	91.90	90.89	1.01	1.11
10m	79.00	78.29	0.71	0.91

Table(3-33)*The watery content of sample No. (5) Lamluda*

<i>Height</i>	<i>Weight of Sample humid</i>	<i>Weight of Sample dryish</i>	<i>Weight of Water</i>	<i>Relative Humidity for the Sample%</i>
2m	84.06	82.99	1.07	1.29
6m	73.27	72.41	0.86	1.18
10m	103.41	102.80	0.61	0.59

Table(3-34)*The watery content of sample No. (6) Derna*

<i>Height</i>	<i>Weight of Sample humid</i>	<i>Weight of Sample dryish</i>	<i>Weight of Water</i>	<i>Relative Humidity for the Sample%</i>
2m	128.26	126.40	1.86	1.47
6m	85.20	83.98	1.22	1.45
10m	85.70	84.90	0.80	0.94

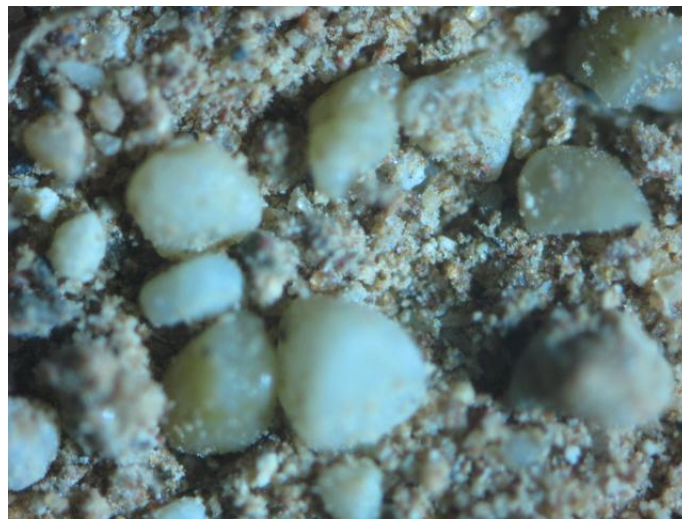
Table(3-35)*The watery content of sample No. (7) UMALrazum*

<i>Height</i>	<i>Weight of Sample humid</i>	<i>Weight of Sample dryish</i>	<i>Weight of Water</i>	<i>Relative Humidity for the Sample%</i>
2m	104.06	102.70	1.36	1.32
6m	91.93	90.80	1.13	1.24

10m	63.30	62.64	0.66	1.05
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3.5.4 Microscopic images for the samples.

Microscopic images for the samples measurement from Libyan Petroleum center. Measurement each sample **5 mm** .



← 5mm →

Fig.(3-2)Sample 1 El Merj 2m



← 5mm →

Fig.(3-3)Sample 1 El Merj 6m

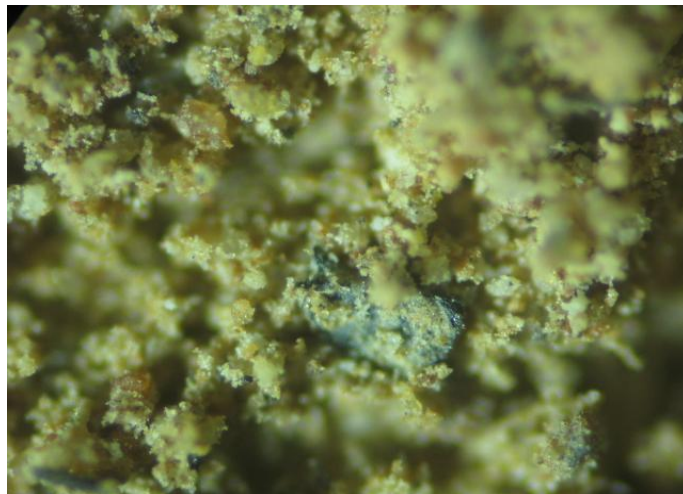


Fig.(3-4)Sample 1 El Merj 10 m

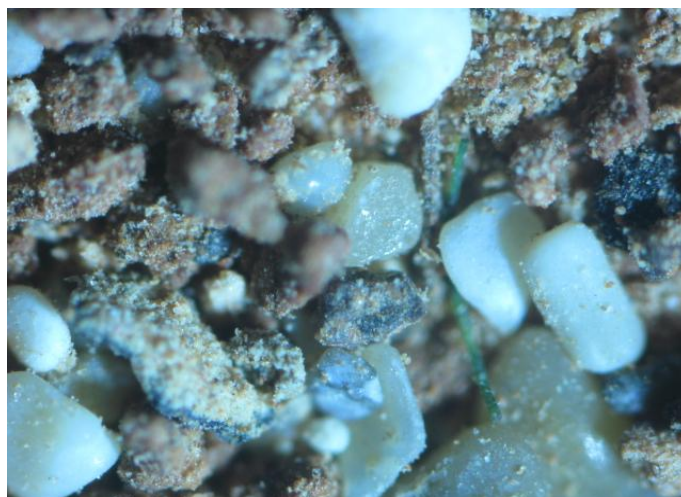


Fig.(3-5)Sample 2 El Garieb 2 m



Fig.(3-6)Sample 2 El Garieb 6 m



Fig.(3-7)Sample 2 *El Garieb* 10 m



Fig.(3-8)Sample 3 *El Byada* 2 m

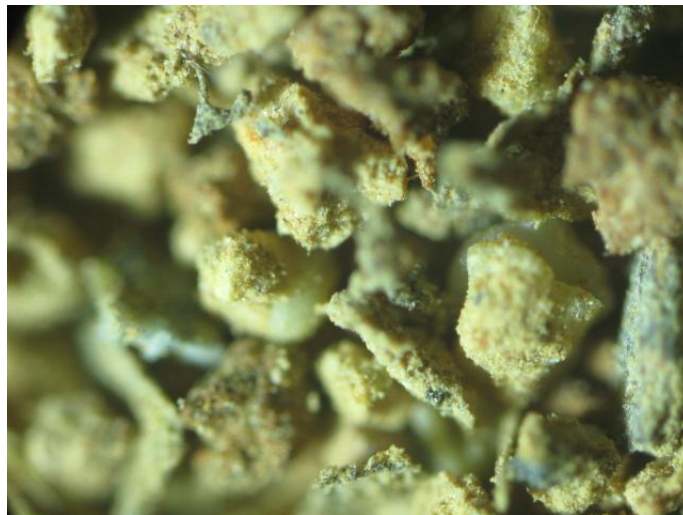


Fig.(3-9)Sample 3 *El Byada* 6 m

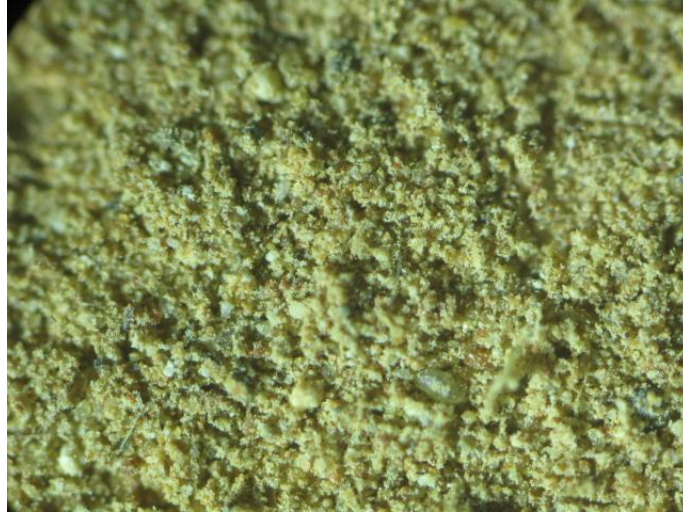


Fig.(3-10)Sample 3 *El Byada* 10 m

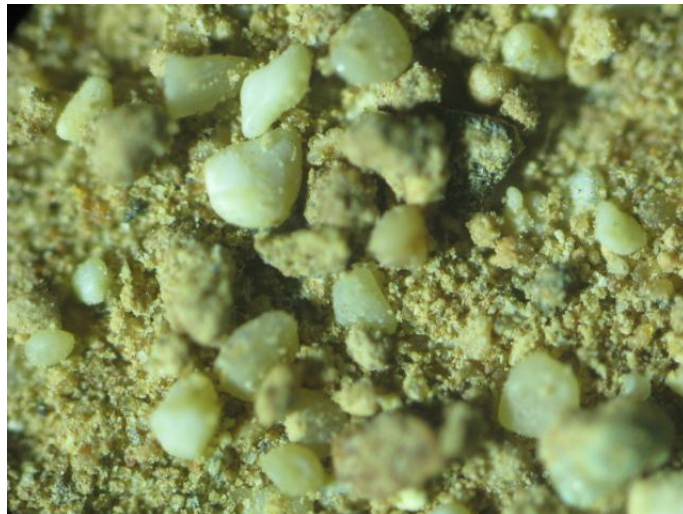


Fig.(3-11)Sample 4 *El Baida* 2 m



Fig.(3-12)Sample 4 *El Baida* 6 m



Fig.(3-13)Sample 4 *El Baida* 10 m

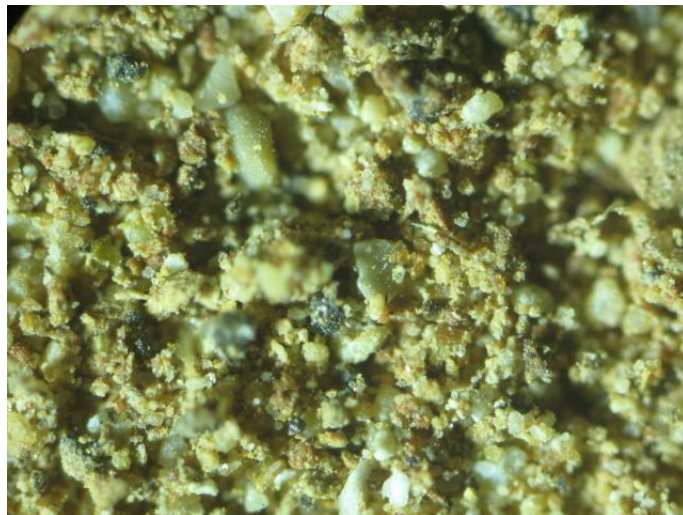


Fig.(3-14)Sample 5 *Lamluda* 2 m

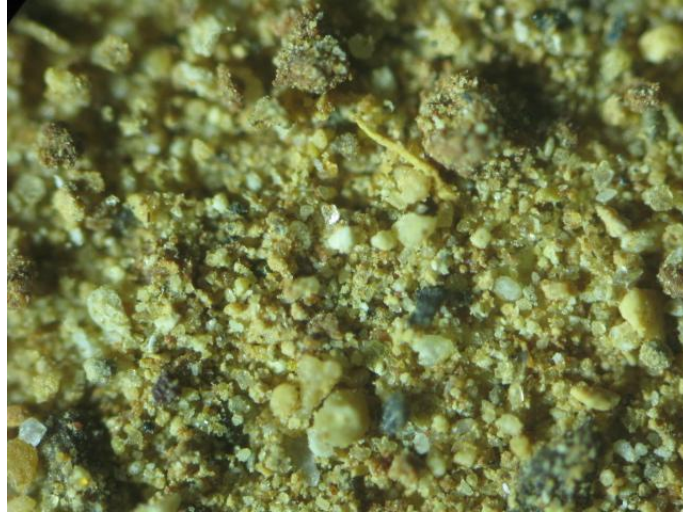


Fig.(3-15)Sample 5 Lamluda 6 m



Fig.(3-16)Sample 5 Lamluda 10 m



Fig.(3-17)Sample 6 Derna 2 m



Fig.(3-18)Sample 6 Derna 6 m



Fig.(3-19)Sample 6 Derna 10 m



Fig.(3-20)Sample 7 Um El Razum 2 m



Fig.(3-21)Sample 7 Um El Razum 6 m



Fig.(3-22)Sample 7 Um El Razum 10 m

3.5.5 Chemical Composition

The chemical composition analysis of the samples as determined by the Libyan petroleum institute laboratory are given in Tables (3-36) to (3-42).

Table (3-36) Chemical Analysis of Sample(1)

Sample No. 1 EL Marj			13/03/2014
Oxide	Mass %		
	2 m	6 m	10 m
Fe ₂ O ₃	2.28	1.36	0.19
CaO	24.51	9.09	33.94
K ₂ O	1.11	3.77	1.10
SiO ₂	47.86	73.94	29.22
Al ₂ O ₃	3.15	0.79	3.00
MgO	0.90	0.14	1.82
Na ₂ O	1.41	1.39	1.59
CO ₂	18.38	6.82	28.73
CL	0.51	3.62	0.56

From Table (3-36) we get major constituents of sample as SiO₂, CaO and CO₂ about 90.48% by weight of sample.

Table (3-37) Chemical Analysis of Sample(2)

Sample No. 2 AL Garieb			13/03/2014
Oxide	Mass %		
	2 m	6 m	10 m
Fe ₂ O ₃	1.73	2.13	0.36
CaO	23.57	29.12	26.43
K ₂ O	1.87	0.81	2.35
SiO ₂	41.16	33.76	37.83
Al ₂ O ₃	4.21	2.57	3.09
MgO	3.32	3.08	3.55

Na ₂ O	1.68	1.55	0.81
CO ₂	17.28	22.52	19.89
CL	3.87	3.58	5.10

From Table (3-37) we get major constituents of sample as SiO₂, CaO and CO₂ about 84.63% by weight of sample.

Table (3-38) Chemical Analysis of Sample(3)

Sample – No. 3 <i>El Byada</i>			13/03/2014
Oxide	Mass %		
	2 m	6 m	10 m
Fe ₂ O ₃	2.16	1.95	2.10
CaO	15.26	36.73	23.81
K ₂ O	0.47	1.44	2.40
SiO ₂	64.38	27.66	20.59
Al ₂ O ₃	1.26	1.43	0.73
MgO	0.71	0.99	0.95
Na ₂ O	1.23	1.14	0.83
CO ₂	12.75	29.30	17.32
CL	0.89	2.19	1.38

From Table (3-38) we get major constituents of sample as SiO₂, CaO and CO₂ about 90.38% by weight of sample.

Table (3-39) Chemical Analysis of Sample(4)

Sample No.4 <i>El Baida</i>			13/03/2014
Oxide	Mass %		
	2 m	6 m	10 m
Fe ₂ O ₃	1.48	1.25	0.93
CaO	30.62	41.42	47.56
K ₂ O	2.29	3.12	2.73

SiO ₂	41.30	14.61	9.87
Al ₂ O ₃	1.41	0.92	1.17
MgO	0.13	0.97	1.31
Na ₂ O	0.85	0.96	1.06
CO ₂	24.23	30.39	37.33
CL	3.16	4.52	2.30

From Table (3-39) we get major constituents of sample as SiO₂ , CaO and CO₂
about 90.03% by weight of sample.

Table (3-40) Chemical Analysis of Sample(5)

Sample No. 5 <i>Lamluda</i>			13/03/2014
Oxide	Mass %		
	2 m	6 m	10 m
Fe ₂ O ₃	1.58	0.43	1.39
CaO	32.71	37.79	37.31
K ₂ O	0.87	1.58	1.43
SiO ₂	31.29	27.89	27.68
Al ₂ O ₃	2.91	1.44	1.15
MgO	0.80	0.70	0.38
Na ₂ O	1.58	0.72	1.66
CO ₂	23.77	29.21	29.29
CL	5.72	3.64	4.21

From Table (3-40) we get major constituents of sample as SiO₂ , CaO and CO₂
about 89.49% by weight of sample.

Table (3-41) Chemical Analysis of Sample(6)

Sample No. 6 <i>Derna</i>			13/03/2014
Oxide	Mass %		
	2 m	6 m	10 m

Fe ₂ O ₃	1.05	1.73	1.43
CaO	37.39	29.49	19.95
K ₂ O	1.13	0.91	0.65
SiO ₂	22.69	32.52	49.61
Al ₂ O ₃	1.97	2.02	2.00
MgO	2.61	3.51	3.05
Na ₂ O	1.20	1.23	2.47
CO ₂	30.75	23.76	17.53
CL	2.34	5.17	4.27

From Table (3-41) we get major constituents of sample as SiO₂ , CaO and CO₂ about 87.19% by weight of sample.

Table (3-42) Chemical Analysis of Sample(7)

Sample No. 7 <i>Um El Razum</i>			13/03/2014
Oxide	Mass %		
	2 m	6 m	10 m
Fe ₂ O ₃	1.46	2.48	3.75
CaO	6.37	16.93	23.48
K ₂ O	2.78	1.20	2.49
SiO ₂	75.80	54.68	33.84
Al ₂ O ₃	5.94	5.44	1.40
MgO	0.39	0.57	2.64
Na ₂ O	1.78	2.51	0.85
CO ₂	5.48	14.10	17.56
CL	4.81	3.76	6.50

From Table (3-42) we get major constituents of sample as SiO₂ , CaO and CO₂ about 82.93% by weight of sample.

3.5.6 Elements Composition

The compounds in samples can be estimated by manual analysis so that getting elements weighty all the compounds.

Table(3-43) Elements Analysis of samples.

Elements	Sample No. 1 EL Marj		
	2 m	6 m	10 m
Fe	1.596	0.952	0.133
Ca	17.507	6.493	24.243
K	0.921	3.128	0.913
Si	22.335	34.505	13.636
Al	1.668	0.418	1.588
Mg	0.540	0.084	1.092
Na	1.046	1.031	1.180
C	5.013	1.860	7.835

Table(3-44) Elements Analysis of samples.

Elements	Sample No. 2 AL Garieb		
	2 m	6 m	10 m
Fe	1.211	1.491	0.252
Ca	16.836	20.800	18.879
K	1.552	0.672	1.950
Si	19.208	15.755	17.654
Al	2.229	1.361	1.636
Mg	1.992	1.848	2.130
Na	1.246	1.150	0.601
C	4.713	6.142	5.425

Table(3-45) Elements Analysis of samples.

Elements	Sample No. 3 El Byada		
	2 m	6 m	10 m
Fe	1.512	1.365	1.470
Ca	10.900	26.236	17.007
K	0.390	1.195	1.991
Si	30.044	12.908	9.607
Al	0.667	0.757	0.386
Mg	0.426	0.594	0.570
Na	0.913	0.477	0.616
C	3.477	7.991	4.724

Table(3-46) Elements Analysis of samples.

Elements	Sample No. 4 <i>El Baida</i>		
	2 m	6 m	10 m
Fe	1.036	0.875	0.651
Ca	21.871	29.586	33.971
K	1.900	2.589	2.265
Si	19.273	6.818	4.606
Al	0.746	0.487	0.619
Mg	0.078	0.582	0.786
Na	0.631	0.712	0.787
C	6.608	8.288	10.181

Table(3-47) Elements Analysis of samples.

Elements	Sample No. 5 <i>Lamluda</i>		
	2 m	6 m	10 m
Fe	1.106	0.301	0.973
Ca	23.364	26.993	26.650
K	0.722	1.311	1.187
Si	14.602	13.015	12.917
Al	1.541	0.762	0.609
Mg	0.480	0.420	0.228
Na	1.172	0.534	1.232
C	6.483	7.966	7.988

Table(3-48) Elements Analysis of samples.

Elements	Sample No. 6 <i>Derna</i>		
	2 m	6 m	10 m
Fe	0.735	1.211	1.001
Ca	26.707	21.064	13.993
K	0.938	0.755	0.539
Si	10.589	15.176	23.151
Al	1.043	1.069	1.059
Mg	1.566	2.106	1.830
Na	0.890	0.913	1.833
C	8.386	6.480	4.781

Table(3-49) Elements Analysis of samples.

Elements	Sample No. 7 <i>Um El Razum</i>		
	2 m	6 m	10 m
Fe	1.022	1.736	2.625
Ca	4.550	12.039	16.771
K	2.307	0.996	2.066
Si	35.373	25.564	15.792
Al	3.145	2.880	0.741
Mg	0.234	0.342	1.584
Na	1.321	1.862	0.631
C	1.495	3.845	4.789

CHAPTER 4

Analysis of the results

4.1 Introduction

In this chapter, the measurements and analysis data presented in chapter three will be used, by finding the average complex permittivity, the average density of samples and estimating the difference effects on the microwave signals like the attenuation and cross polarization constants.

4.2 Calculation of the Complex Permittivity of Samples

From the values of the complex permittivity and the relative volume of all substances, we can calculate the complex permittivity of the composite component.

by using the Looyang Equation as given by [1].

$$\epsilon_m^{1/3} = \sum_i \epsilon_i^{1/3} V_i \dots\dots\dots(4-1)$$

Where: ϵ_m is the complex dielectric constant of the mixture.

ϵ_i is the complex dielectric constant of the i^{th} substance.

V_i is the relative volume of the i^{th} sample from the volume of the total sample.

Using the results presented in Tables (3-36) to (3-42) and Equation (4-1) we get the complex dielectric constant of a mixture and using Table(4-1) the complex permittivity of each substance.

Table (4-1)Complex Permittivity of Substances[1, 10, 14]

Compound	Complex Permittivity
SiO ₂	4.43-j0.04
Al ₂ O ₃	12.66-j1.31
Fe ₂ O ₃	16.58-j0.93
CaCO ₃	8.22-j0.12
MgCO ₃	5.03-j0.17
CaSO ₄	5.01-j0.08
MnO ₂	75.74-j26.29
CO ₂	4.389-j0.829
NaCl	5.70-j0.09
KCl	4.70-j0.05

From
Tables
(3-36)
to (3-
42)
along

with Table (4-1) we see that Na₂O, CL and K₂O do not have a complex permittivity as is so we consulted a chemical science university staff member, he pointed that they are results from dissolving the KCL, NaCL so we a adapted this point of view and considers Na₂O, CL and K₂O as the result of the two salts.

KCL and NaCL with the mass of each as the average of the two masses that make the compound.

Analysis of Samples on height (2-m)

Table(4-2a) Analysis of sample (1) El Merj 2m

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.4781	0.7852-j0.0024
Al ₂ O ₃	12.66-j1.31	0.0315	0.0735-j0.0025
Fe ₂ O ₃	16.58-j0.93	0.0227	0.0759-j0.0011
CaCO ₃	8.22-j0.12	0.2448	0.4941-j0.0024
MgCO ₃	5.03-j0.17	0.0089	0.0153-j0.0002
CO ₂	4.389-j0.829	0.1836	0.3018-j0.0188
NaCl	5.70-j0.09	0.0096	0.0171-j0.0001
KCl	4.70-j0.05	0.0081	0.0136-j0.0001

From Table above and from equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 5.4338-j0.2560$

Quantity lost in weight of sample is (0.0127) and therefore we work with normalization of sample weight.

Table (4-2b) Normalization Results of Table (4-2a).

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.4841	0.7951-j0.0024
Al ₂ O ₃	12.66-j1.31	0.0319	0.0744-j0.0026
Fe ₂ O ₃	16.58-j0.93	0.0229	0.0584-j0.0011
CaCO ₃	8.22-j0.12	0.2479	0.5003-j0.0024
MgCO ₃	5.03-j0.17	0.0090	0.0154-j0.0002
CO ₂	4.389-j0.829	0.1859	0.3056-j0.0190
NaCl	5.70-j0.09	0.0097	0.0173-j0.0001
KCl	4.70-j0.05	0.0082	0.0137-j0.0001

From Table (4-2b) and Equation (4-1) we get the complex dielectric constant of the mixture is $\epsilon_m = 5.6374-j0.2651$

The average of the two will be:

$$1/2(5.4338-j0.2560 + 5.6374-j0.2651) = \mathbf{5.5356-j0.2605}$$

Table(4-3a) Analysis of sample (2) El Garieb 2 m

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.4171	0.6850-j0.0021
Al ₂ O ₃	12.66-j1.31	0.0427	0.0996-j0.0034
Fe ₂ O ₃	16.58-j0.93	0.0175	0.0446-j0.0008
CaCO ₃	8.22-j0.12	0.2388	0.4819-j0.0023
MgCO ₃	5.03-j0.17	0.0336	0.0576-j0.0006
CO ₂	4.389-j0.829	0.1751	0.2878-j0.0179
NaCl	5.70-j0.09	0.0281	0.0502-j0.0003
KCl	4.70-j0.05	0.0291	0.0487-j0.0002

From Table above and from Equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 5.4051 - j0.2551$

Quantity lost in weight of sample is (0.0180) and therefore we work with normalization of sample weight .

Table (4-3b) Normalization Results of Table (4-3a) .

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.4246	0.6974-j0.0021
Al ₂ O ₃	12.66-j1.31	0.0435	0.1015-j0.0035
Fe ₂ O ₃	16.58-j0.93	0.0178	0.0454-j0.0008
CaCO ₃	8.22-j0.12	0.2431	0.4906-j0.0024
MgCO ₃	5.03-j0.17	0.0342	0.0586-j0.0007
CO ₂	4.389-j0.829	0.1783	0.2931-j0.0183
NaCl	5.70-j0.09	0.0286	0.0511-j0.0003
KCl	4.70-j0.05	0.0296	0.0496-j0.0002

From Table (4-2b) and Equation (4-1) we get the complex dielectric constant of the mixture is $\epsilon_m = 5.7051 - j0.2712$

The average of the two will be:

$$1/2(5.4051 - j0.2551 + 5.7051 - j0.2712) = \mathbf{5.5551 - j0.2631}$$

Table(4-4a) Analysis of sample (3) El Byada 2 m

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.6496	1.0669-j0.0032
Al ₂ O ₃	12.66-j1.31	0.0127	0.0296-j0.0010
Fe ₂ O ₃	16.58-j0.93	0.0218	0.0556-j0.0010
CaCO ₃	8.22-j0.12	0.1539	0.3106-j0.0015
MgCO ₃	5.03-j0.17	0.0072	0.0123-j0.0001
CO ₂	4.389-j0.829	0.1287	0.2115-j0.0132
NaCl	5.70-j0.09	0.0107	0.0191-j0.0001
KCl	4.70-j0.05	0.0067	0.0112-j0.0001

From Table above and from Equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 5.0580 - j0.1785$

Quantity lost in weight of sample is (0.0087) and therefore we work with normalization of sample weight.

Table (4-4b) Normalization Results of Table (4-4a) .

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.6553	1.0762-j0.0032
Al ₂ O ₃	12.66-j1.31	0.0128	0.0299-j0.0010
Fe ₂ O ₃	16.58-j0.93	0.0220	0.0561-j0.0010
CaCO ₃	8.22-j0.12	0.1552	0.3132-j0.0015
MgCO ₃	5.03-j0.17	0.0073	0.0125-j0.0001
CO ₂	4.389-j0.829	0.1298	0.2133-j0.0133
NaCl	5.70-j0.09	0.0108	0.0193-j0.0001
KCl	4.70-j0.05	0.0068	0.0114-j0.0001

From Table (4-2b) and equation (4-1) we get the complex dielectric constant of the mixture is $\epsilon_m = 5.1926 - j0.1826$

The average of the two will be:

$$1/2(5.0580 - j0.1785 + 5.1926 - j0.1826) = \mathbf{5.1253 - j0.1805}$$

Table(4-5a) Analysis of sample (4) El Baida 2 m

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.3915	0.6430-j0.0019
Al ₂ O ₃	12.66-j1.31	0.0133	0.0310-j0.0011
Fe ₂ O ₃	16.58-j0.93	0.0140	0.0357-j0.0007
CaCO ₃	8.22-j0.12	0.2903	0.5859-j0.0029
MgCO ₃	5.03-j0.17	0.0012	0.0021-j0.0001
CO ₂	4.389-j0.829	0.2297	0.3776-j0.0235
NaCl	5.70-j0.09	0.0190	0.0339-j0.0002
KCl	4.70-j0.05	0.0258	0.0432-j0.0002

From Table above and from Equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 5.3764 - j0.2818$

Quantity lost in weight of sample is (0.0152) and therefore we work with normalization of sample weight.

Table (4-5b) Normalization Results of Table (4-5a) .

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.3974	0.6527-j0.0020
Al ₂ O ₃	12.66-j1.31	0.0135	0.0315-j0.0011
Fe ₂ O ₃	16.58-j0.93	0.0142	0.0362-j0.0007
CaCO ₃	8.22-j0.12	0.2947	0.5948-j0.0029
MgCO ₃	5.03-j0.17	0.0013	0.0022-j0.0001
CO ₂	4.389-j0.829	0.2331	0.3831-j0.0239
NaCl	5.70-j0.09	0.0192	0.0343-j0.0002
KCl	4.70-j0.05	0.0261	0.0437-j0.0002

From Table (4-2b) and equation (4-1) we get the complex dielectric constant of the mixture is $\epsilon_m = 5.6203 - j0.2950$

The average of the two will be:

$$1/2(5.3764 - j0.2818 + 5.6203 - j0.2950) = \mathbf{5.4983 - j0.2884}$$

Table(4-6a) Analysis of sample (5) Lamluda 2 m

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.3090	0.5075-j0.0015
Al ₂ O ₃	12.66-j1.31	0.0287	0.0670-j0.0023
Fe ₂ O ₃	16.58-j0.93	0.0156	0.0398-j0.0007
CaCO ₃	8.22-j0.12	0.3231	0.6521-j0.0032
MgCO ₃	5.03-j0.17	0.0079	0.0135-j0.0002
CO ₂	4.389-j0.829	0.2348	0.3859-j0.0240
NaCl	5.70-j0.09	0.0360	0.0643-j0.0003
KCl	4.70-j0.05	0.0325	0.0544-j0.0002

From Table above and from Equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 5.6769 - j0.3094$

Quantity lost in weight of sample is(0.0124) and therefore we work with normalization of sample weight.

Table (4-6b) Normalization Results of Table (4-6a) .

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.3128	0.5137-j0.0015
Al ₂ O ₃	12.66-j1.31	0.0290	0.0677-j0.0023
Fe ₂ O ₃	16.58-j0.93	0.0158	0.0403-j0.0008
CaCO ₃	8.22-j0.12	0.3271	0.6602-j0.0032
MgCO ₃	5.03-j0.17	0.0080	0.0137-j0.0002
CO ₂	4.389-j0.829	0.2377	0.3907-j0.0243
NaCl	5.70-j0.09	0.0364	0.0650-j0.0003
KCl	4.70-j0.05	0.0329	0.0551-j0.0002

From Table (4-2b) and equation (4-1) we get the complex dielectric constant of the mixture is $\epsilon_m = 5.8885 - j0.3209$

The average of the two will be:

$$1/2(5.6769 - j0.3094 + 5.8885 - j0.3209) = \mathbf{5.7872 - j0.3151}$$

Table(4-7a) Analysis of sample (6) Derna 2 m

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.2234	0.3684-j0.0011
Al ₂ O ₃	12.66-j1.31	0.0194	0.0453-j0.0016
Fe ₂ O ₃	16.58-j0.93	0.0103	0.0263-j0.0005
CaCO ₃	8.22-j0.12	0.3697	0.7461-j0.0036
MgCO ₃	5.03-j0.17	0.0258	0.0442-j0.0005
CO ₂	4.389-j0.829	0.3040	0.4997-j0.0311
NaCl	5.70-j0.09	0.0175	0.0313-j0.0002
KCl	4.70-j0.05	0.0171	0.0286-j0.0001

From Table above and from Equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 5.7262 - j0.3718$

Quantity lost in weight of sample is(0.0119) and therefore we work with normalization of sample weight.

Table (4-7b) Normalization Results of Table (4-7a) .

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.2269	0.3727-j0.0011
Al ₂ O ₃	12.66-j1.31	0.0196	0.0457-j0.0016
Fe ₂ O ₃	16.58-j0.93	0.0104	0.0265-j0.0005
CaCO ₃	8.22-j0.12	0.3740	0.7548-j0.0037
MgCO ₃	5.03-j0.17	0.0261	0.0447-j0.0005
CO ₂	4.389-j0.829	0.3076	0.5056-j0.0315
NaCl	5.70-j0.09	0.0177	0.0316-j0.0002
KCl	4.70-j0.05	0.0173	0.0290-j0.0001

From Table (4-2b) and equation (4-1) we get the complex dielectric constant of the mixture is $\epsilon_m = 5.9272 - j0.3854$

The average of the two will be:

$$1/2(5.7262 - j0.3718 + 5.9272 - j0.3854) = \mathbf{5.8267 - j0.3786}$$

Table(4-8a) Analysis of sample (7) Um El Razum 2 m

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.7232	1.1878-j0.0036
Al ₂ O ₃	12.66-j1.31	0.0566	0.1321-j0.0045
Fe ₂ O ₃	16.58-j0.93	0.0139	0.0355-j0.0007
CaCO ₃	8.22-j0.12	0.0607	0.1225-j0.0006
MgCO ₃	5.03-j0.17	0.0037	0.0063-j0.0001
CO ₂	4.389-j0.829	0.0522	0.0858-j0.0053
NaCl	5.70-j0.09	0.0314	0.561-j0.0003
KCl	4.70-j0.05	0.0362	0.0606-j0.0002

From Table above and from Equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 4.7973 - j0.1304$

Quantity lost in weight of sample is(0.0221) and therefore we work with normalization of sample weight.

Table (4-8b) Normalization Results of Table (4-8a) .

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.7391	1.2139-j0.0037
Al ₂ O ₃	12.66-j1.31	0.0578	0.1349-j0.0046
Fe ₂ O ₃	16.58-j0.93	0.0142	0.0362-j0.0007
CaCO ₃	8.22-j0.12	0.0620	0.1251-j0.0006
MgCO ₃	5.03-j0.17	0.0037	0.0063-j0.0001
CO ₂	4.389-j0.829	0.0533	0.0876-j0.0055
NaCl	5.70-j0.09	0.0320	0.0572-j0.0003
KCl	4.70-j0.05	0.0370	0.0620-j0.0002

From Table (4-2b) and equation (4-1) we get the complex dielectric constant of the mixture is $\epsilon_m = 5.1156 - j0.1397$

The average of the two will be:

$$1/2(4.7973 - j0.1304 + 5.1156 - j0.1397) = \mathbf{4.9564 - j0.1350}$$

**Table (4-9) Results of Complex Permittivity
Samples on (2) meter height**

of seven

Sample No.	ϵ_m
1	5.4338-j0.2560
2	5.4051-j0.2551
3	5.0580-j0.1785
4	5.3764-j0.2818
5	5.6769-j0.3094
6	5.7262-j0.3718
7	4.7973-j0.1304
Average ϵ_m	5.3533-j0.2547

Table (4-10) Results when the Samples weight is Normalized

Sample No.	ϵ_m
1	5.6374-j0.2651
2	5.7051-j0.2712
3	5.1926-j0.1826
4	5.6203-j0.2950
5	5.8885-j0.3209
6	5.9272-j0.3854
7	5.1156-j0.1397
Average ϵ_m	5.5838-j0.2657

Analysis of Samples on height (6-m)

Table(4-11a) Analysis of sample (1) El Merj 6m

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.7327	1.2034-J0.0036
Al ₂ O ₃	12.66-j1.31	0.0078	0.0182-J0.0006
Fe ₂ O ₃	16.58-j0.93	0.0135	0.0344-J0.0006
CaCO ₃	8.22-j0.12	0.0901	0.1818-J0.0009
MgCO ₃	5.03-j0.17	0.0014	0.0024-J0.0001
CO ₂	4.389-j0.829	0.0676	0.1111-J0.0069
NaCl	5.70-j0.09	0.0248	0.0443-J0.0002
KCl	4.70-j0.05	0.0366	0.0613-J0.0002

From Table above and from Equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 4.5478 - j0.1078$

Quantity lost in weight of sample is(0.0255) and therefore we work with normalization of sample weight.

Table (4-11b) Normalization Results of Table (4-11a) .

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.7514	1.2341-J0.0037
Al ₂ O ₃	12.66-j1.31	0.0080	0.0187-J0.0006
Fe ₂ O ₃	16.58-j0.93	0.0138	0.0352-J0.0007
CaCO ₃	8.22-j0.12	0.0924	0.1865-J0.0009
MgCO ₃	5.03-j0.17	0.0014	0.0024-J0.0001
CO ₂	4.389-j0.829	0.0693	0.1139-J0.0071
NaCl	5.70-j0.09	0.0254	0.0454-J0.0002
KCl	4.70-j0.05	0.0375	0.0625-J0.0002

From Table (4-2b) and Equation (4-1) we get the complex dielectric constant of the mixture is $\epsilon_m = 4.9034j0.1168$

The average of the two will be:

$$1/2(4.5478-j0.1078 + 4.9034j0.1168) = \mathbf{4.7256-j0.1123}$$

Table(4-12a) Analysis of sample (2) El Garieb 6m

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.3406	0.5594-J0.0017
Al ₂ O ₃	12.66-j1.31	0.0259	0.0604-J0.0021
Fe ₂ O ₃	16.58-j0.93	0.0215	0.0548-J0.0010
CaCO ₃	8.22-j0.12	0.2938	0.5930-J0.0029
MgCO ₃	5.03-j0.17	0.0311	0.0533-J0.0006
CO ₂	4.389-j0.829	0.2272	0.3734-J0.0233
NaCl	5.70-j0.09	0.0259	0.0463-J0.0002
KCl	4.70-j0.05	0.0221	0.0370-J0.0001

From Table above and from Equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 5.6115-j0.3024$

Quantity lost in weight of sample is(0.0119) and therefore we work with normalization of sample weight.

Table (4-12b) Normalization Results of Table (4-12a) .

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.3447	0.5661-j0.0017
Al ₂ O ₃	12.66-j1.31	0.0262	0.0611-j0.0021
Fe ₂ O ₃	16.58-j0.93	0.0218	0.0556-j0.0010
CaCO ₃	8.22-j0.12	0.2973	0.6000-j0.0029
MgCO ₃	5.03-j0.17	0.0315	0.0540-j0.0006
CO ₂	4.389-j0.829	0.2299	0.3779-j0.0235
NaCl	5.70-j0.09	0.0262	0.0468-j0.0002
KCl	4.70-j0.05	0.0224	0.0375-j0.0001

From Table (4-2b) and Equation (4-1) we get the complex dielectric constant of the mixture is $\epsilon_m = 5.8167 - j0.3116$

The average of the two will be:

$$1/2(5.6115 - j0.3024 + 5.8167 - j0.3116) = \mathbf{5.7141 - j0.3070}$$

Table(4-13a) Analysis of sample (3) El Byada 6m

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.2689	0.4416-j0.0013
Al ₂ O ₃	12.66-j1.31	0.0139	0.0324-j0.0011
Fe ₂ O ₃	16.58-j0.93	0.0189	0.0482-j0.0009
CaCO ₃	8.22-j0.12	0.3572	0.7302-j0.0036
MgCO ₃	5.03-j0.17	0.0096	0.0165-j0.0002
CO ₂	4.389-j0.829	0.2849	0.4683-j0.0292
NaCl	5.70-j0.09	0.0161	0.0288-j0.0002
KCl	4.70-j0.05	0.0176	0.0295-j0.0001

From Table above and from Equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 5.6916 - j0.3492$

Quantity lost in weight of sample is(0.0129) and therefore we work with normalization of sample weight.

Table (4-13b) Normalization Results of Table (4-13a) .

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.2723	0.4472-j0.0013
Al ₂ O ₃	12.66-j1.31	0.0140	0.0327-j0.0011
Fe ₂ O ₃	16.58-j0.93	0.0191	0.0487-j0.0009
CaCO ₃	8.22-j0.12	0.3618	0.7302-j0.0036
MgCO ₃	5.03-j0.17	0.0097	0.0166-j0.0002
CO ₂	4.389-j0.829	0.2885	0.4742-j0.0295
NaCl	5.70-j0.09	0.0163	0.0291-j0.0002

KCl	4.70-j0.05	0.0178	0.0298-j0.0001
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From Table (4-2b) and Equation (4-1) we get the complex dielectric constant of the mixture is . $\epsilon_m = 5.9076 - j0.3620$

The average of the two will be:

$$1/2(5.6916 - j0.3492 + 5.9076 - j0.3620) = \mathbf{5.7996 - j0.3556}$$

Table(4-14a) Analysis of sample (4) El Baida 6m

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.1488	0.2444-j0.0007
Al ₂ O ₃	12.66-j1.31	0.0093	0.0217-j0.0007
Fe ₂ O ₃	16.58-j0.93	0.0127	0.0324-j0.0006
CaCO ₃	8.22-j0.12	0.4219	0.8515-j0.0041
MgCO ₃	5.03-j0.17	0.0098	0.0168-j0.0002
CO ₂	4.389-j0.829	0.3095	0.5087-j0.0317
NaCl	5.70-j0.09	0.0279	0.0498-j0.0003
KCl	4.70-j0.05	0.0389	0.0652-j0.0002

From Table above and from Equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 5.7321 - j0.3701$

Quantity lost in weight of sample is(0.0212) and therefore we work with normalization of sample weight.

Table (4-14b) Normalization Results of Table (4-14a) .

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.1519	0.2495-j0.0008
Al ₂ O ₃	12.66-j1.31	0.0095	0.0222-j0.0008
Fe ₂ O ₃	16.58-j0.93	0.0130	0.0332-j0.0006
CaCO ₃	8.22-j0.12	0.4308	0.8694-j0.0042
MgCO ₃	5.03-j0.17	0.0100	0.0171-j0.0002
CO ₂	4.389-j0.829	0.3160	0.5194-j0.0324

NaCl	5.70-j0.09	0.0285	0.0509-j0.0003
KCl	4.70-j0.05	0.0397	0.0665-j0.0002

From Table (4-2b) and Equation (4-1) we get the complex dielectric constant of the mixture is $\epsilon_m = 6.1018 - j0.3959$

The average of the two will be:

$$1/2(5.7321 - j0.3701 + 6.1018 - j0.3959) = \mathbf{5.9169 - j0.3830}$$

Table(4-15a) Analysis of sample (5) Lamluda 6m

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.2697	0.4429-j0.0013
Al ₂ O ₃	12.66-j1.31	0.0139	0.0324-j0.0011
Fe ₂ O ₃	16.58-j0.93	0.0041	0.0105-j0.0002
CaCO ₃	8.22-j0.12	0.3654	0.7375-j0.0036
MgCO ₃	5.03-j0.17	0.0067	0.0115-j0.0001
CO ₂	4.389-j0.829	0.2824	0.4642-j0.0289
NaCl	5.70-j0.09	0.0210	0.0375-j0.0002
KCl	4.70-j0.05	0.0252	0.0422-j0.0001

From Table above and from Equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 5.6206 - j0.3368$

Quantity lost in weight of sample is(0.0116) and therefore we work with normalization of sample weight.

Table (4-15b) Normalization Results of Table (4-15a) .

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.2728	0.4480-j0.0013
Al ₂ O ₃	12.66-j1.31	0.0140	0.0327-j0.0011
Fe ₂ O ₃	16.58-j0.93	0.0041	0.0105-j0.0002

CaCO ₃	8.22-j0.12	0.3696	0.7459-j0.0036
MgCO ₃	5.03-j0.17	0.0068	0.0117-j0.0001
CO ₂	4.389-j0.829	0.2856	0.4694-j0.0292
NaCl	5.70-j0.09	0.0212	0.0379-j0.0002
KCl	4.70-j0.05	0.0254	0.0425-j0.0002

From Table (4-2b) and Equation (4-1) we get the complex dielectric constant of the mixture is $\epsilon_m = 5.8110 - j0.3483$

The average of the two will be:

$$1/2(5.6206 - j0.3368 + 5.8110 - j0.3483) = \mathbf{5.7158 - j0.3425}$$

Table(4-16a) Analysis of sample (6) Derna 6m

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.3240	0.5321-j0.0016
Al ₂ O ₃	12.66-j1.31	0.0201	0.0469-j0.0016
Fe ₂ O ₃	16.58-j0.93	0.0172	0.0439-j0.0008
CaCO ₃	8.22-j0.12	0.2939	0.5932-j0.0029
MgCO ₃	5.03-j0.17	0.0349	0.0598-j0.0007
CO ₂	4.389-j0.829	0.2367	0.3891-j0.0242
NaCl	5.70-j0.09	0.0318	0.0568-j0.0003
KCl	4.70-j0.05	0.0302	0.0506-j0.0002

From Table above and from Equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 5.5622 - j0.3043$

Quantity lost in weight of sample is(0.0112) and therefore we work with normalization of sample weight.

Table (4-16b) Normalization Results of Table (4-16a) .

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
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SiO ₂	4.43-j0.04	0.3276	0.5380-j0.0016
Al ₂ O ₃	12.66-j1.31	0.0203	0.0474-j0.0016
Fe ₂ O ₃	16.58-j0.93	0.0174	0.0444-j0.0008
CaCO ₃	8.22-j0.12	0.2971	0.5996-j0.0029
MgCO ₃	5.03-j0.17	0.0352	0.0603-j0.0007
CO ₂	4.389-j0.829	0.2393	0.3933-j0.0245
NaCl	5.70-j0.09	0.0321	0.0573-j0.0003
KCl	4.70-j0.05	0.0305	0.0511-j0.0002

From Table (4-2b) and Equation (4-1) we get the complex dielectric constant of the mixture is $\epsilon_m = 5.7430 - j0.3137$

The average of the two will be:

$$1/2(5.5622 - j0.3043 + 5.7430 - j0.3137) = \mathbf{5.6526 - j0.3090}$$

Table(4-17a) Analysis of sample (7) Um El Razum 6m

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.5378	0.8833-j0.0027
Al ₂ O ₃	12.66-j1.31	0.0535	0.1248-j0.0043
Fe ₂ O ₃	16.58-j0.93	0.0243	0.0620-j0.0012
CaCO ₃	8.22-j0.12	0.1665	0.3360-j0.0016
MgCO ₃	5.03-j0.17	0.0056	0.0096-j0.0001
CO ₂	4.389-j0.829	0.1386	0.2278-j0.0142
NaCl	5.70-j0.09	0.0308	0.0550-j0.0003
KCl	4.70-j0.05	0.0243	0.0407-j0.0001

From Table above and from Equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 5.2575 - j0.2222$

Quantity lost in weight of sample is(0.0186) and therefore we work with normalization of sample weight.

Table (4-17b) Normalization Results of Table (4-17a).

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.5478	0.8997-j0.0027
Al ₂ O ₃	12.66-j1.31	0.0544	0.1269-j0.0044
Fe ₂ O ₃	16.58-j0.93	0.247	0.0630-j0.0012
CaCO ₃	8.22-j0.12	0.1695	0.3421-j0.0017
MgCO ₃	5.03-j0.17	0.0057	0.0098-j0.0001
CO ₂	4.389-j0.829	0.1411	0.2319-j0.0145
NaCl	5.70-j0.09	0.0313	0.0559-j0.0003
KCl	4.70-j0.05	0.0247	0.0414-j0.0001

From Table (4-2b) and Equation (4-1) we get the complex dielectric constant of the mixture is $\epsilon_m = 5.5484 - j0.2350$

The average of the two will be:

$$1/2(5.2575 - j0.2222 + 5.5484 - j0.2350) = \mathbf{5.4029 - j0.2286}$$

Table (4-18) Results of Complex Permittivity of seven Samples on (6) meter height

Sample No.	ϵ_m
1	4.5478-j0.1078
2	5.6115-j0.3024
3	5.6916-j0.3492
4	5.7321-j0.3701
5	5.6206-j0.3368
6	5.5622-j0.3043
7	5.2575-j0.2222
Average ϵ_m	5.4319-j0.2846

Table (4-19) Results when the Samples weight is Normalized

Sample No.	ϵ_m
1	4.9034j0.1168
2	5.8167-j0.3116
3	5.9076-j0.3620
4	6.1018-j0.3959
5	5.8110-j0.3483
6	5.7430-j0.3137
7	5.5484-j0.2350
Average ϵ_m	5.6902-j0.2976

Analysis of Samples on height (10-m)

Table(4-20a) Analysis of sample (1) El Merj 10m

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.2918	0.4792-j0.0014
Al ₂ O ₃	12.66-j1.31	0.0300	0.0700-j0.0024
Fe ₂ O ₃	16.58-j0.93	0.0019	0.0048-j0.0001
CaCO ₃	8.22-j0.12	0.3389	0.6840-j0.0033
MgCO ₃	5.03-j0.17	0.0182	0.0312-j0.0004
CO ₂	4.389-j0.829	0.2869	0.4716-j0.0294
NaCl	5.70-j0.09	0.0107	0.0191-j0.0001
KCl	4.70-j0.05	0.0083	0.0139-j0.0001

From Table above and from Equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 5.5736-j0.3510$

Quantity lost in weight of sample is(0.0133) and therefore we work with normalization of sample weight.

Table (4-20b) Normalization Results of Table (4-20a) .

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.2957	0.4856-j0.0015
Al ₂ O ₃	12.66-j1.31	0.0304	0.0709-j0.0024
Fe ₂ O ₃	16.58-j0.93	0.0019	0.0048-j0.0001
CaCO ₃	8.22-j0.12	0.3434	0.6931-j0.0034
MgCO ₃	5.03-j0.17	0.0184	0.0315-j0.0004
CO ₂	4.389-j0.829	0.2907	0.4778-j0.0298
NaCl	5.70-j0.09	0.0108	0.0193-j0.0001
KCl	4.70-j0.05	0.0084	0.0141-j0.0001

From Table (4-2b) and Equation (4-1) we get the complex dielectric constant of the mixture is $\epsilon_m = 5.7962 - j0.3661$

The average of the two will be:

$$1/2(5.5736 - j0.3510 + 5.7962 - j0.3661) = \mathbf{5.6849 - j0.3585}$$

Table(4-21a) Analysis of sample (2) El Garieb 10m

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.3805	0.6249-j0.0019
Al ₂ O ₃	12.66-j1.31	0.0311	0.0726-j0.0025
Fe ₂ O ₃	16.58-j0.93	0.0036	0.0092-j0.0002
CaCO ₃	8.22-j0.12	0.2659	0.5366-j0.0026
MgCO ₃	5.03-j0.17	0.0357	0.0612-j0.0007
CO ₂	4.389-j0.829	0.2001	0.3289-j0.0205
NaCl	5.70-j0.09	0.0297	0.0531-j0.0003
KCl	4.70-j0.05	0.0375	0.0628-j0.0002

From Table above and from Equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 5.3485 - j0.2652$

Quantity lost in weight of sample is(0.0159) and therefore we work with normalization of sample weight.

Table (4-21b) Normalization Results of Table (4-21a) .

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.3865	0.6348-j0.0019
Al ₂ O ₃	12.66-j1.31	0.0316	0.0737-j0.0025
Fe ₂ O ₃	16.58-j0.93	0.0037	0.0094-j0.0002
CaCO ₃	8.22-j0.12	0.2701	0.5451-j0.0027
MgCO ₃	5.03-j0.17	0.0363	0.0622-j0.0007
CO ₂	4.389-j0.829	0.2033	0.3342-j0.0208
NaCl	5.70-j0.09	0.0302	0.0539-j0.0003
KCl	4.70-j0.05	0.0381	0.0638-j0.0002

From Table (4-2b) and Equation (4-1) we get the complex dielectric constant of the mixture is $\epsilon_m = 5.6076 - j0.2775$

The average of the two will be:

$$1/2(5.3485 - j0.2652 + 5.6076 - j0.2775) = \mathbf{5.4780 - j0.2713}$$

Table(4-22a) Analysis of sample (3) El Byada 10m

Compound	$\varepsilon' + j\varepsilon''$	V	$\varepsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.2936	0.4822-j0.0015
Al ₂ O ₃	12.66-j1.31	0.0104	0.0243-j0.0008
Fe ₂ O ₃	16.58-j0.93	0.0299	0.0763-j0.0014
CaCO ₃	8.22-j0.12	0.3396	0.6854-j0.0033
MgCO ₃	5.03-j0.17	0.0135	0.0231-j0.0003
CO ₂	4.389-j0.829	0.2470	0.4060-j0.0253
NaCl	5.70-j0.09	0.0157	0.0280-j0.0001
KCl	4.70-j0.05	0.0269	0.0451-j0.0002

From Table above and from Equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 5.5430 - j0.3092$

Quantity lost in weight of sample is(0.0233) and therefore we work with normalization of sample weight.

Table (4-22b) Normalization Results of Table (4-22a) .

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.3004	0.4934-j0.0015
Al ₂ O ₃	12.66-j1.31	0.0106	0.0247-j0.0009
Fe ₂ O ₃	16.58-j0.93	0.0305	0.0778-j0.0015
CaCO ₃	8.22-j0.12	0.3475	0.7013-j0.0034
MgCO ₃	5.03-j0.17	0.0138	0.0236-j0.0003
CO ₂	4.389-j0.829	0.2527	0.4154-j0.0259
NaCl	5.70-j0.09	0.0160	0.0286-j0.0002
KCl	4.70-j0.05	0.0275	0.0461-j0.0002

From Table (4-2b) and Equation (4-1) we get the complex dielectric constant of the mixture is $\epsilon_m = 5.9322 - j0.3334$

The average of the two will be:

$$1/2(5.5430 - j0.3092 + 5.9322 - j0.3334) = \mathbf{5.7376 - j0.3213}$$

Table(4-23a) Analysis of sample (4) El Baida 10m

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.0946	0.1554-j0.0005
Al ₂ O ₃	12.66-j1.31	0.0112	0.0261-j0.0009
Fe ₂ O ₃	16.58-j0.93	0.0089	0.0227-j0.0004
CaCO ₃	8.22-j0.12	0.4561	0.9205-j0.0045
MgCO ₃	5.03-j0.17	0.0125	0.0214-j0.0002
CO ₂	4.389-j0.829	0.3580	0.5884-j0.0367
NaCl	5.70-j0.09	0.0161	0.0288-j0.0002

KCl	4.70-j0.05	0.0241	0.0404-j0.0001
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From Table above and from Equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 5.8577 - j0.4244$

Quantity lost in weight of sample is(0.0185) and therefore we work with normalization of sample weight.

Table (4-23b) Normalization Results of Table (4-23a) .

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.0963	0.1582-j0.0005
Al ₂ O ₃	12.66-j1.31	0.0114	0.0266-j0.0009
Fe ₂ O ₃	16.58-j0.93	0.0091	0.0232-j0.0004
CaCO ₃	8.22-j0.12	0.4645	0.9375-j0.0046
MgCO ₃	5.03-j0.17	0.0127	0.0218-j0.0002
CO ₂	4.389-j0.829	0.3646	0.5993-j0.0373
NaCl	5.70-j0.09	0.0164	0.0293-j0.0002
KCl	4.70-j0.05	0.0245	0.0410-j0.0001

From Table (4-2b) and Equation (4-1) we get the complex dielectric constant of the mixture is . $\epsilon_m = 6.1872 - j0.4473$

The average of the two will be:

$$1/2(5.8577 - j0.4244 + 6.1872 - j0.4473) = \mathbf{6.0224 - j0.4358}$$

Table(4-24a) Analysis of sample (5) Lamluda 10m

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.2648	0.4408-j0.0013
Al ₂ O ₃	12.66-j1.31	0.0110	0.0257-j0.0009
Fe ₂ O ₃	16.58-j0.93	0.0133	0.0339-j0.0006
CaCO ₃	8.22-j0.12	0.3570	0.7205-j0.0035
MgCO ₃	5.03-j0.17	0.0036	0.0062-j0.0001
CO ₂	4.389-j0.829	0.2802	0.4606-j0.0287

NaCl	5.70-j0.09	0.0280	0.0500-j0.0003
KCl	4.70-j0.05	0.0269	0.0451-j0.0002

From Table above and from Equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 5.6767-j0.3400$

Quantity lost in weight of sample is(0.0152) and therefore we work with normalization of sample weight.

Table (4-24b) Normalization Results of Table (4-24a) .

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.2688	0.4415-j0.0013
Al ₂ O ₃	12.66-j1.31	0.0112	0.0261-j0.0009
Fe ₂ O ₃	16.58-j0.93	0.0135	0.0344-j0.0006
CaCO ₃	8.22-j0.12	0.3624	0.7314-j0.0036
MgCO ₃	5.03-j0.17	0.0037	0.0063-j0.0001
CO ₂	4.389-j0.829	0.2844	0.4675-j0.0291
NaCl	5.70-j0.09	0.0284	0.0507-j0.0003
KCl	4.70-j0.05	0.0273	0.0457-j0.0002

From Table (4-2b) and Equation (4-1) we get the complex dielectric constant of the mixture is $\epsilon_m = 5.8599-j0.3521$

The average of the two will be:

$$1/2(5.6767-j0.3400 + 5.8599-j0.3521) = \mathbf{5.7683-j0.3460}$$

Table(4-25a) Analysis of sample (6) Derna 10m

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.4913	0.8069-j0.0024
Al ₂ O ₃	12.66-j1.31	0.0198	0.0462-j0.0016
Fe ₂ O ₃	16.58-j0.93	0.0141	0.0360-j0.0007

CaCO ₃	8.22-j0.12	0.1976	0.3988-j0.0019
MgCO ₃	5.03-j0.17	0.0302	0.0518-j0.0006
CO ₂	4.389-j0.829	0.1736	0.2853-j0.0178
NaCl	5.70-j0.09	0.0333	0.0595-j0.0003
KCl	4.70-j0.05	0.0243	0.0407-j0.0001

From Table above and from Equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 5.1313 - j0.2266$

Quantity lost in weight of sample is(0.0158) and therefore we work with normalization of sample weight.

Table (4-25b) Normalization Results of Table (4-25a) .

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.4990	0.8195-j0.0025
Al ₂ O ₃	12.66-j1.31	0.0201	0.0469-j0.0016
Fe ₂ O ₃	16.58-j0.93	0.0143	0.0365-j0.0007
CaCO ₃	8.22-j0.12	0.2007	0.4051-j0.0020
MgCO ₃	5.03-j0.17	0.0306	0.0524-j0.0006
CO ₂	4.389-j0.829	0.1763	0.2898-j0.0181
NaCl	5.70-j0.09	0.0338	0.0604-j0.0003
KCl	4.70-j0.05	0.0246	0.0412-j0.0001

From Table (4-2b) and Equation (4-1) we get the complex dielectric constant of the mixture is $\epsilon_m = 5.3723 - j0.2383$

The average of the two will be:

$$1/2(5.1313 - j0.2266 + 5.3723 - j0.2383) = \mathbf{5.2518 - j0.2324}$$

Table(4-26a) Analysis of sample (7) Um El Razum 10m

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.3657	0.6006-j0.0018
Al ₂ O ₃	12.66-j1.31	0.0151	0.0352-j0.0012

Fe ₂ O ₃	16.58-j0.93	0.0405	0.1033-j0.0019
CaCO ₃	8.22-j0.12	0.2538	0.5122-j0.0025
MgCO ₃	5.03-j0.17	0.0285	0.0488-j0.0006
CO ₂	4.389-j0.829	0.1898	0.3120-j0.0194
NaCl	5.70-j0.09	0.0397	0.0709-j0.0004
KCl	4.70-j0.05	0.0485	0.0812-j0.0003

From Table above and from Equation (4-1) the complex dielectric constant of the mixture is $\epsilon_m = 5.4866 - j0.2622$

Quantity lost in weight of sample is(0.0184) and therefore we work with normalization of sample weight.

Table (4-26b) Normalization Results of Table (4-26a) .

Compound	$\epsilon' + j\epsilon''$	V	$\epsilon^{1/3}V$
SiO ₂	4.43-j0.04	0.3724	0.6116-j0.0018
Al ₂ O ₃	12.66-j1.31	0.0153	0.0357-j0.0012
Fe ₂ O ₃	16.58-j0.93	0.0412	0.1051-j0.0020
CaCO ₃	8.22-j0.12	0.2584	0.5215-j0.0025
MgCO ₃	5.03-j0.17	0.0290	0.0488-j0.0006
CO ₂	4.389-j0.829	0.1932	0.3176-j0.0198
NaCl	5.70-j0.09	0.0404	0.0722-j0.0004
KCl	4.70-j0.05	0.0493	0.0826-j0.0003

From Table (4-2b) and Equation (4-1) we get the complex dielectric constant of the mixture is . $\epsilon_m = 5.7800 - j0.2763$

The average of the two will be:

$$1/2(5.4866 - j0.2622 + 5.7800 - j0.2763) = 5.6333 - j0.2692$$

Table (4-27) Results of Complex Permittivity **of seven**
Samples on (10) meter height

Sample No.	ϵ_m
1	5.5736-j0.3510

2	5.3485-j0.2652
3	5.5430-j0.3092
4	5.8577-j0.4244
5	5.6767-j0.3400
6	5.1313-j0.2266
7	5.4866-j0.2 622
Average ϵ_m	5.5167-j0.3112

Table (4-28) Results when the Samples weight is Normalized

Sample No.	ϵ_m
1	5.7962-j0.3661
2	5.6076-j0.2775
3	5.9322-j0.3334
4	6.1872-j0.4473
5	5.8599-j0.3521
6	5.3723-j0.2383
7	5.7800-j0.2763
Average ϵ_m	5.7907-j0.3272

The average complex permittivity of samples total :-

$$\epsilon_{m \text{ (total)}} = 5.4339 - j0.2835$$

$$\epsilon_{m N \text{ (total)}} = 5.6882 - j0.2968$$

$$\epsilon_{m \text{ TOTAL}} = 1/2[\epsilon_{m \text{ (total)}} + \epsilon_{m N \text{ (total)}}] = 5.5611 - j0.2902$$

4-3 Summary of the Average Density, Conductivity and Complex Permittivity for Samples:

- 1- The major constituents of samples are **SiO₂**, **CaO** and **CO₂** about **87.88%** by weight of samples.
- 2- The average complex dielectric constant from Table (4-9) and Table (4-10) is equal to **5.4685-j0.2602**
- 3- The average complex dielectric constant from Table (4-18) and Table (4-19) is equal to **5.5611-j0.2911**
- 4- The average complex dielectric constant from Table (4-27) and Table (4-28) is equal to **5.6537-j0.3192**
- 5- The average complex permittivity of samples total is equal to **5.5611-j0.2902** and this could be used as the effective complex permittivity for the studied area of Libya (El-jabal Alakhdar).
- 6- The average density of samples from Tables (3-26),(3-27) and (3-28) is equal to **1.3855gm/cm³** and this could be used as the effective density for the studied area of Libya (El-jabal Alakhdar).
- 7- The average conductivity of samples from Tables (3-26) ,(3-27) and (3-28) is equal to **928.381 μs / cm** .

4-4 Calculation of the Probability from PSD Analysis

From the results presented in Tables (3-5) to (3-25).

The distribution probability are given in the following tables (4-29) to (4-49) respectively.

Table (4-29) Sample (1) on height (2 m) in ELMarej

Sieve Size (μm)	Probability Weight(%)	Normalization →	Sieve Size (μm)	Probability Weight(%)
600	0		600	0
425	10.65		425	10.67
300	19.11		300	19.15
212	11.16		212	11.19
150	7.20		150	7.22
75	10.64		75	10.66
63	8.05		63	8.07
pan	32.96		pan	33.04

Weight Ratio (%)

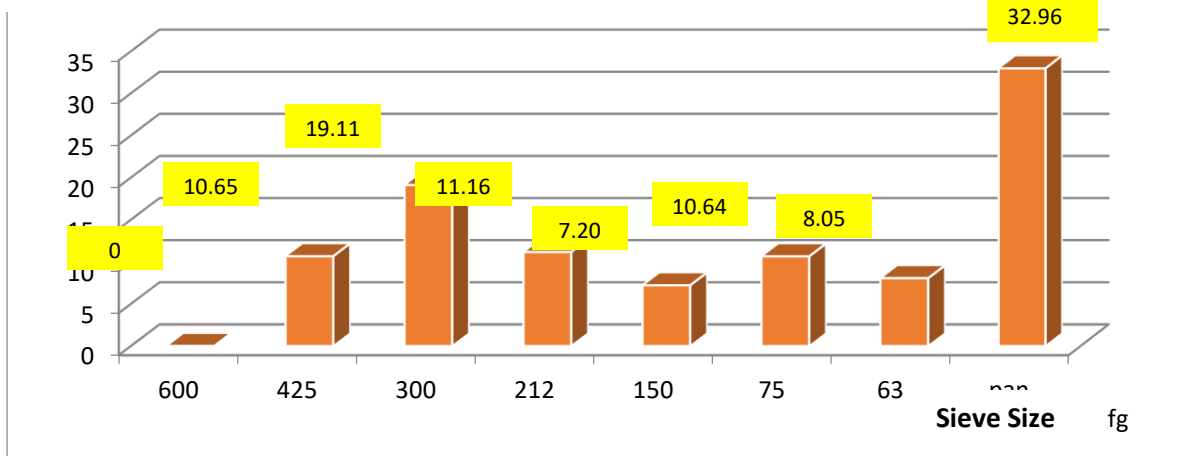


Fig.(4-1a) Graph Between Weight % and Grain Diameter(micron)of sample

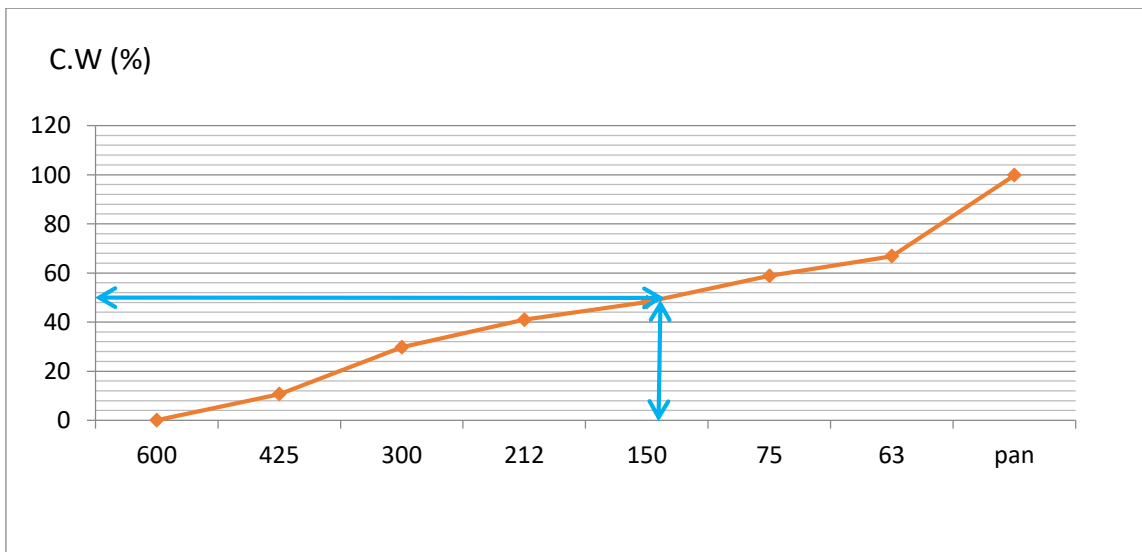


Fig.(4-1b) Graph Between the accumulative weight% of sample

Table (4-30) Sample (2) on height (6 m) in ELmarej

Sieve Size (μm)	Probability weight(%)	Normalization →	Sieve Size (μm)	Probability weight(%)
600	0		600	0
425	3.63		425	3.63
300	7.53		300	7.54
212	6.07		212	6.07
150	3.62		150	3.62
75	56.28		75	56.31
63	9.81		63	9.82
pan	13.00		pan	13.01

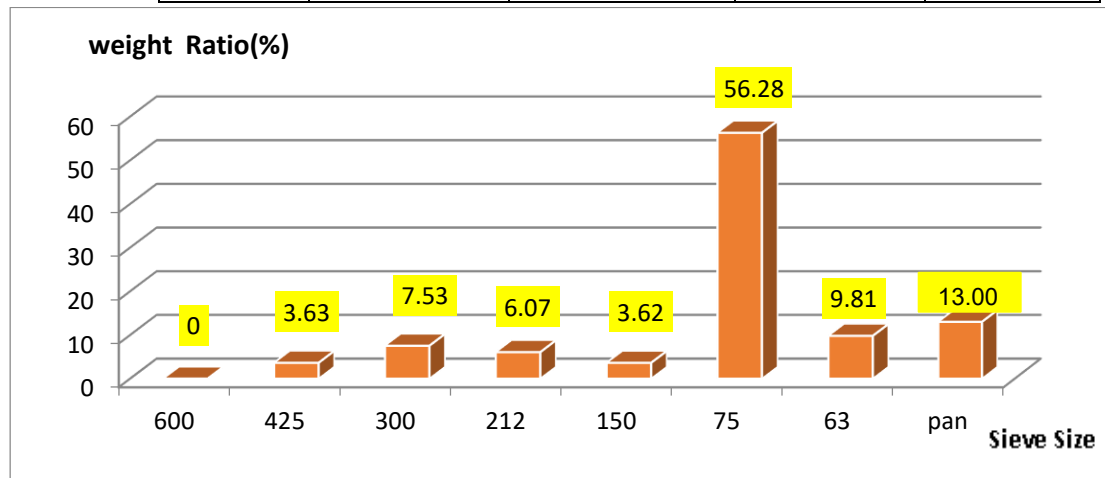


Fig. (4-2a) Graph Between Weight % and Grain Diameter(micron)of sample

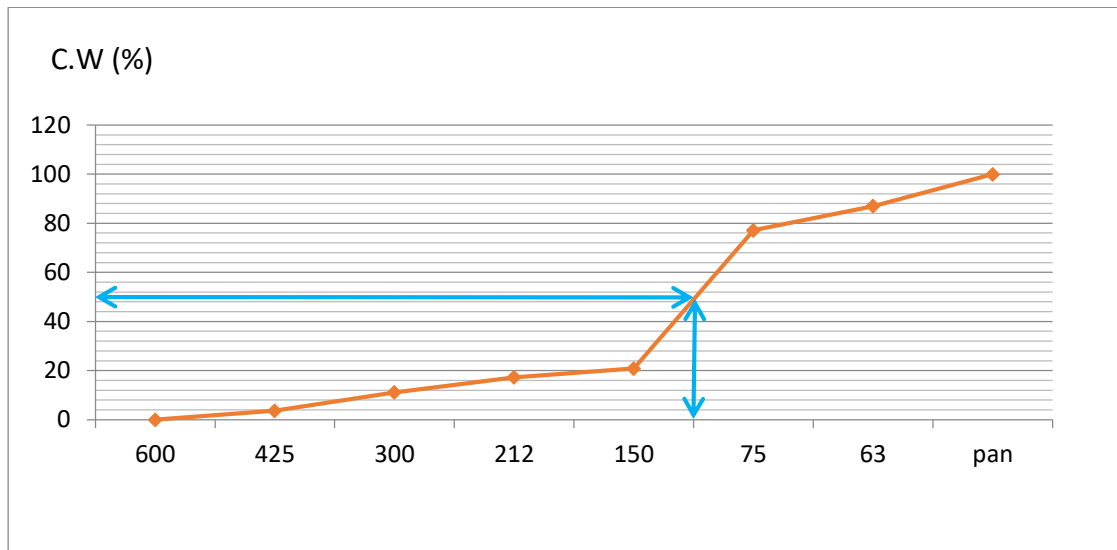
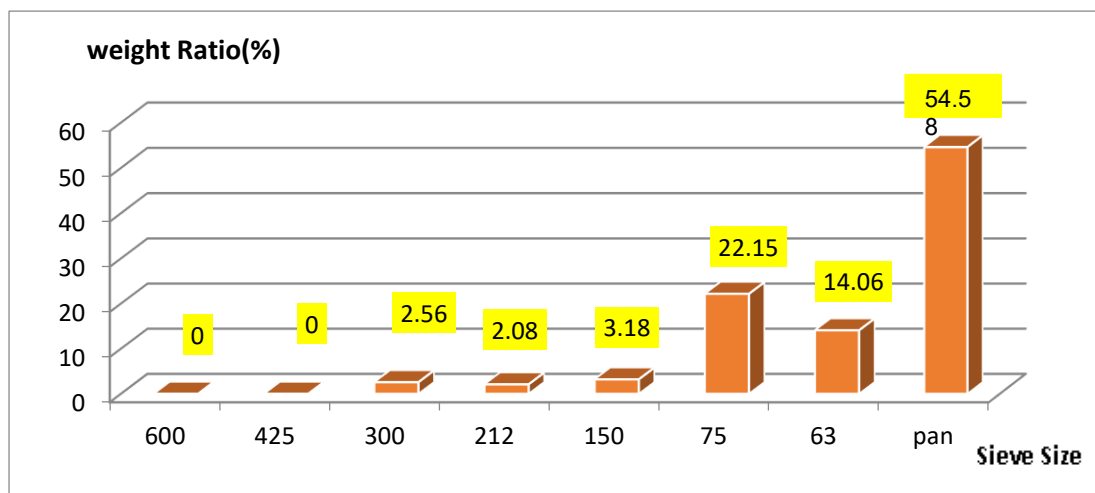


Fig.(4-2b) Graph Between the accumulative weight% of sample

**Table (4-
Sample (**
height
ELmarej

Sieve Size(μm)	Probability weight(%)	Normalization →	Sieve Size (μm)	Cumulative Weiht(%)
600	0		600	0
425	0		425	0
300	2.56		300	2.60
212	2.08		212	2.11
150	3.18		150	3.22
75	22.15		75	22.46
63	14.06		63	14.26
pan	54.58		pan	55.35

31)
3) on
(10 m) in



sample

Sieve Size (μm)	Probability weight(%)	Normalization →	Sieve Size (μm)	Probability weight(%)
600	0		600	0
425	15.89		425	15.94
300	17.72		300	17.78
212	13.19		212	13.23
150	12.73		150	12.77
75	12.44		75	12.48
63	5.04		63	5.06
Pan	22.97		pan	23.04

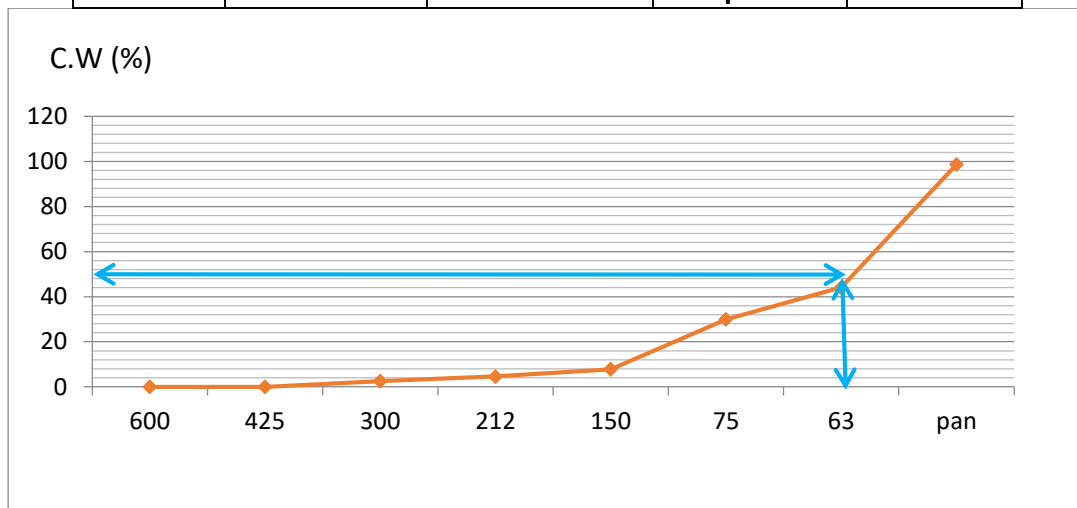


Fig.(4-3b) Graph Between the accumulative weight% of sample

Table (4-32) Sample (4) on height (2 m) in ALGarieb

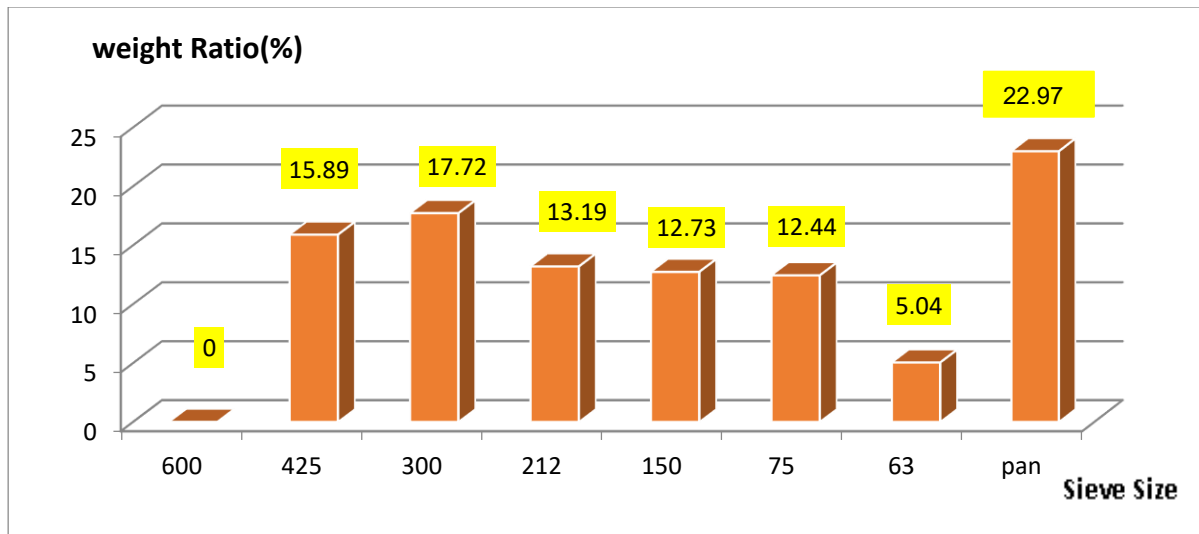


Fig.(4-4a) Graph Between Weight % and Grain Diameter(micron)of sample

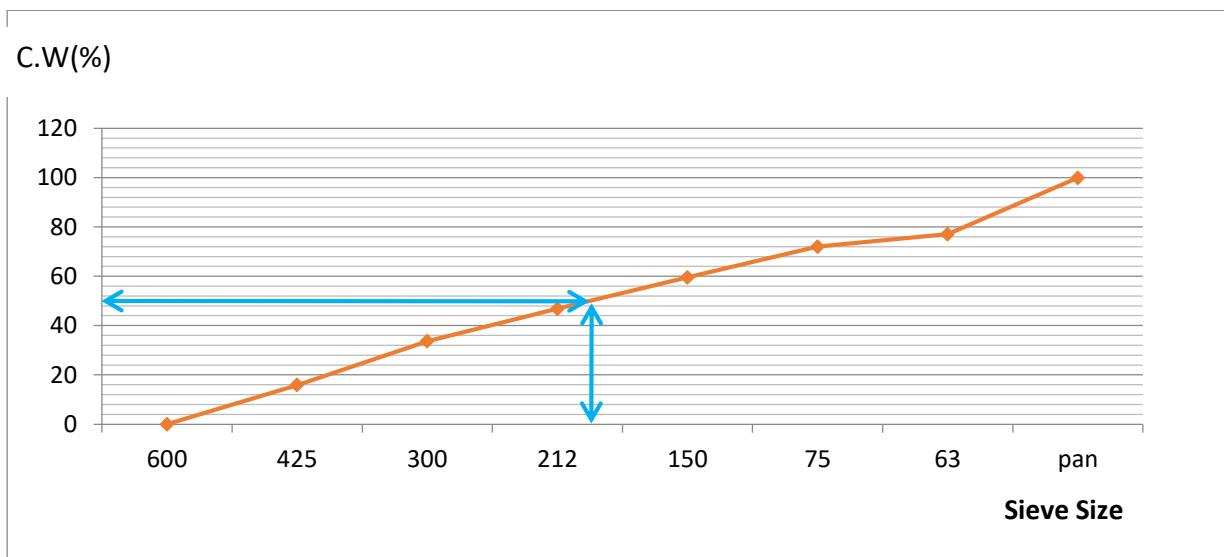


Fig.(4-4b) Graph Between the accumulative weight% of sample

Table (4-33) Sample (5) on height (6 m) in ALGarieb

Sieve Size(μm)	Probability weight(%)	Normalization →	Sieve Size (μm)	Probability weight(%)
600	0		600	0
425	14.75		425	16.69
300	16.25		300	18.38
212	11.70		212	13.24
150	10.50		150	11.88
75	10.69		75	12.09
63	4.74		63	5.36
Weight Ratio (%)	19.77		pan	22.36

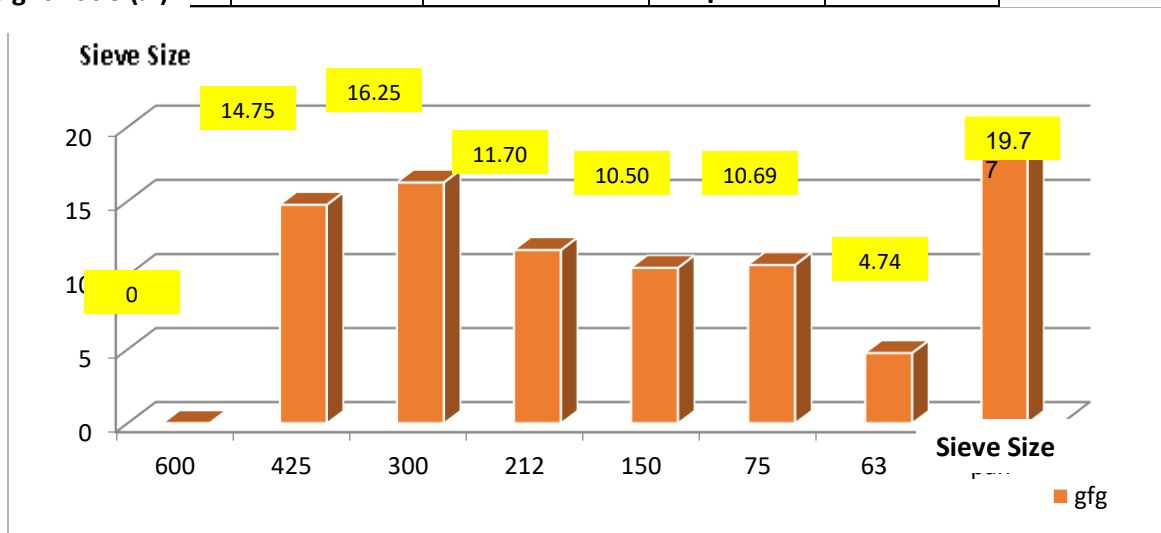


Fig .(4-5a) Graph Between Weight % and Grain Diameter(micron)of sample

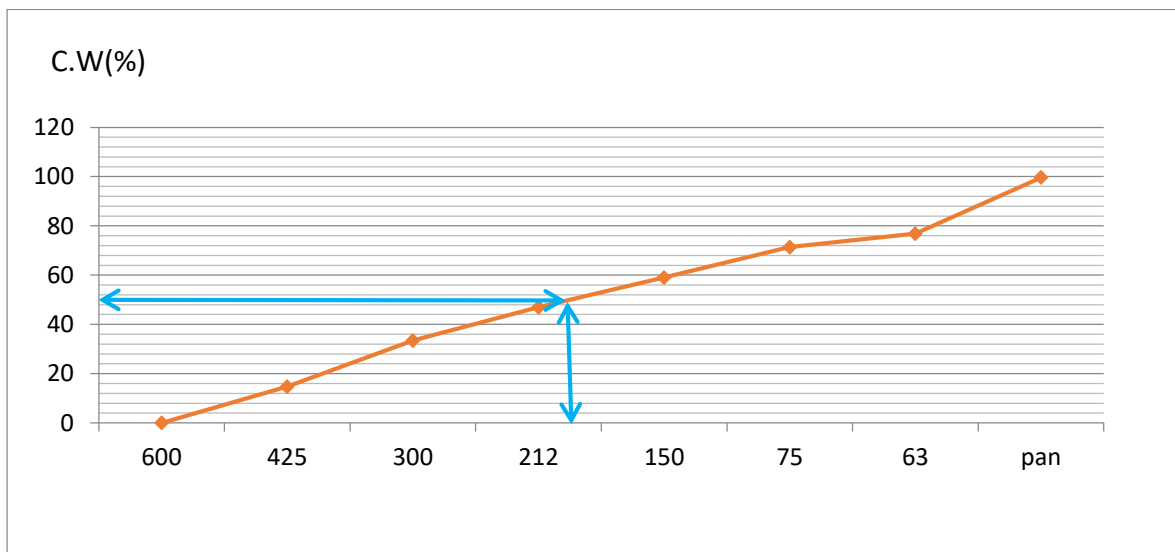


Fig.(4-5b) Graph Between the accumulative weight% of sample

(4-34) (6) on (10 m)	Sieve Size (μm)	Probability weight(%)	Normalization →	Sieve Size (μm)	Probability weight(%)	Table Sample height in
	600	0		0	0	
	425	0		0	0	
	300	9.67		9.67	11.22	
	212	11.97		21.64	13.89	
	150	11.49		33.13	13.33	
	75	15.60		48.73	18.10	
	63	12.70		61.43	14.74	
	Pan	24.75		86.18	28.72	

ALGarieb

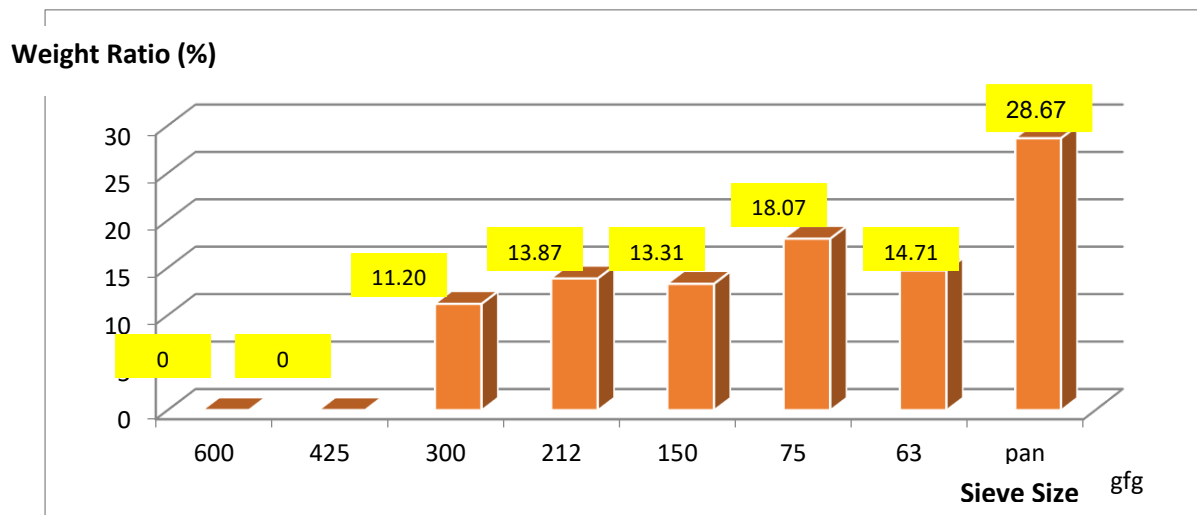


Fig.(4-6a) Graph Between Weight % and Grain Diameter(micron)of sample

Sieve Size	Probability weight(%)	Normalization →	Sieve Size (μm)	Probability weight(%)
600	1.63		600	1.63
425	9.49		425	9.51
300	11.89		300	11.91
212	9.84		212	9.86
150	7.08		150	7.09
75	35.21		75	35.27
63	8.97		63	8.99
Pan	15.72		pan	15.75

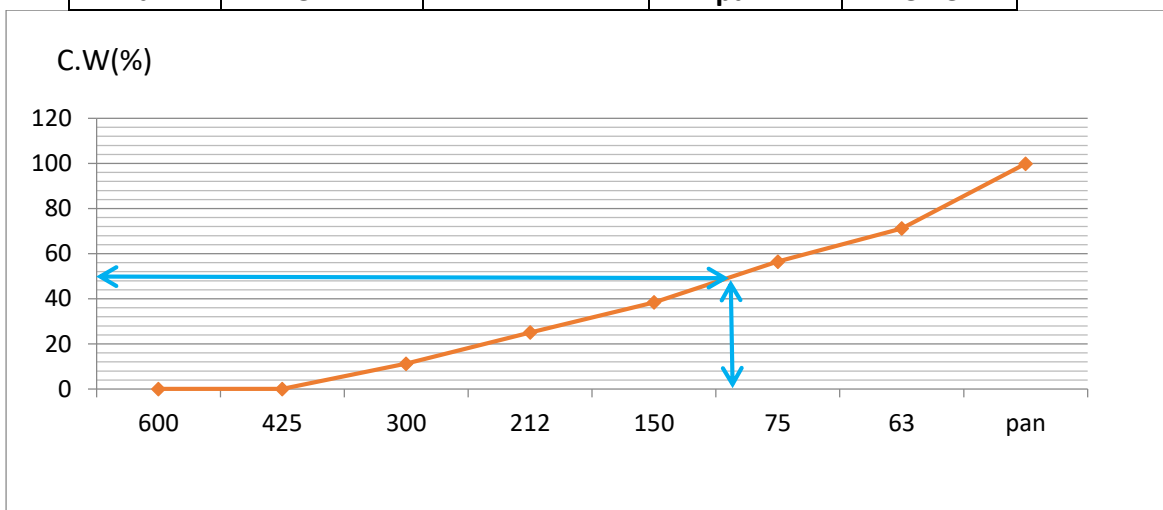


Fig.(4-6b) Graph Between the accumulative weight% of sample

Table (4-35) Sample (7) on height (2 m) in ALByada

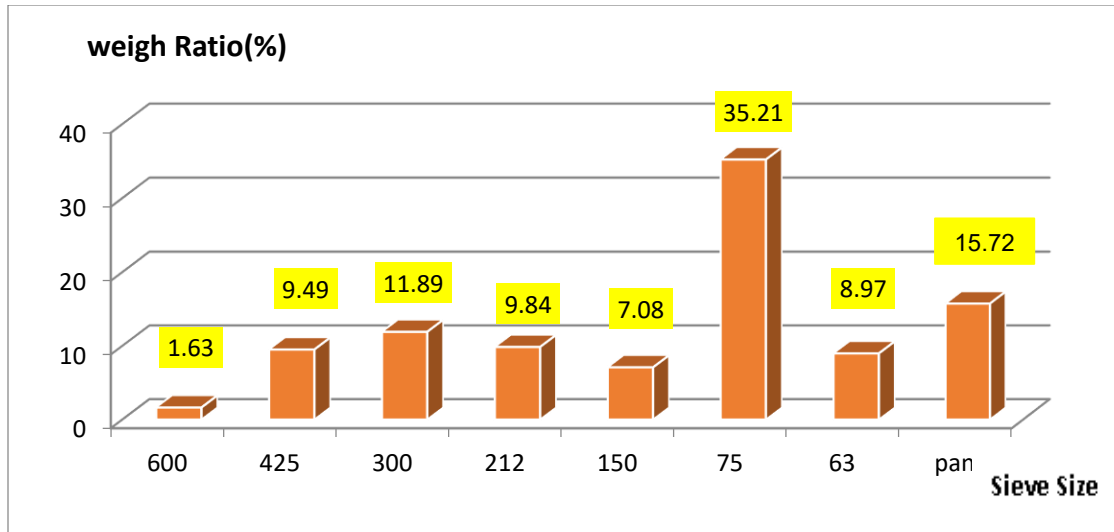


Fig.(4-7a) Graph Between Weight % and Grain Diameter(micron)of sample

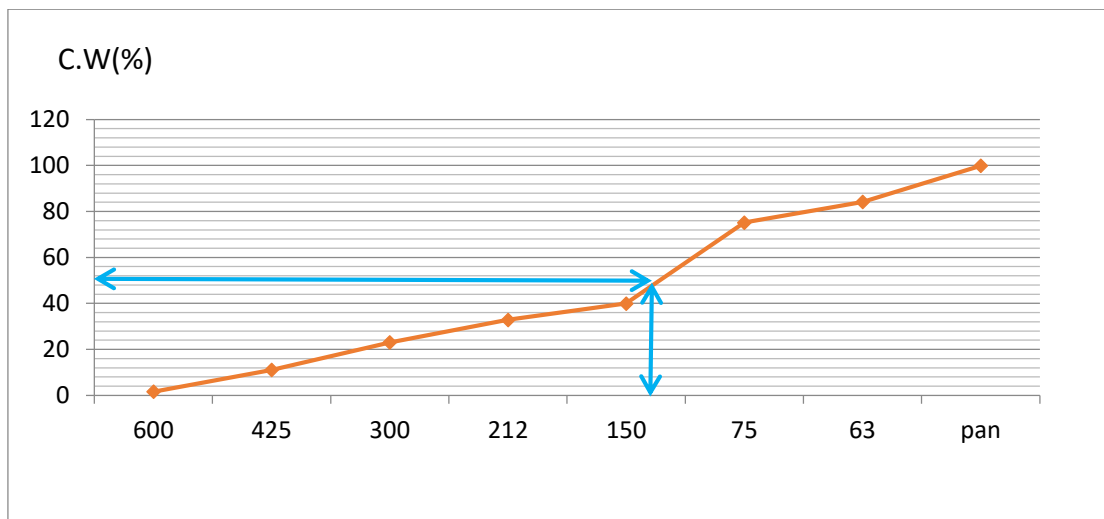


Fig.(4-7b) Graph Between the accumulative weight% of sample

Table (4-36) Sample (8) on height (6 m) in ALByada

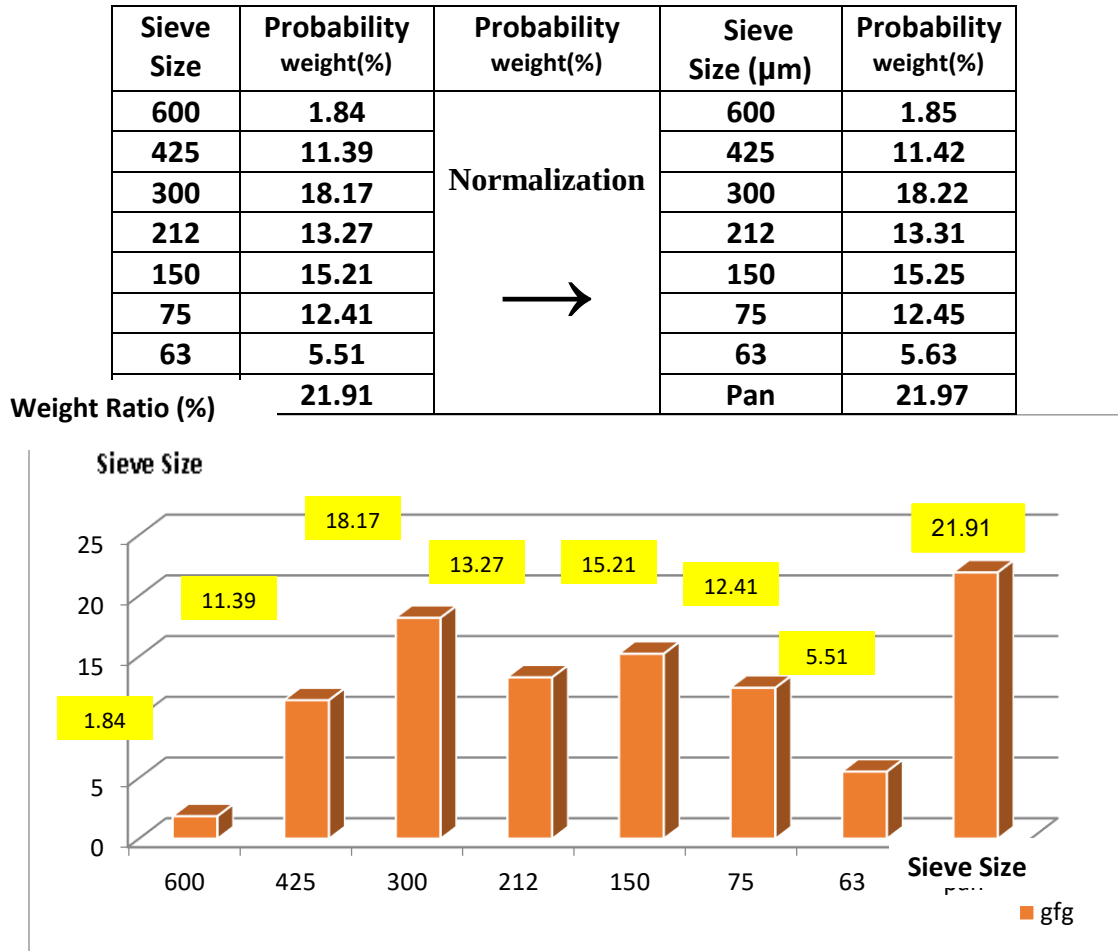


Fig .(4-8a) Graph Between Weight % and Grain Diameter(micron)of sample

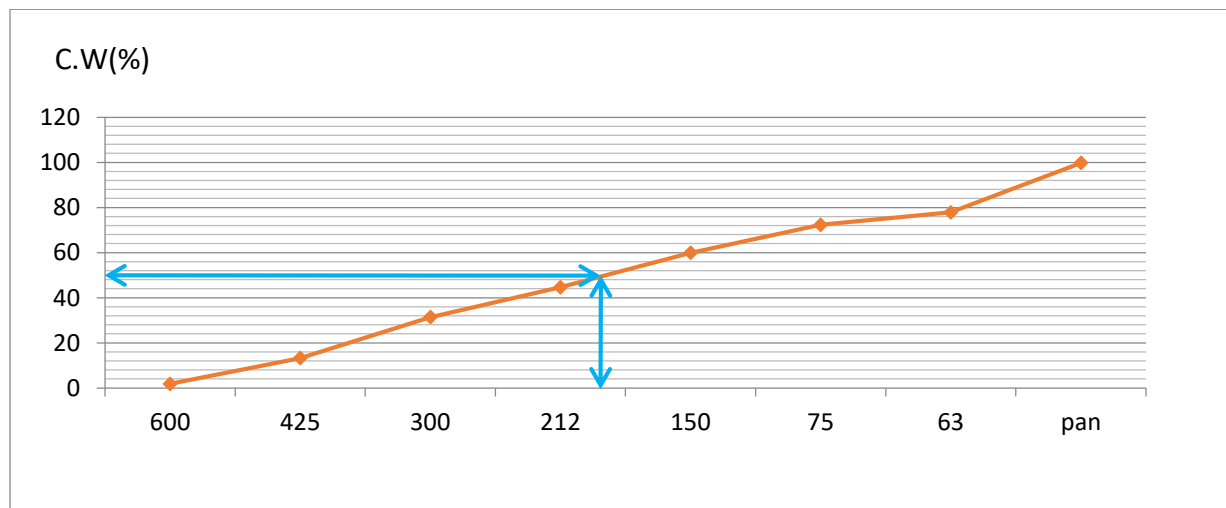


Fig.(4-8b) Graph Between the accumulative weight% of sample

Table (4-

Sieve Size (μm)	Probability weight(%)	Probability weight(%)	Sieve Size (μm)	Probability weight(%)
600	0.19	Normalization 	600	0.19
425	3.01		425	3.03
300	11.15		300	11.24
212	14.55		212	14.67
150	9.29		150	9.37
75	21.16		75	21.33
63	14.84		63	14.96
Pan	24.99		Pan	25.20

37)Sample (9) on height (10 m) in ALByada

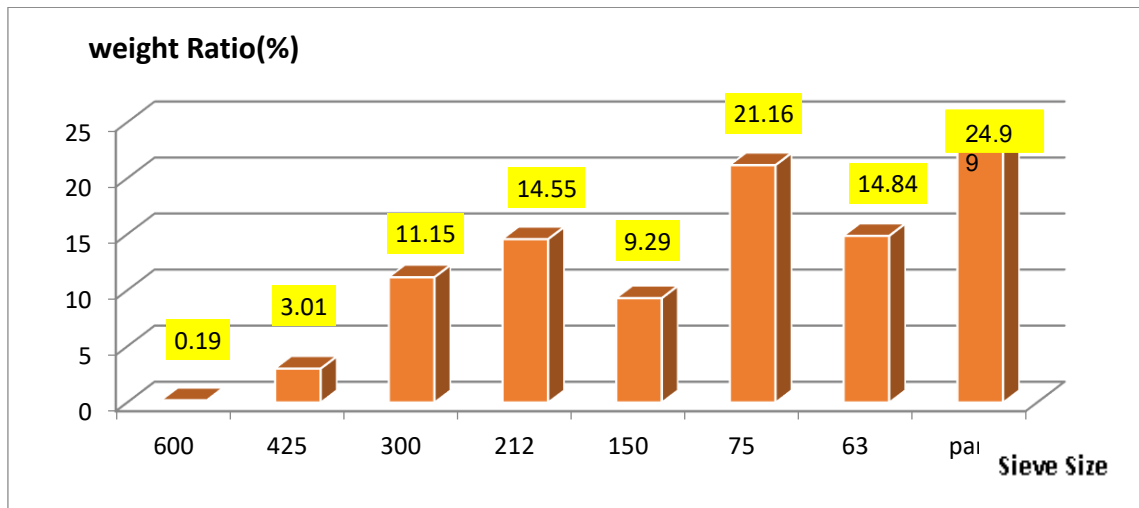


Fig .(4-9a) Graph Between Weight % and Grain Diameter(micron)of sample

Sieve Size (μm)	Probability weight(%)	Normalization →	Sieve Size	Probability weight(%)
600	1.55		600	1.56
425	10.01		425	10.05
300	14.04		300	14.10
212	14.34		212	14.40
150	12.79		150	12.84
75	22.04		75	22.13
63	8.01		63	8.04
Pan	16.82		Pan	16.89

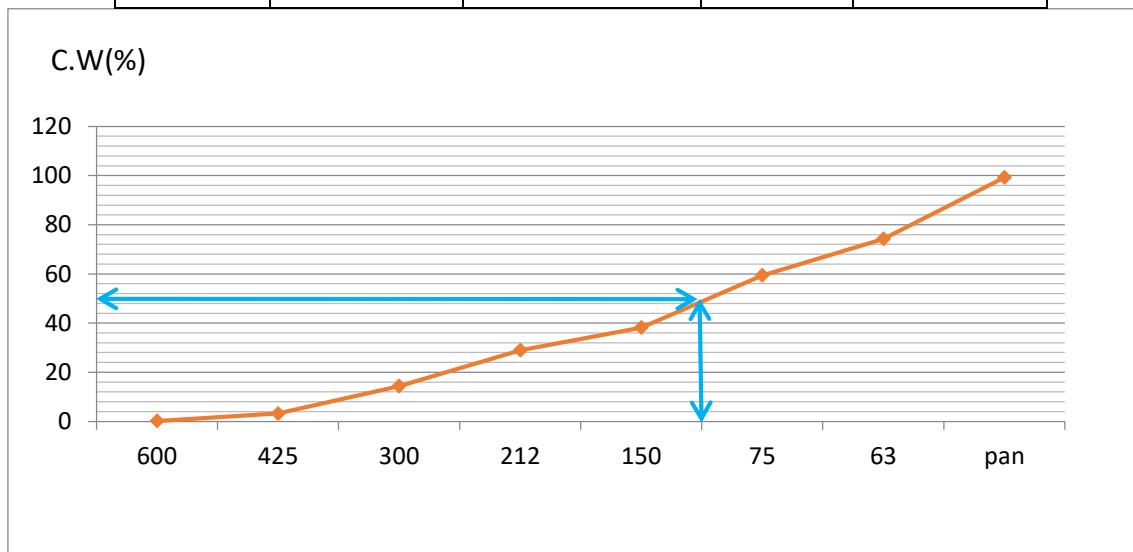


Fig.(4-9b) Graph Between the accumulative weight% of sample

Table (4-38) Sample (10) on height (2 m) in ALBaida

Sieve Size (μm)	Probability weight(%)	Normalization →	Sieve Size (μm)	Probability weight(%)
600	0.92		600	0.92
425	10.95		425	10.98
300	14.50		300	14.54
212	13.07		212	13.11
150	11.75		150	11.78
75	18.79		75	18.84
63	8.46		63	8.48
Pan	21.27		Pan	21.33

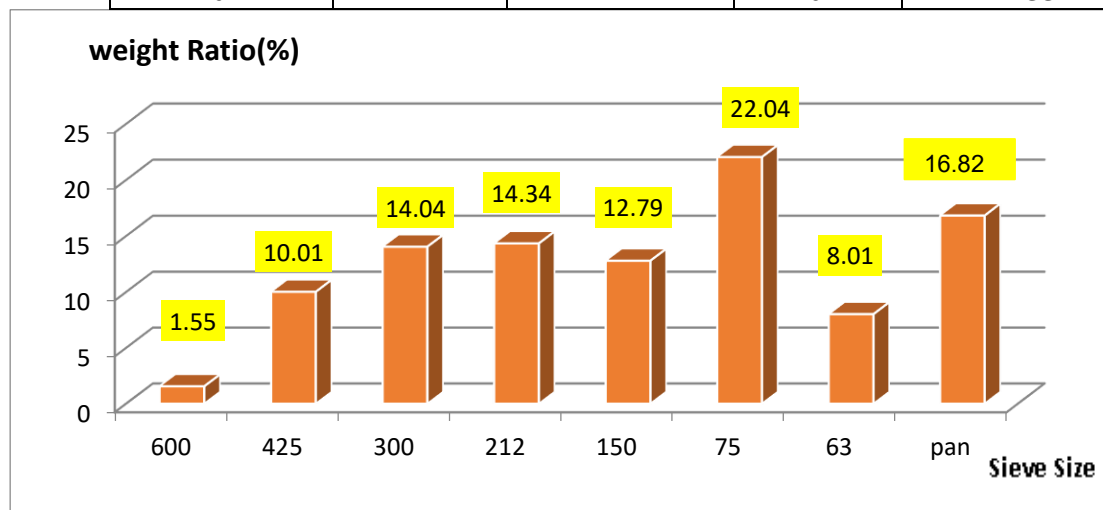


Fig.(4-10a) Graph Between Weight % and Grain Diameter(micron)of sample

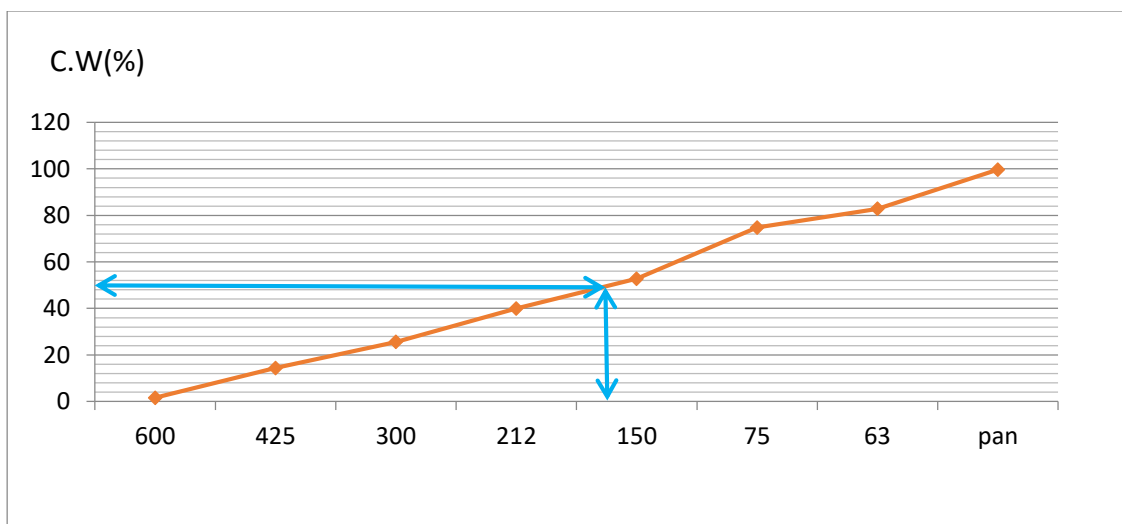


Fig.(4-10b) Graph Between the accumulative weight% of sample

Table (4-39) Sample (11) on height (6 m) in ALBaida

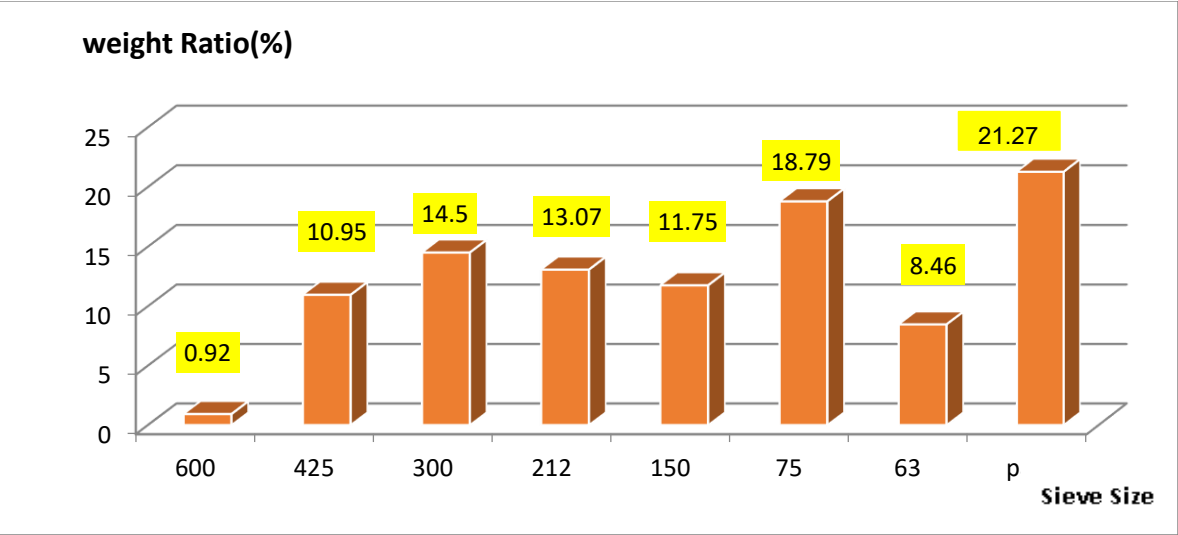


Fig.(4-11a) Graph Between Weight % and Grain Diameter(micron)of sample

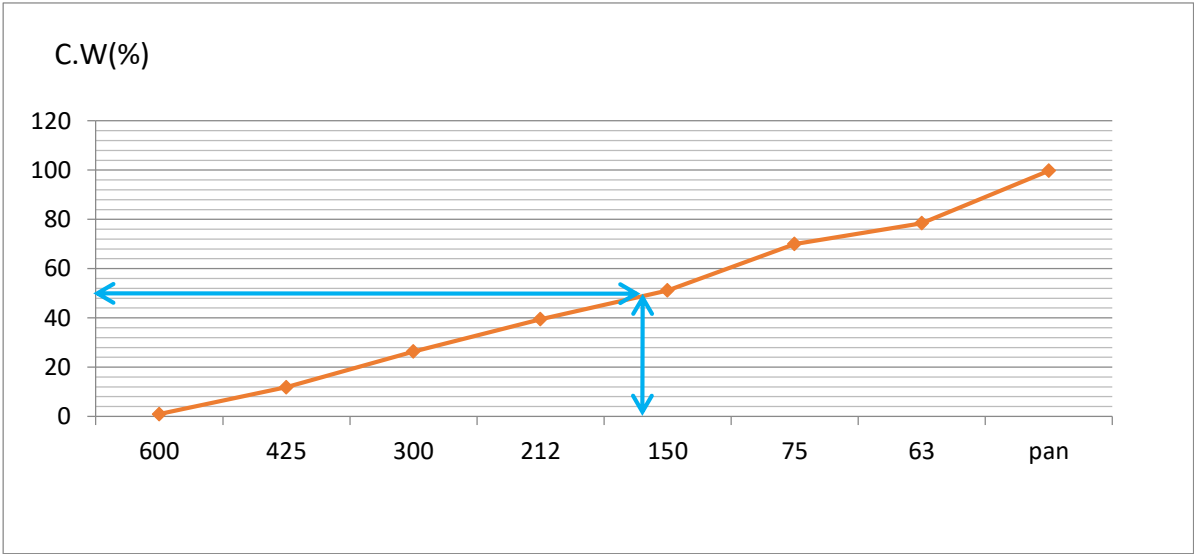


Fig.(4-11b) Graph Between the accumulative weight% of sample

Table (4-40) Sample (12) on height (10 m) in ALBaida

Sieve Size (μm)	Probability weight(%)	Normalization →	Sieve Size (μm)	Probability weight(%)
600	0.66		600	0.67
425	5.87		425	5.94
300	12.60		300	12.74
212	8.99		212	9.09
150	11.53		150	11.66
75	24.67		75	24.95
63	16.29		63	16.47
Pan	18.27		Pan	18.48

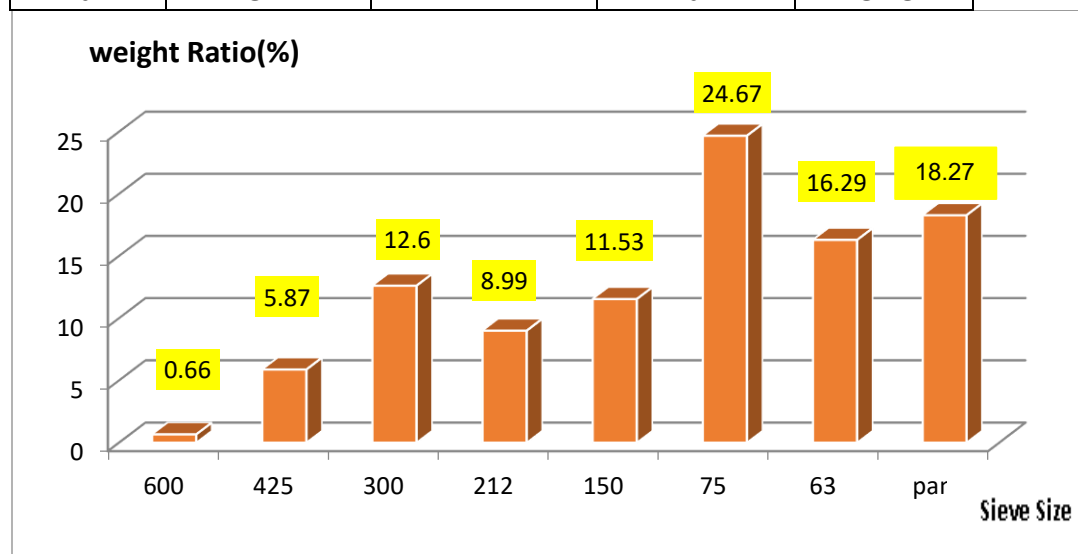


Fig. (4-12a) Graph Between Weight % and Grain Diameter(micron)of sample

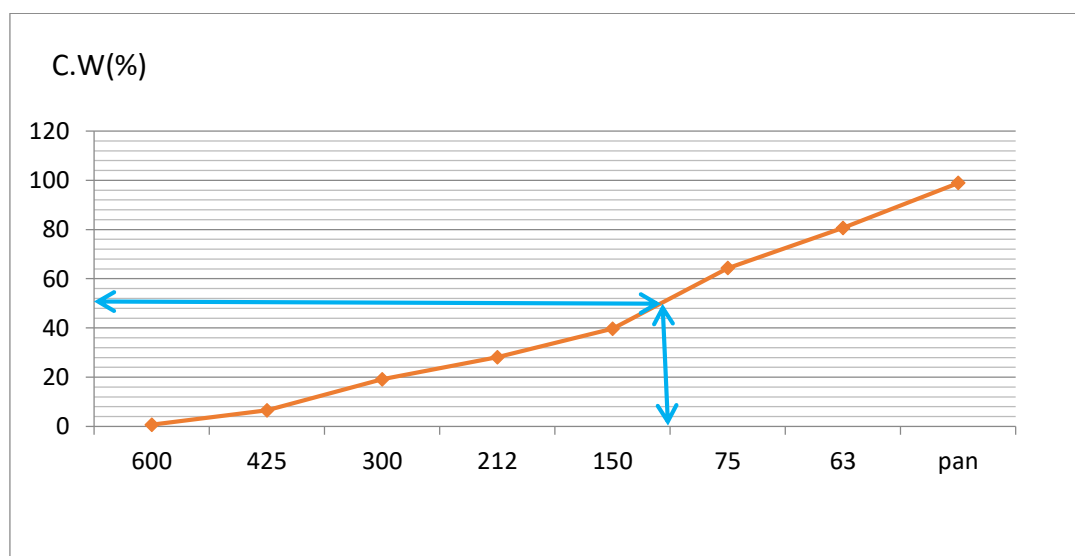


Fig. (4-12b) Graph Between the accumulative weight% of sample

Table (4-41) Sample (13) on height (2 m) in Lamluda

Sieve Size (μm)	Probability weight(%)	Normalization →	Sieve Size (μm)	Probability weight(%)
600	0.75		600	0.75
425	6.02		425	6.05
300	8.29		300	8.33
212	7.29		212	7.32
150	8.56		150	8.60
75	25.88		75	26.00
63	13.21		63	13.27
pan	29.55		pan	29.68

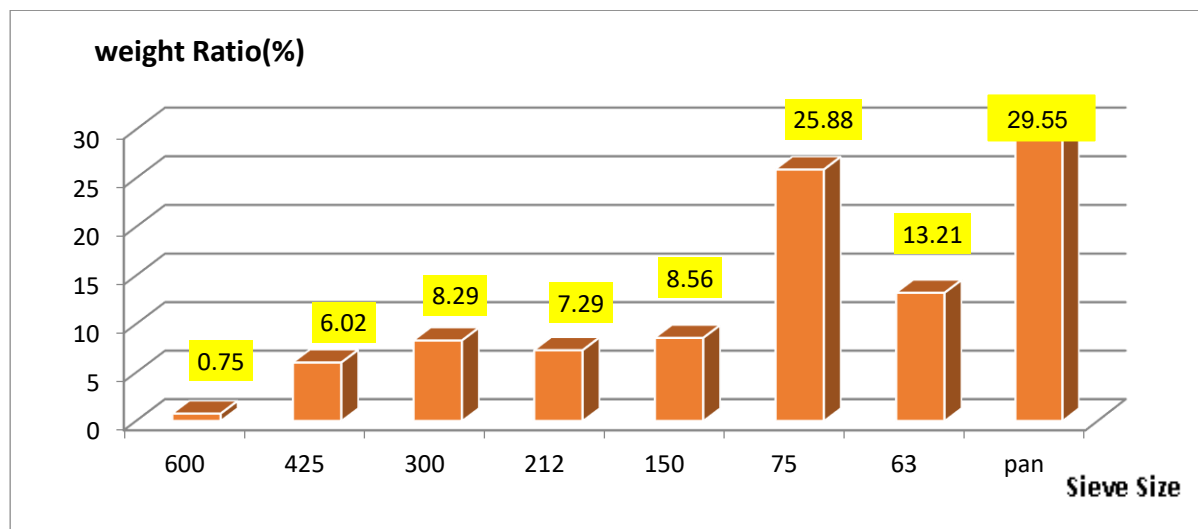


Fig.(4-13a) Graph Between Weight % and Grain Diameter(micron)of sample

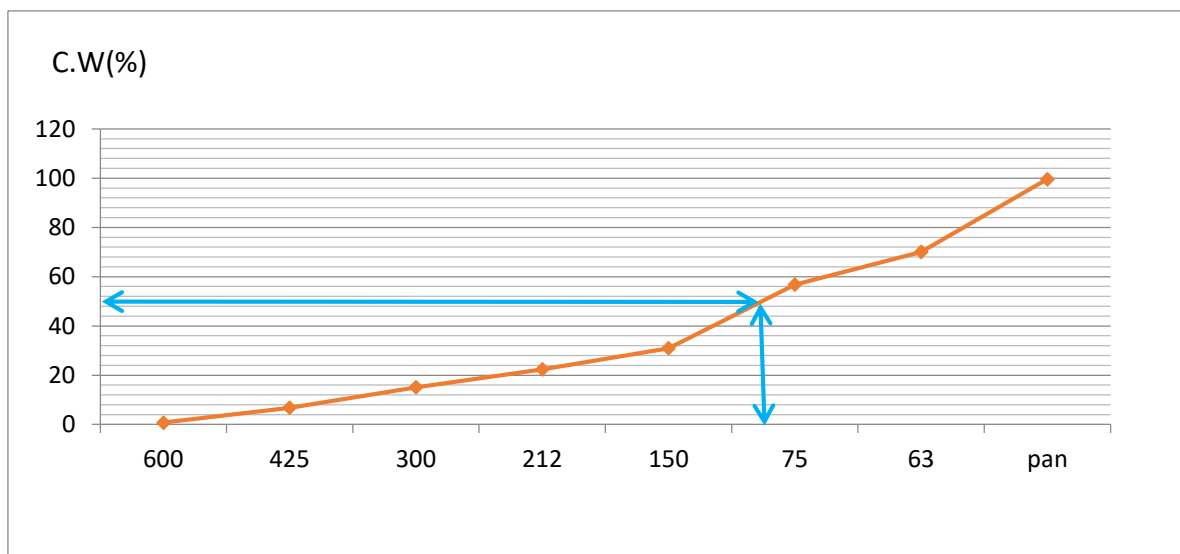


Fig.(4-13b) Graph Between the accumulative weight% of sample

Table (4-42) Sample (14) on height (6 m) in Lamluda

Sieve Size (μm)	Probability weight(%)	Normalization →	Sieve Size (μm)	Probability weight(%)
600	0.49		600	0.49
425	3.89		425	3.91
300	5.53		300	5.56
212	6.39		212	6.43
150	8.94		150	8.99
75	33.68		75	33.89
63	13.86		63	13.95
pan	26.61		pan	26.77

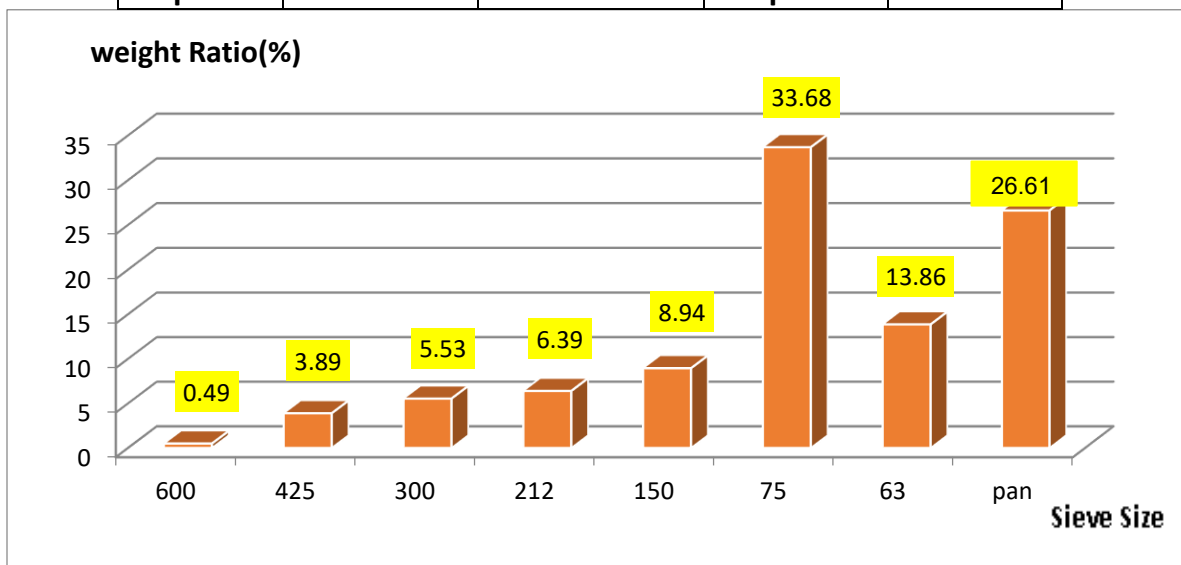


Fig.(4-14a) Graph Between Weight % and Grain Diameter(micron)of sample

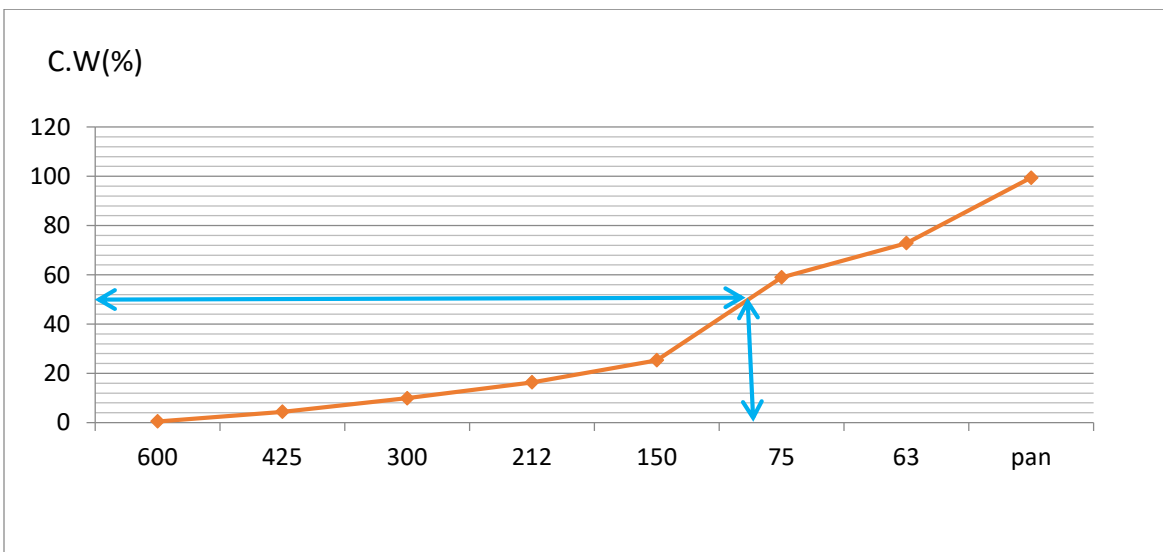


Fig.(4-14b) Graph Between the accumulative weight% of sample

43)
(15) on
(10 m) in

Sieve Size (μm)	Probability weight(%)	Normalization →	Sieve Size (μm)	Probability weight(%)
600	0		600	0
425	0.11		425	0.11
300	4.27		300	4.30
212	4.78		212	4.81
150	8.17		150	8.23
75	40.30		75	40.59
63	22.90		63	23.06
pan	18.76		pan	18.89

Table (4-
Sample
height
Lamluda

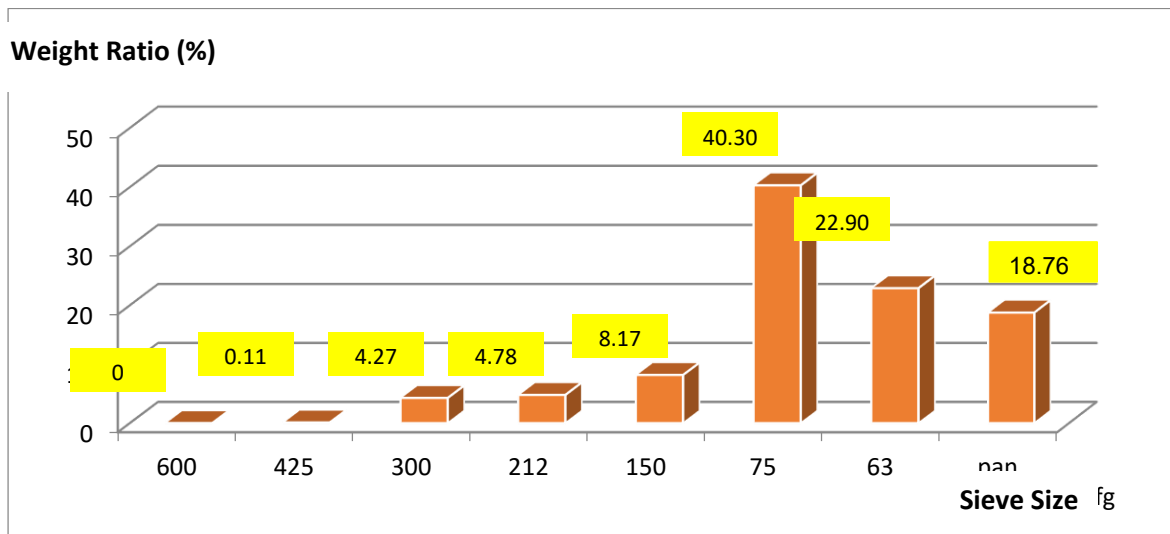


Fig .(4-15a) Graph Between Weight % and Grain Diameter(micron)of sample

Sieve Size (μm)	Probability weight(%)	Normalization →	Sieve Size (μm)	Probability
600	3.02		600	3.03
425	4.96		425	4.98
300	14.65		300	14.70
212	9.38		212	9.41
150	5.29		150	5.31
75	30.94		75	31.04
63	10.82		63	10.85
Pan	20.62		Pan	20.69

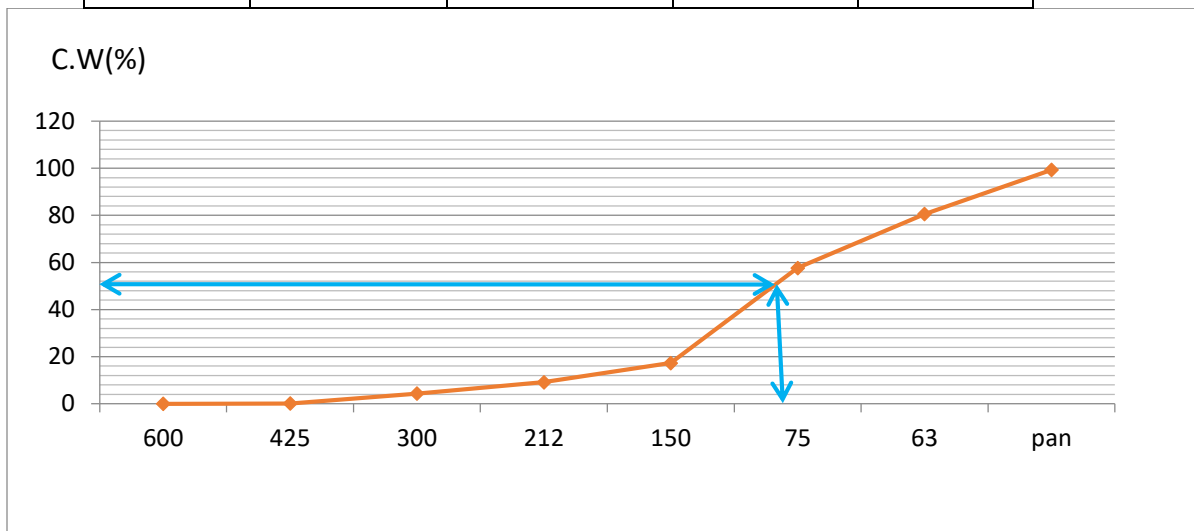


Fig.(4-15b) Graph Between the accumulative weight% of sample

Table (4-44) Sample (16) on height (2 m) in Derna

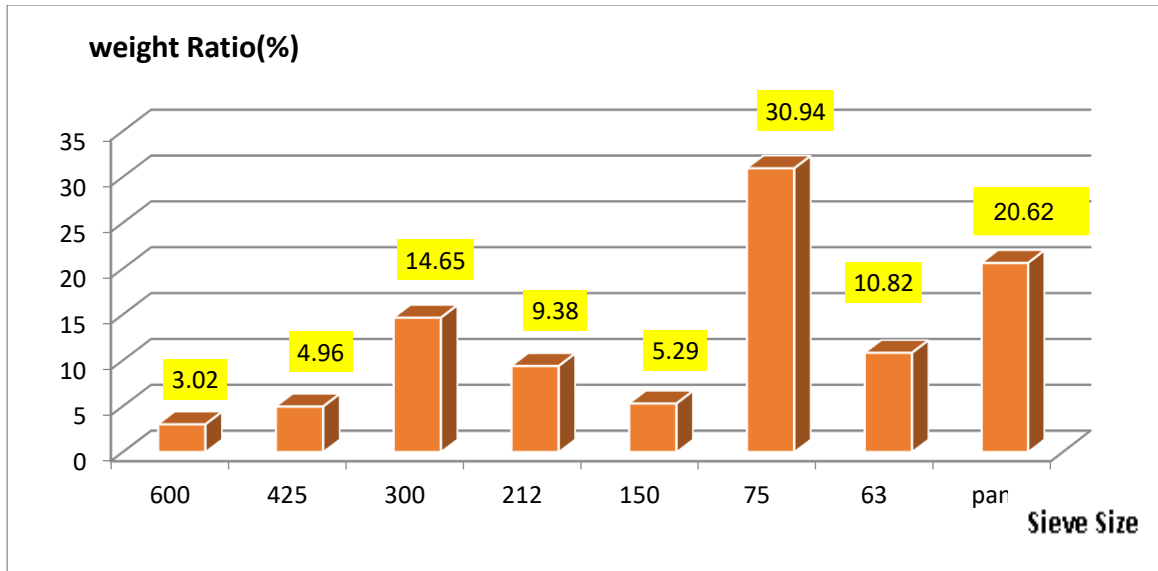


Fig.(4-16a) Graph Between Weight % and Grain Diameter(micron)of sample

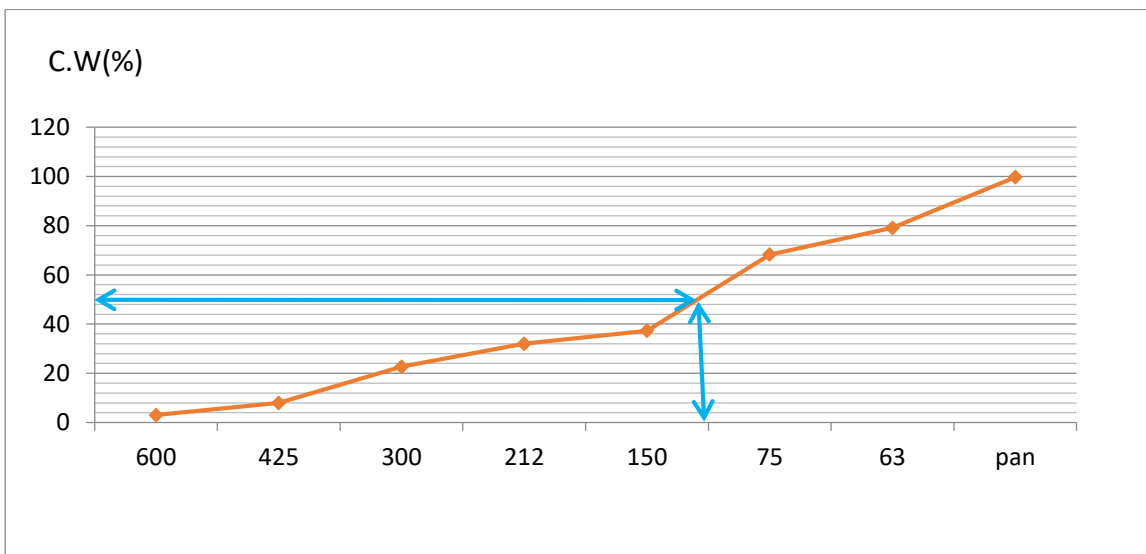


Fig.(4-16b) Graph Between the accumulative weight% of sample

Table (4-45) Sample (17) on height (6 m) in Derna

Sieve Size (μm)	Probability weight(%)	Normalization →	Sieve Size (μm)	Probability weight(%)
600	0.71		600	0.71
425	18.58		425	18.70
300	14.25		300	14.34
212	10.94		212	11.01
150	16.80		150	16.91
75	13.90		75	13.99
63	6.63		63	6.67
Pan	17.55		Pan	17.66

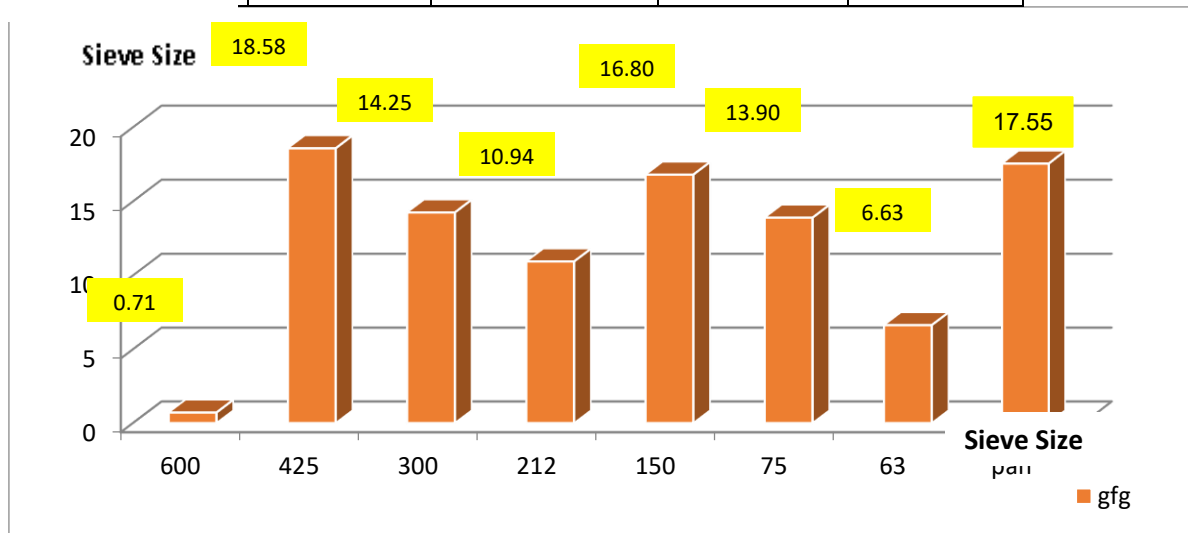


Fig.(4-17a) Graph Between Weight % and Grain Diameter(micron)of sample

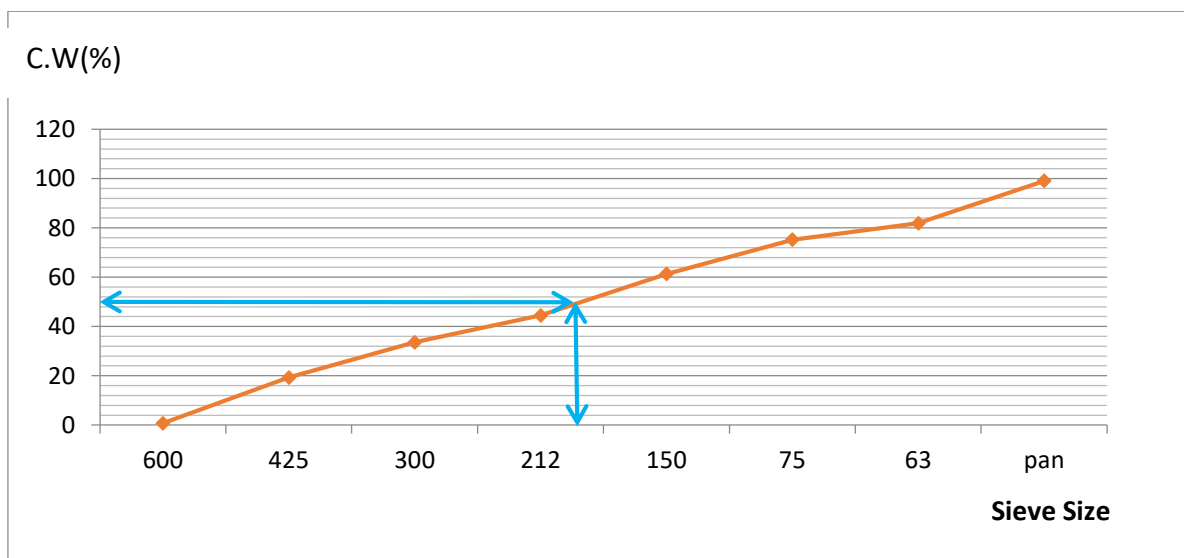


Fig.(4-17b) Graph Between the accumulative weight% of sample

Table (4-46) Sample (18) on height (10 m) in Derna

Sieve Size (μm)	Probability weight(%)	Normalization →	Sieve Size (μm)	Probability weight(%)
600	0.10		600	0.10
425	2.65		425	2.65
300	13.98		300	14.00
212	19.63		212	19.66
150	24.67		150	24.70
75	19.55		75	19.58
63	14.58		63	15.00
pan	4.71		pan	4.72

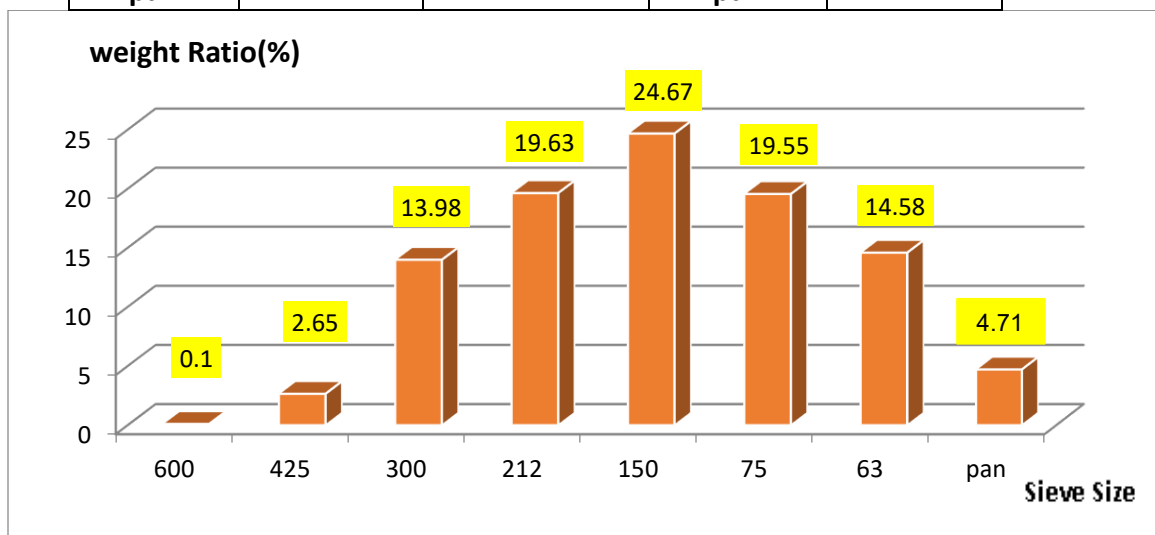


Fig.(4-18a) Graph Between Weight % and Grain Diameter(micron)of sample

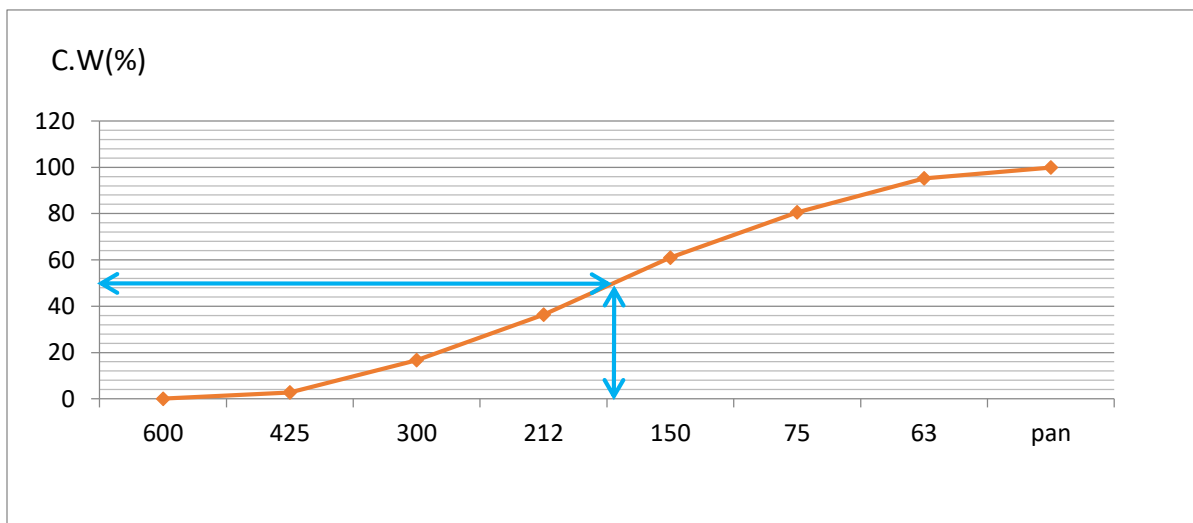


Fig.(4-18b) Graph Between the accumulative weight% of sample

(4-47)
(19) on
(2 m)

Sieve Size (μm)	Probability weight(%)	Normalization →	Sieve Size (μm)	Probability weight(%)
600	2.64		600	2.66
425	1.11		425	1.12
300	4.13		300	4.15
212	3.72		212	3.74
150	4.01		150	4.03
75	27.52		75	27.68
63	36.23		63	36.45
Pan	20.05		Pan	20.17

Table
Sample
height
in UM

Alrazum

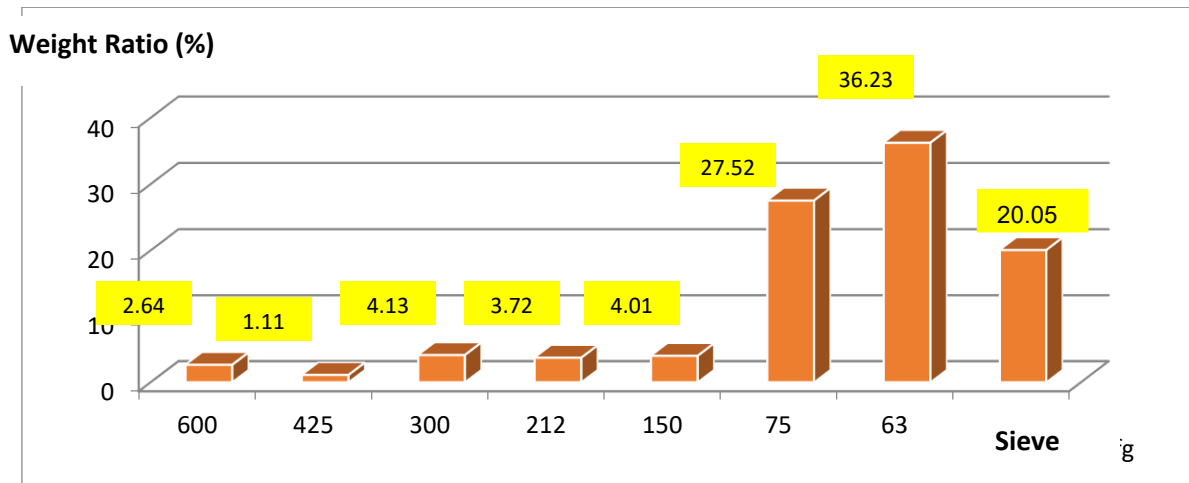


Fig.(4-19a) Graph Between Weight % and Grain Diameter(micron)of sample

Sieve Size	Probability weight(%)	Normalization →	Sieve Size (μm)	Probability
600	1.17		600	1.18
425	6.66		425	6.70
300	10.63		300	10.69
212	8.44		212	8.49
150	11.37		150	11.43
75	20.23		75	20.34
63	19.05		63	19.15
Pan	21.55		Pan	21.67

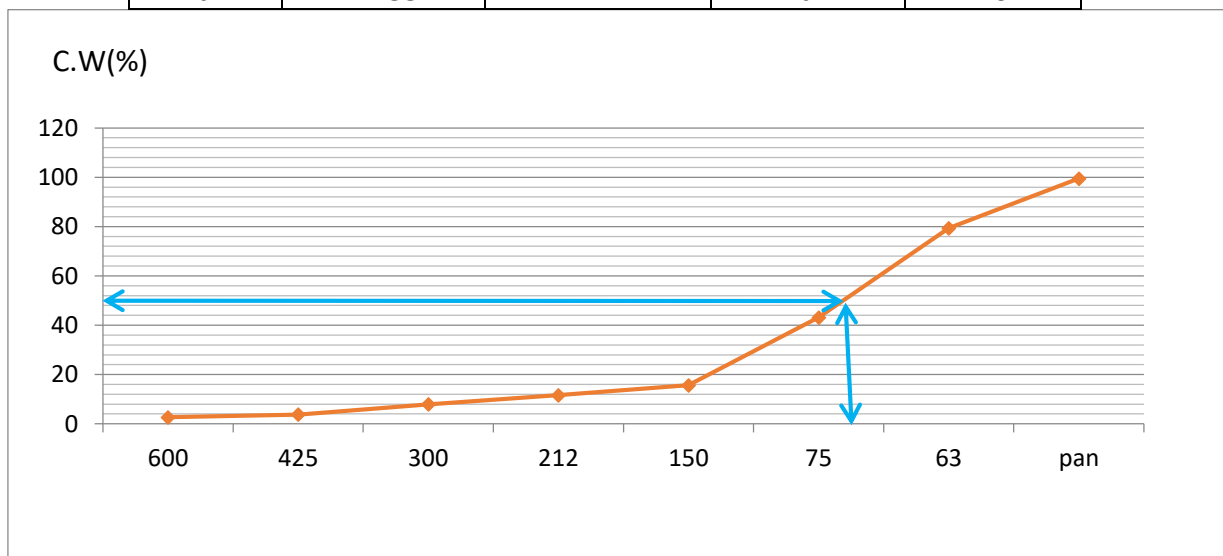


Fig.(4-19b) Graph Between the accumulative weight% of sample

Table (4-48) Sample (20) on height (6 m) in UM Alrazum

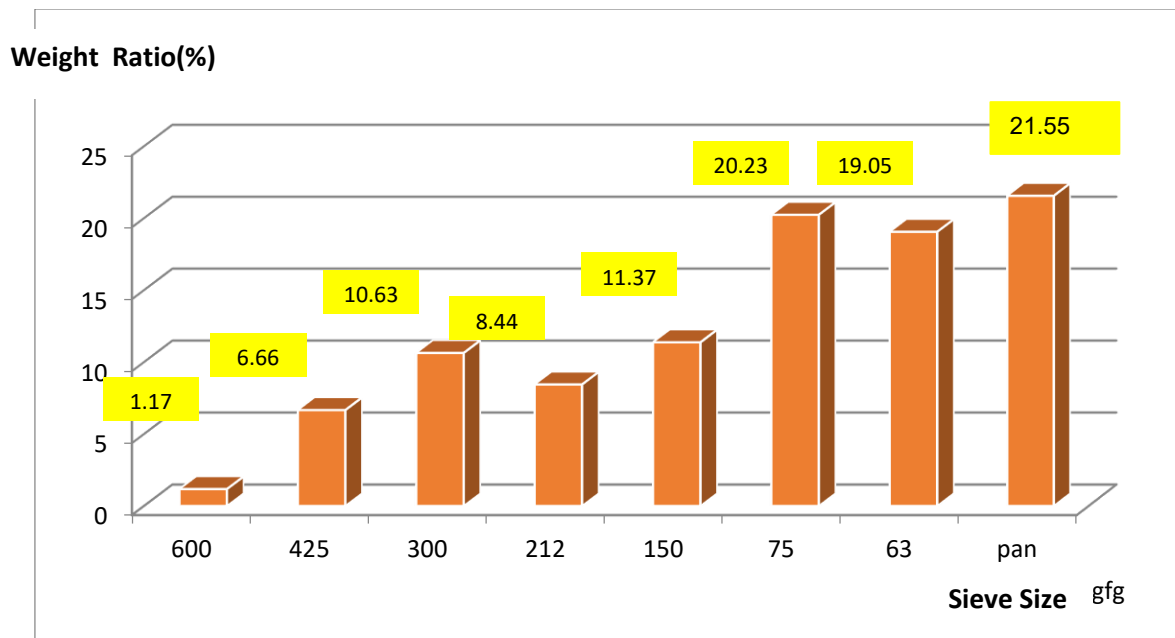


Fig.(4-20a) Graph Between Weight % and Grain Diameter(micron)of sample

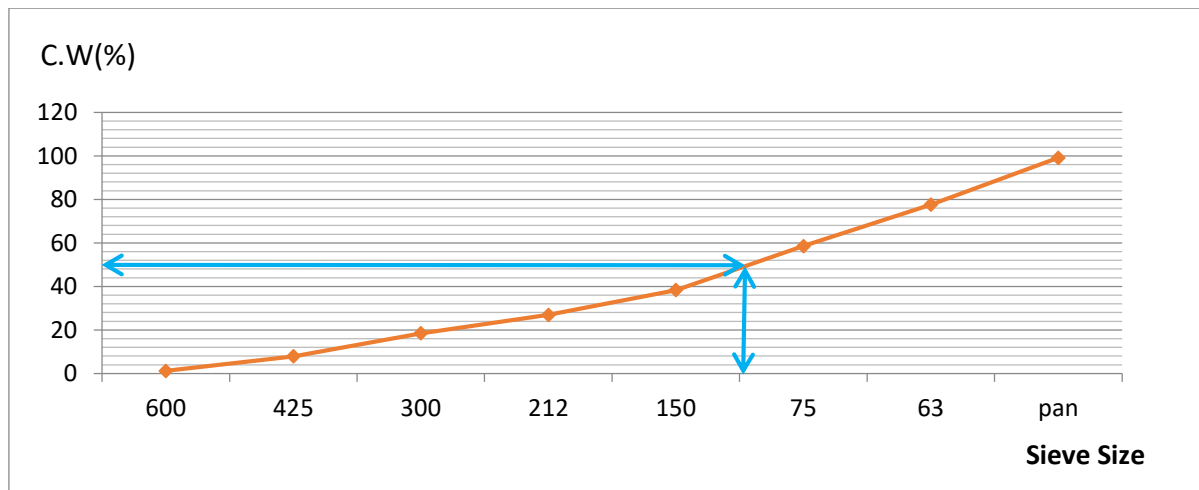


Fig.(4-20b) Graph Between the accumulative weight% of sample

Table (4-49) Sample (21) on height (10 m) in UM ALrazum

Weight Ratio(%)	Probability weight(%)	Normalization	Sieve Size (μm)	Probability weight(%)
Size (μm)				
600	0		600	0
425	0.22		425	0.22
300	4.78		300	4.82
212	49.18		212	20.53
150	13.90		150	14.02
75	20.478		75	4.35
63	4.35		63	4.39
Pan	6.19		Pan	6.24

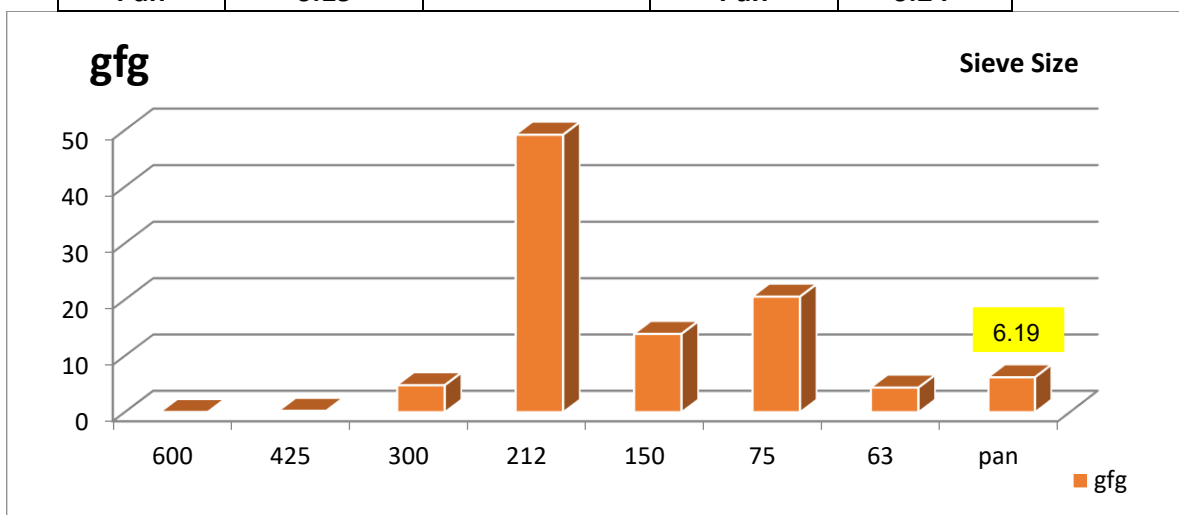


Fig.(4-21a) Graph Between Weight % and Grain Diameter(micron)of sample

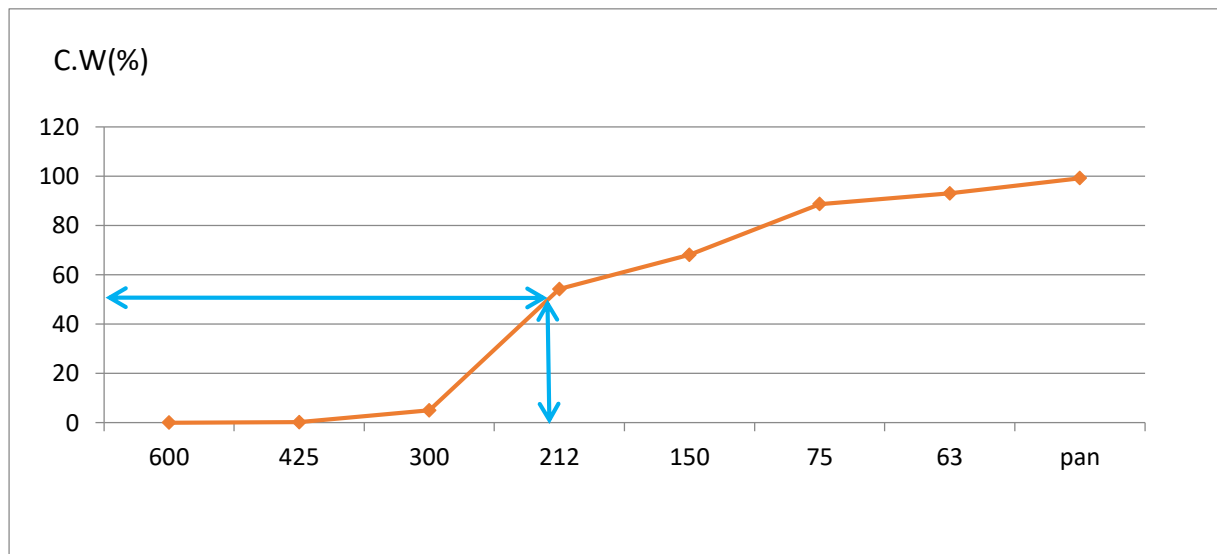


Fig.(4-21b) Graph Between the accumulative weight% of sample

4-5 Estimation of Air Relative Humidity Effect

The complex permittivity depends on moisture content of samples, S. M. Sharief [9] arrived at the following empirical relation for the variation of complex permittivity with relative humidity.

$$\varepsilon' = 5.52 + 0.04H - 7.78 \times 10^{-4} H^2 + 5.56 \times 10^{-6} H^3 \quad \dots\dots(4-2)$$

$$\varepsilon'' = 0.16 + 0.02H - 3.71 \times 10^{-4} H^2 + 2.76 \times 10^{-6} H^3$$

Where:

H is the air relative humidity (percentage).

We can use the Equations (4-2) and (4-3) to estimate the effect of relative humidity on the complex permittivity in the studied area (El-jabal Alakhdar region), by changing the first term of both Equations of the real part and imaginary part of complex permittivity of dry samples respectively and for our case the Equations will be:

$$\dots\dots(4-4) \quad \varepsilon' = 5.5611 + 0.04H - 7.78 \times 10^{-4} H^2 + 5.56 \times 10^{-6} H^3$$

$$\dots(4-5) \quad \varepsilon'' = 0.2902 + 0.02H - 3.71 \times 10^{-4} H^2 + 2.76 \times 10^{-6} H^3$$

By using program in [Appendix(B)], the results are given in Tables

(4-45) , (4-46) and Fig. (4-22) .

Where the number **5.5611** is the averaged real part and **0.2902** is the averaged imaginary part for the El-jabal Alakhdar region.

4-6 Estimating the Wave Attenuation

For dust, the imaginary part of the dielectric constant is very dependent on the hygroscopic water content of the sample this can be concluded from the variations of the dielectric constant with humidity of the sample. Attenuation dust to scattering depends on the shape of the scattering particles and their orientation relative to the wave polarization.[1]

.....(4-7)

$$\alpha = \frac{2.46 \times 10^5 \times \nu}{\lambda_C} \times \left[\frac{\epsilon''}{(\epsilon' + 2)^2 + \epsilon''^2} \right]$$

$$\nu = \frac{\rho \times V_o^\gamma \left(\frac{h}{h_o} \right)^b}{\dots\dots\dots(4-8)}$$

Where:

ν is the relative volume occupied by particles(m^3/m^3) .

V_o is the visibility at h_o ; its minimum value is about 5m.

$h_o = 2m$ is the reference height.

$C = 2.3 \times 10^{-5}$

$\gamma = 1.07$

ρ is the average measured density of the samples collected in El-jabal Alakhdar region is **1.3855gm/ml**.

$\epsilon_m = 5.5611 - j0.2902$ is the complex permittivity of sample.

Table(4-45)Attenuation per Km as function of the humidity

H(%)	Att(dB/Km)at h=10m	Att(dB/Km)at h=20m	Att(dB/Km)at h=30m	Att(dB/Km)at h=40m	Att(dB/Km)at h=50m
45.46	0.0012	0.0010	0.0009	0.0008	0.0007
48.46	0.0013	0.0010	0.0009	0.0009	0.0008
51.46	0.0014	0.0011	0.0010	0.0009	0.0009
54.46	0.0015	0.0012	0.0011	0.0010	0.0009
57.46	0.0016	0.0013	0.0012	0.0011	0.0010
60.46	0.0018	0.0015	0.0013	0.0012	0.0011
63.46	0.0019	0.0016	0.0014	0.0013	0.0012
66.46	0.0021	0.0017	0.0016	0.0014	0.0014
69.46	0.0023	0.0019	0.0017	0.0016	0.0015
72.46	0.0026	0.0021	0.0019	0.0018	0.0016
75.46	0.0029	0.0024	0.0021	0.0019	0.0018
78.46	0.0032	0.0026	0.0023	0.0021	0.0020
SUM	0.0238	0.0194	0.0174	0.0160	0.0149

Table(4-46)Attenuation per Km as function of the humidity

H(%)	Att(dB/Km)at h=60m	Att(dB/Km)at h=70m	Att(dB/Km)at h=80m	Att(dB/Km)at h=90m	Att(dB/Km)at h=100m
45.46	0.0007	0.0007	0.0006	0.0006	0.0006
48.46	0.0008	0.0007	0.0007	0.0007	0.0007
51.46	0.0008	0.0008	0.0008	0.0007	0.0007
54.46	0.0009	0.0009	0.0008	0.0008	0.0008
57.46	0.0010	0.0009	0.0009	0.0009	0.0008
60.46	0.0011	0.0010	0.0010	0.0010	0.0009
63.46	0.0012	0.0011	0.0011	0.0010	0.0010
66.46	0.0013	0.0012	0.0012	0.0011	0.0011
69.46	0.0014	0.0014	0.0013	0.0013	0.0012
72.46	0.0016	0.0015	0.0014	0.0014	0.0014
75.46	0.0017	0.0017	0.0016	0.0015	0.0015
78.46	0.0019	0.0018	0.0018	0.0017	0.0017
SUM	0.0144	0.0137	0.0132	0.0127	0.0124

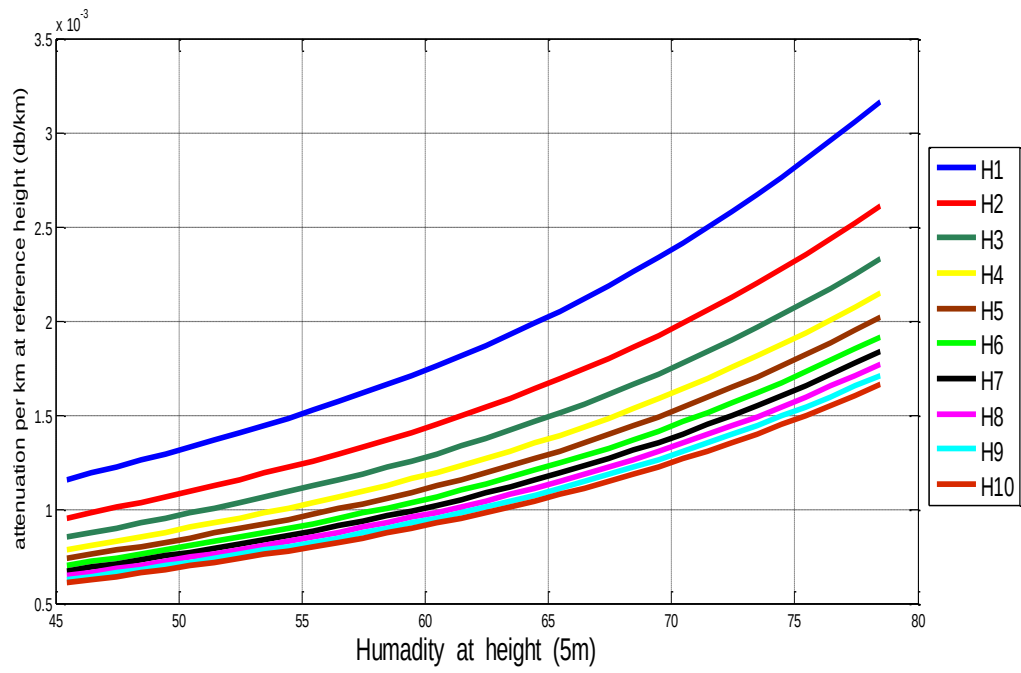


Fig .(4-22) plot of the results presented in table (4-45) and (4-46)

CHAPTER 5

Conclusion and Recommendations

5-1 Conclusion

From the collected samples and using the standard approach for analysis we can draw the following remarks:

- 1-The studied area has yearly average Relative humidity over 15 years equal **66.74%** and average wind speed equal **7.61** knots average Temperature equal **18.27 C°**.
- 2- The major constituents of samples are **SiO₂** , **CaO** and **CO₂** about **87.88%** by weight of samples
- 3-The average relative dielectric constant for the selected area El-jabal Alakhdar of Libya found to be **$\epsilon_m=5.5611-j0.2902$** .
- 4-The average density of sample in El-jabal Alakhdar equal to **1.3855(g/ml)**.
- 5- The average conductivity of samples is equal to **928.381 $\mu\text{s} / \text{cm}$** .
- 6- From the pervious Tables (4-29) to (4-49) the following remarks can be pointed out:
 - About 72.54% of the samples have a diameter between (pan 75 μm), therefore the dominant grain size is a fine sand size.
 - Size of particles does not depend on site of samples.
- 7- The average attenuation of signal due dust storms in study at humidity equal :
(0.0238,0.0194,0.0174,0.0160,0.0149,0.0144,0.0137,0.0132,0.0127 and 0.0124 dB/km respectively).

8- Relative Humidity for the Sample in laboratory on heights 2m, 6m and 10m :

Sample	Relative Humidity for the Sample in laboratory on height%		
	2m	6m	10m
ALmarej	1.90	1.83	1.20
AL Garieb	4.58	3.53	1.73
AL Byada	4.58	2.65	2.23
AL Baida	1.79	1.11	0.91
Lamluda	1.29	1.18	0.59
Derna	1.47	1.45	0.94
UmALrazum	1.32	1.24	1.05

5-2 Recommendations

The results of this study should not be drawn for all of Libya, but it is valid for the studied area and any similar part only, for other areas that are not similar, parallel study should be conducted.

An experimental study should be conducted by designing and building a special microwave link that takes into account all effects of storms over a couple of years.

we need some advanced equipment to reduce the impact of dust storms on microwave link .

Reference:

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- [14] Keat G. Ong and Craig A. Grimes, "A Carbon Nanotube-based Sensor for CO Monitoring" IEEE Trans on Ant. and prog. Received: 8 October 2001 / Accepted: 17 October 2001 / Published: 2 November 2001.
- [15] Abdel.Hakim, "Transition from Analog to digital Terrestrial Television & opportunities Tunisia" –Tunis, March 2012 .

Appendix(A)

I- Center Post in Tripoli

height , location of towers and distance between towers

Station Number	Station/ Exchange Name	Latitude N	Longitude E	Tower Height (meter)	Distance Between Towers (km)
1	<i>Elmarej</i>	32 29 37.90	020 49 55.10	80	-
2	<i>Al Garieb</i>	32 33 07.51	021 06 54.81	92	27.37
3	<i>Al Byada</i>	32 37 35.30	021 28 18.60	60	34.48
4	<i>Al Baida</i>	32 45 50.80	021 45 44.10	72	31.22
5	<i>Lamluda</i>	32 47 16.50	022 07 47.30	147	34.54
6	<i>Derna REP</i>	32 44 06.90	022 40 06.70	122	50.82
7	<i>UM Alrazum</i>	32 32 48.50	022 59 22.80	122	36.67

II- Libyan Center of Metrology

Relative humidity, Temperature and Wind speed forAL Marej

Month	Relative Humidity %	Wind speed(knots)	Temperature (C°)
JAN.	72.81	6.17	9.60
FEB.	72.09	6.48	9.44
MAR.	68.09	5.33	11.68
APR.	61.81	6.80	14.62
MAY.	62.72	6.78	20.10
JUN.	63.63	6.66	22.49
JUL.	68.09	6.68	24.46
AUG.	69.18	6.29	25.34
SEP.	66.54	6.12	23.90
OCT.	70.27	5.73	20.86
NOV.	71.81	6.87	16.26
DEC.	78.00	7.65	11.82
Yearly Average	68.75	6.46	17.54

Relative humidity, Temperature and Wind speed for AL Baida

Month	Relative Humidity %	Wind speed(knots)	Temperature (C°)
JAN.	75.74	4.68	10.00
FEB.	68.00	5.59	9.80
MAR.	65.23	5.61	11.82
APR.	55.47	5.73	15.35
MAY.	48.47	4.95	19.04
JUN.	45.46	4.18	20.80
JUL.	55.17	4.86	23.42
AUG.	58.23	4.70	22.60
SEP.	59.58	4.33	21.89
OCT.	60.70	4.31	19.33
NOV.	67.35	4.72	14.96
DEC.	73.35	5.03	11.42
Yearly Average	61.062	4.899	16.702

Relative humidity, Temperature and Wind speed for Derna

Month	Relative Humidity %	Wind speed(knots)	Temperature (C°)
JAN.	71.88	12.27	14.58
FEB.	69.83	12.53	14.25
MAR.	68.27	11.63	15.81
APR.	67.22	11.08	18.05
MAY.	71.77	9.89	21.00
JUN.	72.88	10.67	24.16
JUL.	74.88	13.41	26.29
AUG.	74.22	12.57	27.16
SEP.	71.22	9.87	26.06
OCT.	69.11	9.77	23.50
NOV.	66.16	11.25	19.66
DEC.	67.38	12.63	16.22
Yearly Average	70.401	11.464	20.561

Density and Conductivity.

NO.	Samples name	Density (g / ml)	Conductivity (μ s /cm)
1	ALmarej 2m	1.3736	182
2	AL Garieb 2m	1.3274	4030
3	AL Byada 2m	1.3953	788
4	AL Baida 2m	1.3636	489
5	Lamluda 2m	1.4286	754
6	Derna 2m	1.5116	357
7	UM ALrazum 2m	1.4493	258
	Average	1.4070	979.7142

Table(3-27) Density and Conductivity at height (6m)

NO.	Samples name	Density (g / ml)	Conductivity (μs /cm)
1	ALmarej 6m	1.4525	730
2	AL Garieb 6m	1.3768	955
3	AL Byada 6m	1.3333	595
4	AL Baida 6m	1.3281	1105
5	Lamluda 6m	1.3559	1812
6	Derna 6m	1.3559	684
7	UM ALrazum 6m	1.3393	314
	Average	1.3631	885

Table(3-28) Density and Conductivity at height (10m)

NO.	Samples name	Density (g / ml)	Conductivity (μs /cm)
1	ALmarej 10m	1.3514	1255
2	AL Garieb 10m	1.3462	344
3	AL Byada 10m	1.3725	1813
4	AL Baida 10m	1.3393	1006
5	Lamluda 10m	1.4474	1148
6	Derna 10m	1.5217	264
7	UM ALrazum 10m	1.3265	613

	Average	1.3864	920.428
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IV- Centre Industrial Researches

Relative

Humidity for the Samples

*The watery content of sample No. (1) **ELmarej***

<i>Height</i>	<i>Weight of Sample humid</i>	<i>Weight of Sample dryish</i>	<i>Weight of Water</i>	<i>Relative Humidity for the Sample</i>
2m	115.23	113.08	2.15	1.90
6m	98.70	96.92	1.78	1.83
10m	47.00	46.44	0.56	1.20

*The watery content of sample No. (2) **EL Garieb***

<i>Height</i>	<i>Weight of Sample humid</i>	<i>Weight of Sample dryish</i>	<i>Weight of Water</i>	<i>Relative Humidity for the Sample</i>
2m	80.06	76.55	3.51	4.58
6m	68.79	66.44	2.35	3.53
10m	87.80	86.30	1.50	1.73

*The watery content of sample No. (3) **EL Byada***

<i>Height</i>	<i>Weight of Sample humid</i>	<i>Weight of Sample dryish</i>	<i>Weight of Water</i>	<i>Relative Humidity for the Sample</i>
2m	134.74	131.18	3.56	4.58
6m	96.19	93.70	2.49	2.65
10m	77.34	75.65	1.69	2.23

The watery content of sample No. (4) *EL Baida*

<i>Height</i>	<i>Weight of Sample humid</i>	<i>Weight of Sample dryish</i>	<i>Weight of Water</i>	<i>Relative Humidity for the Sample</i>
2m	70.83	69.58	1.25	1.79
6m	91.90	90.89	1.01	1.11
10m	79.00	78.29	0.71	0.91

The watery content of sample No. (5) *Lamluda*

<i>Height</i>	<i>Weight of Sample humid</i>	<i>Weight of Sample dryish</i>	<i>Weight of Water</i>	<i>Relative Humidity for the Sample</i>
2m	84.06	82.99	1.07	1.29
6m	73.27	72.41	0.86	1.18
10m	103.41	102.80	0.61	0.59

The watery content of sample No. (6) *Derna*

<i>Height</i>	<i>Weight of Sample humid</i>	<i>Weight of Sample dryish</i>	<i>Weight of Water</i>	<i>Relative Humidity for the Sample</i>
2m	128.26	126.40	1.86	1.47
6m	85.20	83.98	1.22	1.45
10m	85.70	84.90	0.80	0.94

The watery content of sample No. (7) *UMALrazum*

<i>Height</i>	<i>Weight of Sample humid</i>	<i>Weight of Sample dryish</i>	<i>Weight of Water</i>	<i>Relative Humidity for the Sample</i>
2m	104.06	102.70	1.36	1.32
6m	91.93	90.80	1.13	1.24
10m	63.30	62.64	0.66	1.05

Size Analysis of Samples

Sample(1) on height 2m in ELMarej Weight 113.08g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0	0	0	0	100
425	12.05	10.65	12.05	10.56	89.35
300	21.61	19.11	33.66	29.76	70.24
212	12.63	11.16	46.29	40.93	59.07
150	8.15	7.20	54.44	48.14	51.86
75	12.04	10.64	66.48	58.79	41.21
63	9.11	8.05	75.59	66.84	33.16
pan	37.28	32.96	112.87	99.81	0.19

Sample(1) on height 6m in ELMarej Weight 96.92g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0	0	0	0	100
425	3.52	3.63	3.52	3.63	96.37
300	7.30	7.53	10.82	11.16	88.84
212	5.89	6.07	16.71	17.24	82.76
150	3.51	3.62	20.22	20.86	79.14
75	54.55	56.28	74.77	77.14	22.86
63	9.51	9.81	84.28	86.95	13.05
pan	12.60	13.00	96.88	99.95	0.05

Sample(1) on height 10m in ELMarej Weight 46.44g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0	0	0	0	100
425	0	0	0	0	100
300	1.19	2.56	1.19	2.56	97.44
212	0.97	2.08	2.16	4.65	95.35
150	1.48	3.18	3.64	7.83	92.17

75	10.29	22.15	13.93	29.99	70.01
63	6.53	14.06	20.46	44.05	55.95
pan	25.35	54.58	45.81	98.64	1.36

Sample(2) on height 2m in ALGarieb Weight 76.55g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0	0	0	0	100
425	12.17	15.89	12.17	15.89	84.11
300	13.57	17.72	25.74	33.62	66.38
212	10.10	13.19	35.84	46.81	53.19
150	9.75	12.73	45.59	59.55	40.45
75	9.53	12.44	55.12	72.00	28.00
63	3.86	5.04	58.98	77.04	22.96
pan	17.50	22.97	76.48	99.9	0.01

Sample(2) on height 6m in ALGarieb Weight 66.44g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0	0	0	0	100
425	9.80	14.75	9.80	14.75	85.25
300	12.44	16.25	22.24	33.47	66.53
212	8.96	11.70	31.20	46.95	53.05
150	8.04	10.50	39.24	59.06	40.94
75	8.19	10.69	47.43	71.38	28.62
63	3.63	4.74	51.06	76.85	23.15
pan	15.14	19.77	66.20	99.63	0.37

Sample(2) on height 10m in ALGarieb Weight 86.30g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0	0	0	0	100
425	0	0	0	0	100
300	9.67	11.20	9.67	11.20	88.80
212	11.97	13.87	21.64	25.07	74.93
150	11.49	13.31	33.13	38.38	61.62

75	15.60	18.07	48.73	56.46	43.54
63	12.70	14.71	61.43	71.18	28.82
pan	24.75	28.67	86.18	99.86	0.14

Sample(3) on height 2m in ALByada Weight 131.18g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	2.15	1.63	2.15	1.63	98.37
425	12.45	9.49	14.60	11.12	88.88
300	15.61	11.89	30.21	23.02	76.98
212	12.92	9.84	43.13	32.87	67.13
150	9.29	7.08	52.42	39.96	60.04
75	46.20	35.21	98.62	75.17	24.83
63	11.77	8.97	110.39	84.15	15.85
pan	20.63	15.72	131.02	99.87	0.13

Sample(3) on height 6m in ALByada Weight 93.70g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	1.73	1.84	1.73	1.84	98.16
425	10.68	11.39	12.41	13.24	86.76
300	17.03	18.17	29.44	31.41	68.59
212	12.44	13.27	41.88	44.69	55.31
150	14.26	15.21	56.14	59.91	40.09
75	11.63	12.41	67.77	72.32	27.68
63	5.17	5.51	72.94	77.84	22.16
pan	20.53	21.91	93.47	99.75	0.25

Sample(3) on height 10 m in ALByada Weight 75.65g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0.15	0.19	0.15	0.19	99.81
425	2.28	3.01	2.43	3.21	96.79
300	8.44	11.15	10.87	14.36	85.64

212	11.01	14.55	21.88	28.92	71.08
150	7.03	9.29	28.91	38.21	61.79
75	16.01	21.16	44.92	59.37	40.63
63	11.23	14.84	56.15	74.22	25.78
pan	18.91	24.99	75.06	99.22	0.78

Sample(4) on height 2m in ALBaida Weight 69.58g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	1.08	1.55	1.08	1.55	98.45
425	6.97	10.01	8.05	14.38	85.62
300	9.77	14.04	17.82	25.61	74.39
212	9.98	14.34	27.80	39.95	60.05
150	8.90	12.79	36.70	52.74	47.26
75	15.34	22.04	52.04	74.79	25.21
63	5.58	8.01	57.62	82.81	17.19
pan	11.71	16.82	69.33	99.64	0.36

Sample(4) on height 6m in ALBaida Weight 90.89g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0.84	0.92	0.84	0.92	99.08
424	9.96	10.95	10.80	11.88	88.12
300	13.18	14.50	23.98	26.38	73.62
212	11.88	13.07	35.86	39.45	60.55
150	10.68	11.75	46.54	51.20	48.80
75	17.08	18.79	63.62	69.99	30.01
63	7.69	8.46	71.31	78.45	21.55
pan	19.34	21.27	90.65	99.73	0.27

Sample(4) on height 10m in ALBaida Weight 78.29g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0.52	0.66	0.52	0.66	99.34

425	4.60	5.87	5.12	6.53	93.47
300	9.87	12.60	14.99	19.14	80.86
212	7.04	8.99	22.03	28.13	71.87
150	9.03	11.53	31.06	39.67	60.33
75	19.32	24.67	50.38	64.35	35.65
63	12.76	16.29	63.14	80.64	19.36
pan	14.31	18.27	77.45	98.92	1.08

Sample(5) on height 2m in Lamluda Weight 82.99g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0.63	0.75	0.63	0.75	99.25
425	5.00	6.02	5.63	6.78	93.22
300	6.88	8.29	12.51	15.07	84.93
212	6.05	7.29	18.56	22.36	77.64
150	7.11	8.56	25.67	30.93	69.07
75	21.48	25.88	47.15	56.81	43.19
63	10.97	13.21	58.12	70.03	29.97
pan	24.53	29.55	82.56	99.59	0.41

Sample(5) on height 6m in Lamluda Weight 72.41g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0.36	0.49	0.36	0.49	99.51
425	2.82	3.89	3.18	4.39	95.61
300	4.01	5.53	7.19	9.92	90.08
212	4.63	6.39	11.82	16.32	83.68
150	6.48	8.94	18.30	25.27	74.73
75	24.39	33.68	42.69	58.95	41.05
63	10.04	13.86	52.73	72.82	27.18
pan	19.27	26.61	72.00	99.43	0.57

Sample(5) on height 10m in Lamluda Weight 102.80g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0	0	0	0	100
425	0.12	0.11	0.12	0.11	99.89
300	4.39	4.27	4.51	4.38	95.62
212	4.92	4.78	9.43	9.17	90.83
150	8.40	8.17	17.83	17.34	82.66
75	41.43	40.30	59.26	57.64	42.36
63	23.55	22.90	82.81	80.55	19.45
pan	19.29	18.76	102.10	99.31	0.69

Sample(6) on height 2m in Derna Weight 126.40g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	3.82	3.02	3.82	3.02	96.98
425	6.27	4.96	10.09	7.98	92.02
300	18.53	14.65	28.62	22.64	77.36
212	11.86	9.38	40.48	32.02	67.98
150	9.69	5.29	47.17	37.31	62.69
75	39.11	30.94	86.28	68.25	31.75
63	13.68	10.82	99.96	79.08	20.92
pan	26.07	20.62	126.03	99.70	0.30

Sample(6) on height 6m in Derna Weight 83.98g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0.60	0.71	0.60	0.71	99.29
425	15.61	18.58	16.21	19.30	80.70
300	11.97	14.25	28.18	33.55	66.45
212	9.19	10.94	37.37	44.49	55.51
150	14.11	16.80	51.48	61.30	38.70
75	11.68	13.90	63.16	75.20	24.80
63	5.57	6.63	68.73	81.84	18.16
pan	14.74	17.55	83.20	99.07	0.93

Sample(6) on height 10m in Derna Weight 84.90g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0.09	0.10	0.09	0.10	99.90
425	2.25	2.56	2.34	2.75	97.25
300	11.87	13.98	14.21	16.73	83.27
212	16.67	19.63	30.88	36.37	63.63
150	20.95	24.67	51.83	61.04	38.96
75	16.60	19.55	68.43	80.60	19.40
63	12.38	14.58	80.81	95.18	4.82
pan	4.00	4.71	84.81	99.88	0.12

Sample(7) on height 2m in UM ALrazum Weight 102.70g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	2.72	2.64	2.72	2.64	97.36
425	1.14	1.11	3.86	3.75	96.25
300	4.25	4.13	8.11	7.89	92.11
212	3.83	3.72	11.94	11.62	88.83
150	4.12	4.01	16.06	15.63	84.37
75	28.27	27.52	44.33	43.16	56.84
63	37.21	36.23	81.54	79.39	20.61
pan	20.60	20.05	102.14	99.45	0.55

Sample(7) on height 6m in UM ALrazum Weight 90.80g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	1.07	1.17	1.07	1.17	98.83
425	6.05	6.66	7.12	7.84	92.16
300	9.66	10.63	16.78	18.48	81.16
212	7.67	8.44	24.45	26.92	73.08
150	10.33	11.37	34.78	38.30	61.70
75	18.37	20.23	53.15	58.53	41.47

63	17.30	19.05	70.45	77.58	22.42
pan	19.57	21.55	90.02	99.14	0.86

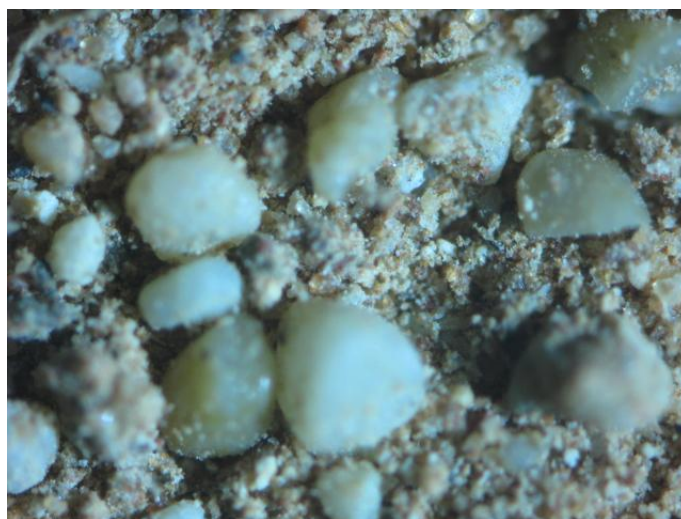
Sample(7) on height 10m in UM ALrazum Weight 62.64g

The sieve size (µm)	Weight (g)	Weight Ratio %	Cumulative weight (g)	Cumulative weight ratio %	The Pass Ratio (%)
600	0	0	0	0	100
425	0.14	0.22	0.14	0.22	99.78
300	3.00	4.78	3.14	5.01	94.99
212	30.81	49.18	33.95	54.19	45.81
150	8.71	13.90	42.66	68.10	31.90
75	12.86	20.53	55.52	88.63	11.37
63	2.73	4.35	58.25	92.99	7.01
pan	3.88	6.19	62.13	99.18	0.82

V- Libyan Petroleum Institute

Microscopic images for the samples.

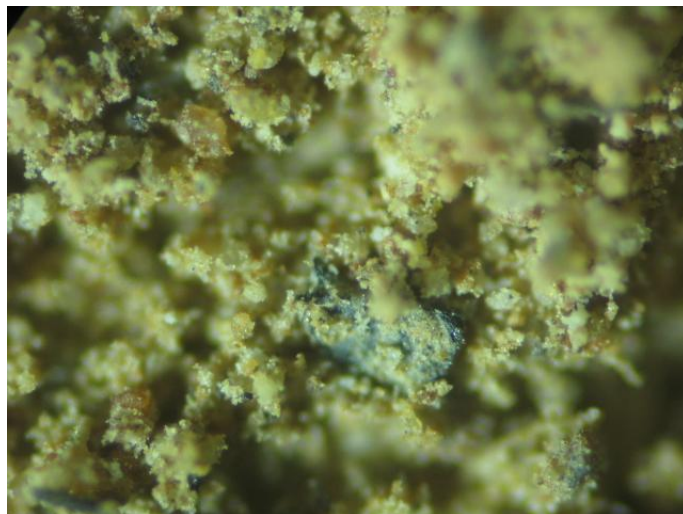
Measurement each sample 5 mm



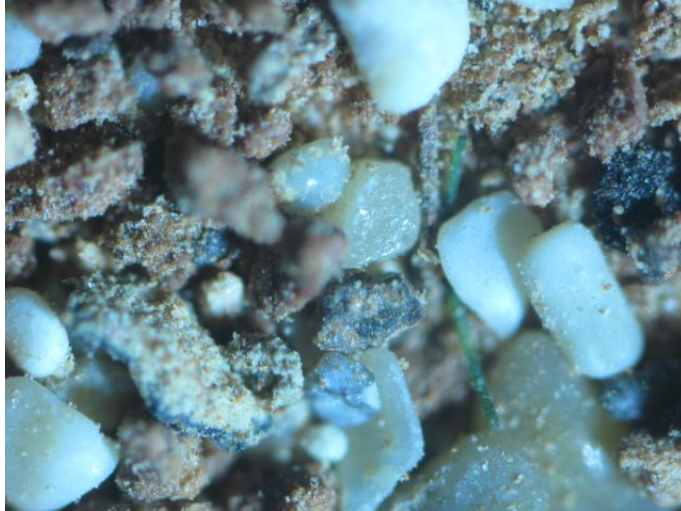
Sample 1 El Merj 2m



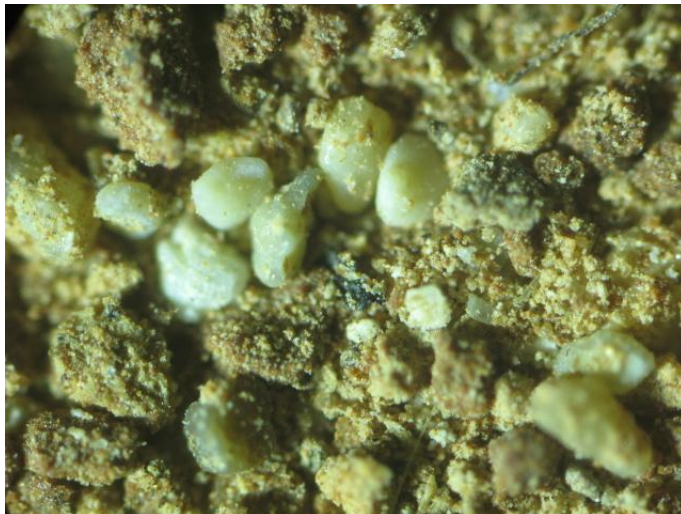
Sample **1** El Merj **6m**



Sample **1** El Merj **10 m**



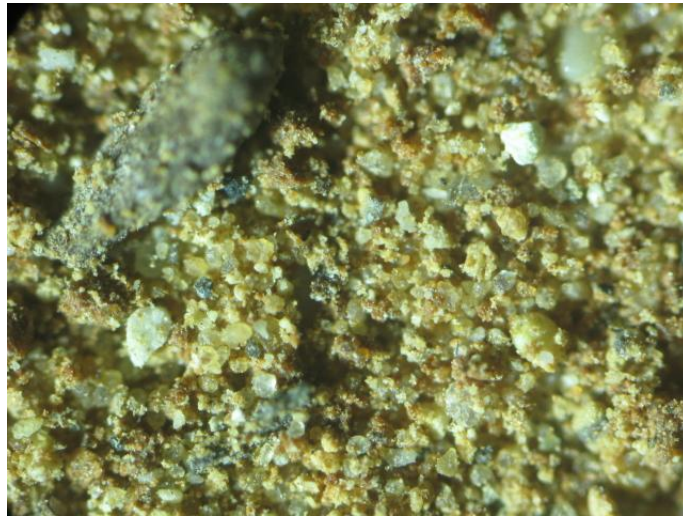
Sample 2 El Garieb 2 m



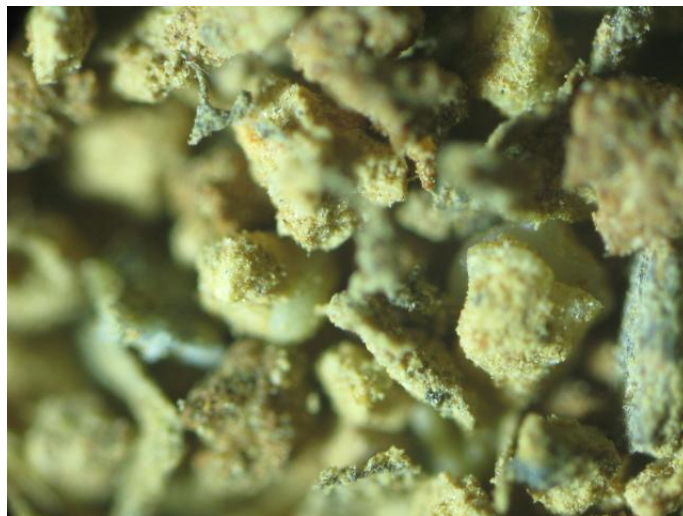
Sample 2 El Garieb 6 m



Sample 2 El Garieb 10 m



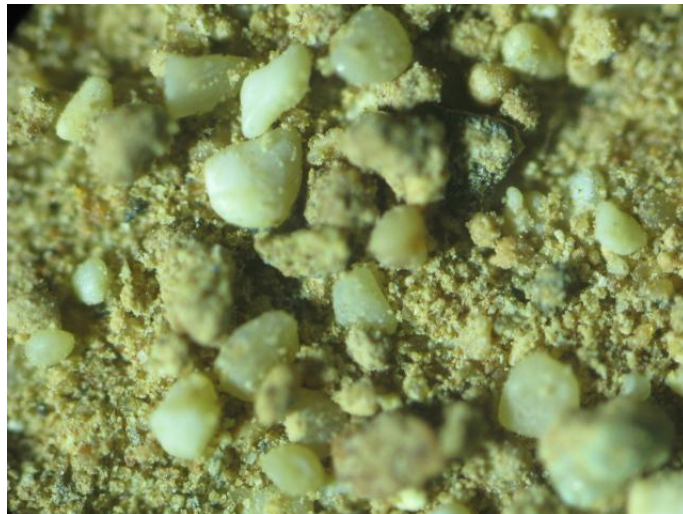
Sample 3 El Byada 2 m



Sample 3 El Byada 6 m



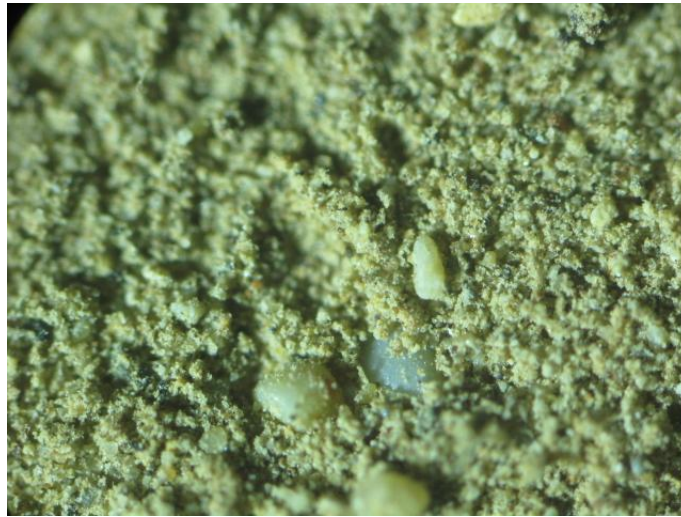
Sample 3 El Byada 10 m



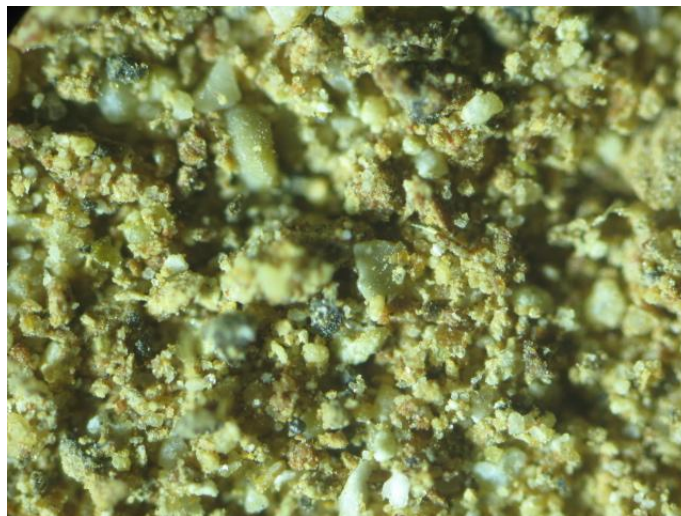
Sample 4 El Baida 2 m



Sample 4 El Baida 6 m



Sample 4 El Baida 10 m



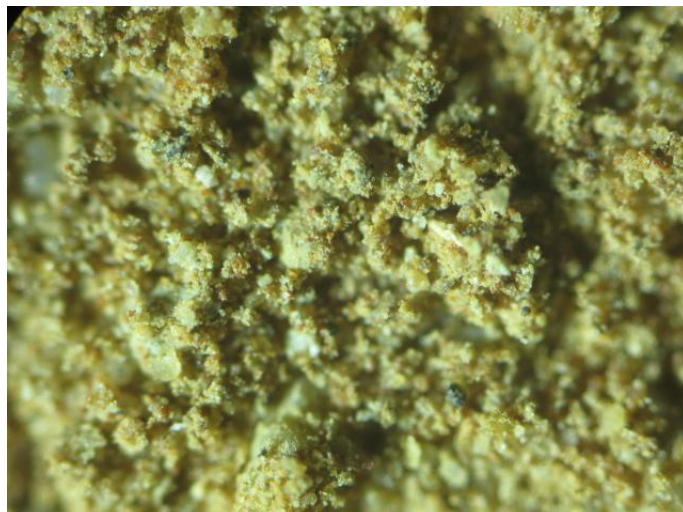
Sample 5 Lamuda 2 m



Sample 5 Lamluda 6 m



Sample 5 Lamluda 10 m



Sample 6 Derna 2 m



Sample 6 Derna 6 m



Sample 6 Derna 10 m



Sample 7 Um El Razum 2 m



Sample 7 Um El Razum 6 m



Sample 7 Um El Razum 10 m

Appendix(B)

*This matlab function is to computer the Attenuation Caused by Dust Storms at 6-7GH

*The program result is attenuation per km as function of the humidity.

*Program // Ahmed Amer Almasri

*Academy of Graduate Studies School of Engineering and Applied sciences.

*Department of Electrical and Electronic Engineering

* Attenuation Caused by Dust Storms at 6-7GH in (El-jabal Al akhdar) Area.

clc

v=input('V=') %relative volume occupied by particles.

per=input('per=') %complex permittivity of constituents.

[N,M]=size(v)

for n=1:N

a=0;

for m=1:M

a=a+v(n,m)*(per(m))^(1/3)

end

perm(n)=a^3

end

H=45.46:78.46;

u=mean(H);

for h=10:10:100;

e=5.5611+0.04*H-7.78*H.^2*(10^-4)+5.56*H.^3*(10^-6); % Real Part.

ee=-.2902+0.02*H-3.71*H.^2*(10^-4)+2.76*H.^3*(10^-6);% Imaginary Part.

f=7; % GHz.

lamda=(0.3)/f; % m.

c=2.3*(10^-5); % kg/m^3.

ho=2; % reference height (m).

segma=1385.5 ; % density (kg/m^3).

b=0.28 ;

Gamma=1.07 ;

```

vis=.1 ; % attenuation per km at reference height (dB/km).
v=c/(segma*((vis)^ Gamma)*(h/ho)^b);
alpha(2.46*v*ee*10^5)./(((e+2).^2+ee.^2)*lamda);
%subplot(1,2,1);
plot(H, alpha
xlabel('Humadity at height(5m)')
ylabel('attenuation per km at reference height(db/km)');grid on
hold on;
disp(h)
disp('  H(%)  Attenuation(dB/km)')
disp([H' alpha
end

```