Chapter One

Introduction

1.1Background Study:

Sound is one of the phenomena that humans and animals use for planning and understanding through the sense of hearing. Sound waves coming from a source, will pass through matter to the ear and brain, it turns into understandable information. Sound waves are able to move in several forms of materials such as solid bodies, liquids, gas, but it does not diffused in vacuum. The speed of sound waves varies according to the mediator in which they travelled and the temperature. It always becomes the highest speed in solid materials, less in liquids and much less in gas. Regarding the spread of the sound in the air, it depends on the pressure which means that sound speed reduces according to its height over the surface of the ground [1].

The sound spreads (diffuses) in different directions. The occurrence of sound depends on the vibrations of the source which works on generating sound waves and its spread depends on the source geometry. The sound can be gendered by mechanical or thermal means; it can also be generated by laser [2].

Laser is an electro-magnetic beam that has photons which are equal in frequency and are in phase. Laser waves overlap constructively to form a pulse of light with high energy and strong cohesion in terms of time and place. Laser is used in different domains and it is also used as an analytical tool that is classified into two groups [3].

1. Light detection method
2. Non-light detection method

Sound can be generated with laser when laser pulses are shed on metal or material which absorbs laser light and transforms it into oscillating kinetic energy for the atoms of the substance that collide with neighboring air atoms and makes them oscillate with the same laser frequency. The kinetic energy so produced is spread over the used material as sound waves [4].

Sound has many applications in different domains as explained below:

A team of scientists were able to make a device which uses the sound to penetrate the very part of vision in the mind. Some of the scientists have mentioned that the laser produced sounds can activate the vision spot in the mind of blind people and can then restore their vision. Sound is also used by physicians to detect what is happening in the body of patients and it is a mean of determining the position with echo. It sends sound waves in the body of patient and provides digital image of what happen [5].

1. 2 Research Problem:

The reason for conducting this research is that there are no enough researches in Sudan concerning sound production by laser.

1.3 Literature Review:

Many attempts were made to produce sound by using laser.

Markup Oksanen *et.al* (2011) were able to generate ultrasonic waves by using a laser pulses over a solid material and/or slices, they used diode laser with Nd: YAG laser with energy E = 2.5μJ, pulse duration = 60ns and thickness = 6.3mm. [6]

David Manuela and his co-workers in (2013) were able to generate sound waves using laser on graphite slice (graphite powder with epoxy material), they used Nd: YAG laser with E = 13μJ and pulse duration of 6ns [7]. Furthermore, **Manabu Enok and his group in (2007)** were also able to generate sound waves by applying laser pulse over heated material using aluminum A7075AL and Nd: YAG laser of energy E = 2 30 GW/Cm and thickness of 2-20mm[8].

In a study made by E.Fernadez and G.M.Bilmes in (2012) ultrasonic waves are produced by natural and induced cavitations in corn stems .This cavitations is induced by irradiating the bare stem of the plant with a continuous wave laser beam. Thus the source of ultrasonic acoustic emission is a transient cavity oscillation. [9]

1.4 The Objectives of the Research:

-The research aims at generating ultra- sound waves from some materials like plant leaves by using laser.

1.5 Thesis Layout:

The research consists of four chapters .Chapter one is the introduction, while chapter two is devoted for Theoretical background. Chapter three is material and method, chapter four is for results and discussion.

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Chapter Two

Theoretical Background

2-1 Introduction:

This chapter gives basic theoretical backgrounds; define sound waves, types of sound waves, the principle of photo acoustic spectroscopy, laser and its properties, laser matter interaction, absorption phenomenon and transmission of laser.

2-2 Sound Waves:

Sound waves are the almost common example of the longitudinal waves.They travel through any material medium with a speed that depends on the properties of the medium.

As the waves travel through air, the element of the air vibrate to produce changes in the density and pressure along the directions of the motion of the wave if the source of the sound waves vibrates sinusoidal, the pressure vibrates are also sinusoidal. The mathematical description of the sinusoidal sound waves is very similar to that of the sinusoidal string waves.

The two conditions that are required for the generation of a sound wave are vibratory disturbance and an elastic medium.

In the most general sense, sound is the propagation of density waves through some medium. In fact most homogeneous substances conduct sound. The density waves are typically created by vibration of some object immersed in the medium, such as a string, membrane or chamber. The waves propagate outwards from their point of origin. Sound waves are divided into three categories that cover different frequency ranges.

(1) Audible waves.

(2) Infrasonic waves.

(3) Ultrasonic waves.[10]

2-2-1 Ultrasonic:

Ultrasonic is simply sound that are above the frequency range of the human hearing. When a disturbance occurs at a portion in an elastic medium, it propagates through the medium in a finite time as a medical sound wave by the vibrations of molecules, atoms or any particles present.

Ultrasound waves or ultrasonic waves are the terms used to describe elastic waves with frequency greater than 20,000 Hz and normally exist in solids, liquids and gases.

Ultrasonic is define as acoustic waves at frequencies greater than 20khz and infrasound can interact with biological tissues by medical and thermal processes. Ultrasound has been widely used in medical practice for at least 50 years diagnostic examinations include obstetric, abdominal, pelvic and cardiac imaging. Therapeutic uses include promotion of bone and soft tissue regeneration, destruction of kidney stones and tumor ablation.

Industrial application include son chemistry, emulsification, welding, cleaning and nondestructive testing; and ultrasound has been used in consumer products such as range finders, movement detectors and pest repellents. Natural sources of ultrasound include bats, dolphins and other species that use it for echolocation.

Human exposures to ultrasound have not been well quantified except for those from medical devices. At high level of exposure ultrasound is capable of causing permanent damage to biological tissues, including teratogen effect, through heating, acoustic cavitations and radiation force.

At lower levels, such as those used for diagnostic cause heating beyond the normal physiological range. Studies of the effects of ultrasound in humans have largely concerned in utero exposure to diagnostic ultrasound there is no consistent evidence of any physiological or behavioral effect of acute exposure to infrasound in humans. There is, however little good quality research and interpretation is complicated because low frequency noise often includes audible as well as infrasonic frequencies.

Ultrasonic sensing techniques have become mature and are widely used in the various fields of the engineering and basic science. Actually, many types of conventional ultrasonic instruments, devices and sophisticate software are commercialized and used for both industrial and medical applications. One of advantages of ultrasound sensing is its outstanding capability to probe inside objectives nondestructively because ultrasound can propagate through any kinds of medium including solids, liquids, and gases except vacuum. In typical ultrasonic sensing the ultrasonic waves are travelling in a medium and often fussed on evaluating objects so that a useful information on the interaction of ultrasonic energy with the objects are acquired as ultrasonic signals that are wave forms variations with transit time. Such ultrasonic data provides the fundamental basic for describing the outputs of ultrasonic sensing and evaluating systems.

2-2-2 infrasonic waves:

Infrasonic or infrasound is widespread in modern society, being generated by cars, trains and many machines and applications. It is also produced by various natural phenomena, such as earthquakes and volcanic eruptions.

Health effect associated with exposure to infrasound are less well understood than for ultrasound. It is important to establish if exposure below hearing thresholds at these low frequencies can cause adverse effects. Infrasound and ultrasound refer to the three frequency bands in an overall spectrum of acoustic waves.

There is some confusion over the meaning of the terms infrasound. A popular interpretation is that is sound such low frequency that it is below the lower frequency limit of hearing generally taken to be around 20Hz. The international electro technical commission and the British standards institution define infrasound as acoustic oscillations whose frequency is below the low frequency limit of audible sound.

Infrasound may be generated through natural geological and weather processes or as the results of manmade activates, infrasound is created whenever a surface moves periodically with a motion that includes frequency components below 20Hz. Such sources may be natural or article and in both cases a wide range of know or putative sources have been reported.

A range of natural environmental source contributes to the complex infrasonic background. Measurements of background infrasound have shown that it’s acoustic pressure increase with decreasing frequency and most natural sources generate infrasound predominantly in the far infrasound.

The nuclear test ban treaty has created a need to monitor nuclear explosions and the associated infrasound forms one of the criteria for such monitoring. Similarly, other explosive devices cause infrasound, as do other ordinance and rocket launches.

The industrial sector, low frequency vibrated of some industrial machinery may cause infrasound, especially in association with air compressors and ventilation systems. The major application of ultrasound lies in medicine where, over a period of 50 years, diagnostic imaging has developed into a key modality for the identification and management of disease. Additionally almost all developing fetus within the UK are the subject of at least one obstetric examination. It has become well stabilized that ultrasound can have an effect on tissue primarily through its heating effect arising from absorption by tissue.

The potential of an ultrasonic field to disrupt or modify a material, primarily though acoustic cavitation, has found extensive and growing applications in cleaning, son chemistry and processing of water. Many of the sources of infrasound are natural, resulting from geological or meteorological conditions.

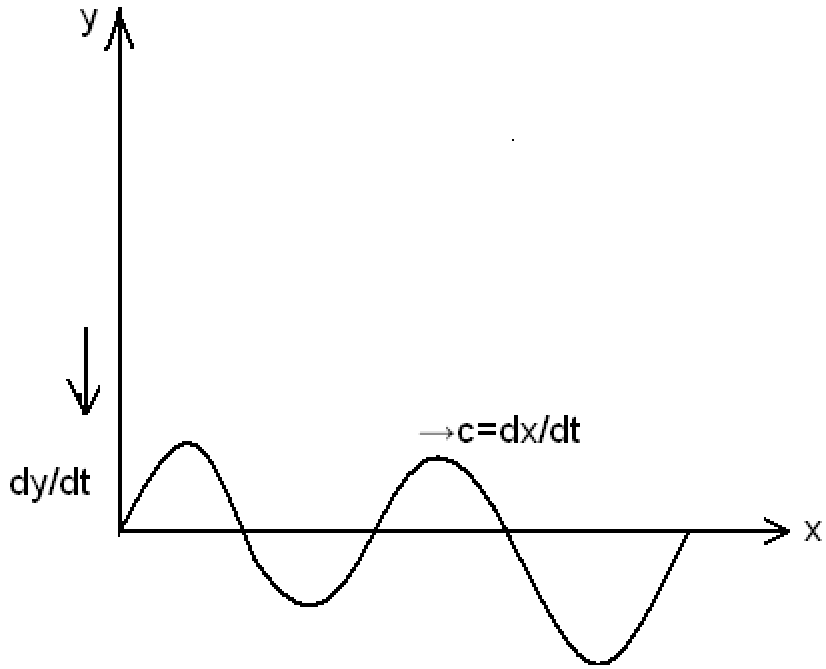
2-2-3 Audible waves:

Audible waves lie within the range of sensitivity of the human ear. The human ear responds to sounds with frequencies in the range from 20Hz to 20,000Hz. This is called the audible range of human ear; examples of vibrating sources that produce sound in the audible range of frequencies are drums, guitar strings, tuning fork, human vocal cords and diaphragms sequences are less than 20Hz are in the infrasonic range. Source of infrasonic waves include earthquakes, thunder, volcanoes and waves produced by vibrating heavy machinery.

Frequencies above 20,000Hz are in the ultrasonic range. The audible range of dogs, cats, moths and mice extends into ultrasound frequencies they can hear very high frequencies that human cannot.[11]

2.3 speed of sound:-

The speed of sound in the air is considered constant; it has scientific value, particularly $331 m/sec$ at zero temperature. The general equation of sound wave velocity can be derived from differential laws(see Fig 2.1)



Fig(2.1) sound wave

$$\frac{dy}{dt} = \frac{dy}{dx}\frac{dx}{dt} = C\frac{dy}{dx} \qquad (2.3.1)$$

$$\frac{d}{dt}\frac{dy}{dt} = C\frac{d}{dt}\frac{dy}{dx} \qquad (2.3.2)$$

So:

$$\frac{d}{dt}\frac{dy}{dt} = C\frac{d^2y}{dx^2}\frac{dx}{dt} = C^2\frac{d^2y}{dx^2} \qquad (2.3.3)$$

$$\frac{d^2y}{dt^2} = C^2\frac{d^2y}{dx^2} \qquad (2.3.4)$$

This is equation of wave moving in$x - direction$. Newton's laws of mechanic can be utilized to deduce the velocity of a transverse wave of stretched string, in a line element Δx with linear densityρ. Therefore there are two forces acting on the string.

The two forces are the tension T components. In the $x - direction$ the resultant net force is given by

$$F_x = Tcos(\theta + \Delta\theta) - Tcos\theta \qquad (2.3.5)$$

$$cos(\theta + \Delta\theta) \approx cos\theta = 1$$

Since the angles (θ and $\Delta\theta$) are very small then $sin\theta \approx \theta$

$$\sin(\theta + \Delta\theta) \approx \theta + \Delta\theta$$

On him other hand the resultant force in y axes is

$$F_y = Tsin(\theta + \Delta\theta) - Tsin\theta$$

$$= T(\theta + \Delta\theta)T(\theta) = T\Delta\theta \qquad (2.3.6)$$

But from second Newton law, the force is

$$F_y = am \qquad (2.3.7)$$

$$F_y = \rho\Delta x \frac{d^2y}{dt^2} \qquad (2.3.8)$$

Where m the mass m is given in terms of density ρ and length Δx by

$$m = \rho\Delta x \qquad (2.3.9)$$

$$a = \frac{d^2y}{dt^2} \qquad (2.3.10)$$

According to Newton equation (2.3.8) and (2.3.6)

$$\rho\Delta x \frac{d^2y}{dt^2} = T\Delta\theta \qquad (2.3.11)$$

Hence:

$$\frac{d^2y}{dt^2} = \frac{T}{\rho}\frac{\Delta\theta}{\Delta x} = \frac{T}{\rho}\frac{d\theta}{dx} \qquad (2.3.12)$$

But the slope is given by

$$\theta = tan\theta = \frac{dy}{dx} \qquad (2.3.13)$$

$$\frac{\Delta\theta}{\Delta x} = \frac{d\theta}{dx} = \frac{d^2y}{dx^2} \qquad (2.3.14)$$

From (2.3.12) we find:

$$\frac{d^2y}{dt^2} = \frac{T}{\rho}\frac{d^2y}{dx^2} \qquad (2.3.15)$$

Comparing equation (2.3.15) with equation (2.3.5) it is clear that speed of light c is equal to:

$$C^2 = \frac{T}{\rho} \qquad (2.3.16)$$

Hence

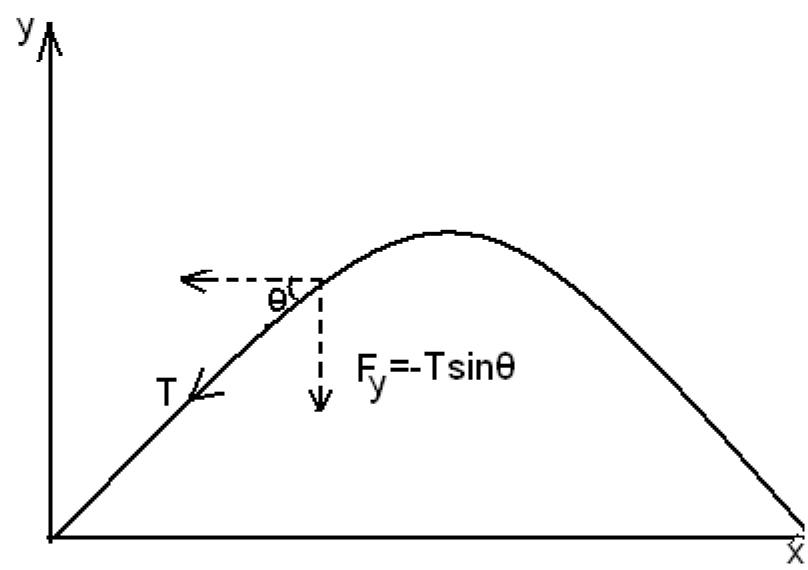
$$C = \sqrt{\frac{T}{\rho}} \qquad (2.3.17)$$

2.4 Sound Power:-

Consider a string of tension$T$. The tension component in the $y - direction$

$$F_y - Tsin\theta \qquad (2.4.1)$$

The displacement of string part ides is given by(see Fig(2.2)



Fig(2.2) sound power

$$y = Asin(\omega t - kx) = Asin\phi$$

$$\phi = \ \omega t - kx \qquad (2.4.2)$$

For vary small angle θ

$$sin\theta = tan\theta = \frac{dy}{dx} \qquad (2.4.3)$$

Inserting equation (2.4.3) in (2.4.1) yields

$$F_y = -T\frac{dy}{dx} \qquad (2.4.4)$$

But from equation (2.4.2)

$$\frac{dy}{dx} = -kAcos(\omega t - kx) = -\frac{\omega}{C}Acos\phi \qquad (2.4.5)$$

Where

$$k = \frac{2\pi}{\lambda} = \frac{2\pi f}{\lambda f} = \frac{\omega}{C} \qquad (2.4.6)$$

Thus according to equations (2.4.4) and (2.4.5)

$$F_y = -T\frac{dy}{dx} = \frac{\omega}{C}TAcos\phi \qquad (2.4.7)$$

Thus the work done to produce one wave in one cycles

$$W = \int F_y\, dy \qquad (2.4.8)$$

Using equation (2.4.2)

$$\frac{dy}{d\phi} = Acos\phi$$

Thus the work done is given by

$$dy = Acos\phi d\phi \qquad (2.4.9)$$

$$W = \frac{\omega}{C}TA^2\int_0^T cos^2\phi \qquad (2.4.10)$$

But

$$cos^2\phi = \frac{1}{2}(1 + cos2\phi) \qquad (2.4.11)$$

Hence

$$W = \frac{\omega}{C}\frac{TA^2}{2}\int_0^T (1 + cos\phi)d\phi$$

$$= \frac{\omega}{C}\frac{TA^2}{2}\left[\phi + \frac{sin2\phi}{2}\right]_0^T \qquad (2.4.12)$$

For simplicisf consider oscillation at$x = 0$, thus from (2.4.2)

$$\phi = \omega t \qquad (2.4.13)$$

Thus equation (2.4.12) given

$$W = \frac{\omega}{2C}TA^2\left[\omega t + \frac{sin\omega t}{2}\right]_0^T$$

$$= \frac{\omega}{2C}TA^2\left[\omega T + \frac{sin\omega T}{2} - 0 - \frac{sin0}{2}\right]_0^T$$

$$= \frac{\omega T}{2C}A^2\left[\omega\left(\frac{1}{f}\right) + 0 - 0 - 0\right]$$

$$\frac{\omega}{2C}A^2T\left[\frac{2\pi f}{f}\right] = \frac{\omega A^2 T}{2C}(2\pi) \qquad (2.4.14)$$

Where

$$T = periodic\ time = \frac{1}{f} = \frac{2\pi}{\omega} \qquad (2.4.15)$$

This is the work done to produce one wave. The power is defined as the energy produced in one second. Thus the power $P_r$is given to be:

$$P_r = energy\ to\ produce\ one\ wave \times\ number\ of\ waves\ in\ one\ second$$

$$= w \times f = \frac{\omega A^2 T}{2C} \times 2\pi f = \frac{\omega^2 A^2 T}{2C} \qquad (2.4.16)$$

But from equation (2.3.17)

$$T = C^2\rho \qquad (2.4.17)$$

The power of sound waves

$$P_r = \frac{\omega A^2 C\rho}{2} \qquad (2.4.18)$$

2.5 Sound Power and Intensity:-

The intensity I of sound wave is as the energy contained in the sound wave per second in the unit area which is perpendicular to the direction of the sound wave propagation:

$$I = \frac{power}{area}$$

$$I = \frac{P_r}{4\pi r^2} \qquad (2.5.1)$$

Using the expression of sound power in equation (2.4.18)

$$I = \frac{\omega A^2 C\rho}{8\pi r^2} \qquad (2.5.2)$$

2.6 Sound Impedance:-

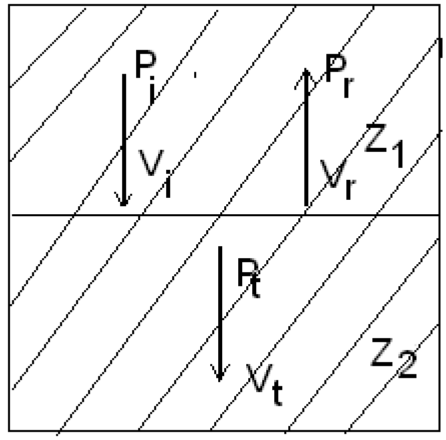
When the sound wave incident on an area between two different medium then its velocity and pressure will change $V_1 to V_2 and P_1 to P_2$ respectively:

The impedance Z is defined by(see Fig 2.3).

$$V = \frac{P}{Z} \qquad (2.6.1)$$

The incident wave given

$$V_i = \frac{P_i}{Z_1}$$



Fig(2.3) sound impedance

While the reflected one gives the wave transmitted satisfies also

$$V_t = \frac{P_t}{Z_2} \qquad (2.6.2)$$

The pressure obeys

$$P_i + P_r = P_t \qquad (2.6.3)$$

Since the displacements of incident, reflected transmitted waves are :

$$\begin{aligned} \check{S}_i &= S_i \sin(kx - \omega t) \\ \check{S}_r &= S_r \sin(kx - \omega t) \\ \check{S}_t &= S_t \sin(kx - \omega t) \end{aligned} \qquad (2.6.4)$$

So their corresponding velocities are given by:

$$\begin{aligned} V_i &= -\omega S_i \cos(kx - \omega t) \\ &= V_i \cos(kx - \omega t) \\ V_r &= -\omega S_r \cos(kx - \omega t) \\ &= -V_r \cos(kx - \omega t) \\ V_t &= -\omega S_t \cos(kx - \omega t) \\ &= V_t \cos(kx - \omega) \end{aligned} \qquad (2.6.5)$$

Then we find:

$$V_i = -\omega S_i$$
$$V_r = -\omega S_r \qquad (2..6)$$
$$V_t = -\omega S_t$$

Since the resultant displacement of transmitted wave is equal to the sum of incident and refloated wave displacement. So:

$$\check{S}_t = \check{S}_i + \check{S}_r \qquad (2.6.7)$$
$$S_t = S_i + S_r$$

Multiply the above equation by – ω yield:

$$-\omega S_t = \omega S_i - \omega S_r \qquad (2.6.8)$$
$$V_t = V_i + V_r$$

Substitute equation (2.6.2) in equation (2.6.8) given:

$$\frac{p_t}{z_2} = \frac{p_i}{z_1} - \frac{p_r}{z_1} \qquad (2.6.9)$$
$$P_i - P_r = \frac{z_1}{z_2} P_t$$

Using equation (2.6.3):

$$P_i + P_r = P_t$$

In (2.6.9) given:

$$P_i - P_r = \frac{z_1}{z_2}(P_i + P_r)$$

$$Z_2 P_i - Z_2 P_r = Z_1 P_i + Z_1 P_r$$

$$-(Z_1 + Z_2) P_r = (Z_1 - Z_2) P_i$$

$$P_i = \frac{Z_2 - Z_1}{Z_2 + Z_1} \qquad (2.6.10)$$

Thus using equation (2.6.10):

$$P_r = \frac{Z_2 - Z_1}{Z_2 + Z_1} P_i \qquad (2.6.11)$$

Inserting (2.6.11) in (2.6.3) yields:

$$P_t = P_r + P_i = \frac{Z_2 - Z_1}{Z_2 + Z_1} P_i + P_i = \left(\frac{2Z_2}{Z_2 + Z_1}\right) P_i$$

Hence

$$\frac{P_t}{P_i} = \frac{2Z_2}{Z_2 + Z_1}$$

2.7 Free and Forced Vibrations of Crystal:

Consider and the atom in a chain has displacementu_n. The forces on it by the a descent atoms are:

$$F_1 = C(u_{n-1} - u_n)$$

$$F_2 = C(u_{n+1} - u_n)$$

Thus:

$$-\omega^2 m = C(e^{ika} + e^{-ika} - 2)$$

$$-\omega^2 m = C(coska + isinka) + C(coska - isinka - 2)$$

$$sin^2 x = 2C(coska - 1) \qquad (2.7.1)$$

But: $C = constant$

$$cos2x = cos^2 x - sin^2 = 1 - 2sin^2 x$$

$$sin^2 x = \frac{1}{2}(1 - cos2x), = sin^2 x = \frac{1}{2}(cosx - 1)$$

$$-\omega^2 m = -4C\ sin^2 \frac{ka}{2}$$

Divided both side by $-m$we get

$$\omega^2 = \frac{4c}{m} sin^2 \frac{ka}{2}$$

$$\omega = \sqrt{\frac{c}{m}} sin \frac{ka}{2} \qquad (2.7.2\ )$$

When the distance between two atoms are very small:

$$a \to 0$$

$$ka \ll 1$$

$$sin\frac{ka}{2} \approx \frac{ka}{2}$$

The frequency became is:

$$\omega = \sqrt{\frac{c}{m}}\frac{ka}{2}$$

When crystals are forced to vibrate by the force F:

$$F = F_0 e^{i\omega t} e^{ikna} \qquad (2.7.3)$$

The equation of motion thus becomes

$$m\ddot{U}_n = -(F_1 F_2) - F$$

Substituting for F, F_1, F_2, u_n yield

$$-\omega^2 mA = C\left(e^{ika} + e^{-ika} - 2\right)A - F_0$$

$$-\omega^2 mA = 2C(1 - coska + a) - F_0$$

$$-\omega^2 A = \frac{2C}{m}\left(2sin^2\frac{ka}{2}\right)A + \frac{F_0}{m}$$

Setting

$$\omega_0^2 = \frac{4C}{m} sin^2 \frac{ka}{2} \qquad (2.7.4)$$

Where $\omega_0$is the natural frequency equation became

$$(\omega^2 - \omega_0^2)A = \frac{F_0}{m} \qquad (2.7.5)$$

Thus the amplitude became

$$A = \frac{F_0}{m(\omega^2 - \omega_0^2)} \qquad (2.7.6)$$

$$T = \frac{1}{2}mV^2 = \frac{1}{2}m[un]^2$$

$$un = Ae^{i\omega t}e^{ikna}$$

$$|un| = A$$

$$T = \frac{1}{2}m\omega^2 A^2 = \frac{m\omega^2 F_0^2}{2m^2\left(\omega^2-\omega_0^2\right)^2} \qquad (2.7.7)$$

$$V = -\int Cun\, dun = -\frac{1}{2}cu_n^2$$

$$V = -\frac{1}{2}c|un|^2 = \frac{1}{2}CA^2$$

$$E = T + V = \frac{1}{2}m\omega^2 A^2 - \frac{1}{2}CA^2$$

$$= \frac{1}{2}(m\omega^2 - C)A^2$$

$$E = \frac{(m\omega^2-C)F_0^2}{2m^2(\omega^2-\omega_0)^2(\omega^2-\omega_0)^2} \qquad (2.7.8)$$

2.8 The vibration Energy:-

According to the lows of quantum mechanics the vibrational energy by:

$$E_n\left(n+\frac{1}{2}\right)\hbar\omega \qquad (2.8.1)$$

The quantum number n is given by $n ==$,1,2,3, ...

The vibrational energy takes the form:

$$E = \frac{\hbar^2 L(L+1)}{2I} \qquad (2.8.2)$$

The orbital quantum number:

$$L = 0,1,2,3, \ldots.$$

$I \equiv moment\ of\ Inertia$[12]

2-9 Principles of photo acoustic spectroscopy:

The phenomenon of the generation of sound when a material is illuminated with nonstationary light is called the photoacoustic effect which discovered by

Alexander Graham Bell in 1880.Later Bell showed that material exposed the non visible portions of the solar spectrum (IRand UV) can also produce sounds. The application of the PA effect for spectroscopic purposes is called photo acoustic spectroscopy.

Photo acoustic spectroscopy is the measurement of the effect of absorbed electromagnetic energy on matter by means of acoustic detection.

A photo acoustic spectrum of a sample can be recorded by measuring the sound at different wavelengths. This spectrum can be used to identify the absorbing components of the sample[13].

Features of photo acoustic

Photoacoustic (PA) has proven to be one of the best analytical techniques for the identification and quantitative determination of trace constituents in gas mixtures, and the main features are:

- Multi-compound detection.
- High sensitivity foe detection of very low concentration (ppt).
- High selectivity to differentiate different species present in multi-components mixture.
- A large dynamic range to monitor (ppt) and high concentration (ppm) with single instrument.
- Good temporal resolution to enable on line monitoring.
- Portability for in situ measurement.

2-10 Laser and its properties:

Laser is shortcut for (Light Amplification by Stimulated Emission of Radiation) laser is a powerful source of light having extraordinary properties which are not found in the normal light sources like tungsten lamps, mercury lamps, etc. the unique property of the laser is that its light waves travel very long distances with the very little divergence.

In case of conventional source of light, the light is emitted in a jumble of separate waves that cancel each other at random, and hence can travel very short distance only. It is this coherency that makes all the difference to make the laser light so narrow, so powerful and so easy to focus on a given object. The light with such qualities is not found in nature.

A light degree of directionality and monochromatic is also associated with these light beams. Therefore, in laser beam the light waves not only are in the same phase but also have the same color (wavelength) throughout their journey. The beam of the ordinary light spreads out very quickly.

Another remarkable feature of laser is the concentration of the energy to extremely high intensities, the intensity remaining almost constant over long distances because of low divergence. The unique characteristics of laser have made it an important tool in various applications. Laser has several properties incopass the following:

2.10.1. Coherence:

Coherence is another unusual property of laser light that influences possible applications. The concept of coherence is linked to the orderliness of the light Coherence refers to the how much in step or in phase various portions of a single laser beam are. The closeness in phase of various portions of the laser frequency bandwidth is referred to as temporal or longitudinal coherence. The closeness in phase of different spatial portions of beam after the beam has propagated a certain distance is referred to as spatial or transverse coherence. This phased relationship determines how readily the various portions of the beam can interfere with each other.

2.10.2-linewidth

Laser light is highly monochromatic that is it has very narrow spectral width. The spectral width is greater than zero , typically it is much less than that of conventional light sources .the narrow spectral line width is one of the most important feature of the lasers early calculation indicated that the line width could be a small fraction of 1HZof course , most practical lasers have much greater line width.

2.10.3-collimation

One of the most important characteristics of laser radiation is the highly collimated directional nature of the beam collimation allows the energy carried by a laser beam . Collimated light is light in which all of the light rays or waves are traveling in a specific direction and hence they are all parallel to each other. Lasers produce the most collimated light of any type of light source.

2.10.4.Intensity and Radiance:

Intensity is a measure of the amount of energy that can be applied to a specific region within a given amount of time. It is one of the two most important parameters in using the laser for materials processing application such as welding, cutting, heat treating, ablating and drilling.

Radiance is a parameter that includes the beam intensity and takes into account the beam divergence angle. Radiance becomes useful when a beam must be propagated over reasonable distance before it is used.

2.10.5. Focusability:

Many applications of lasers involve their ability to be focused to very small spot size[14.15.16]

2-11 Laser matter interaction:

Lasers provide the ability to accurately deliver large amounts of energy into confined regions of a material in order to achieve a desired response.

The electromagnetic radiation can interact only with the electrons of the atoms of the material because the much heavier nuclei are not able to follow the high frequencies of visible radiation.

While core electrons have binding energies usually far higher than those provided by visible light and binding electrons interact only weakly with the electromagnetic wave below resonance, free electrons are accelerated and can absorb energy. This energy is then either re emitted or transferred to the lattice.

The optical properties of an isotropic material with characteristic configuration length much shorter than the wave length of the light can be described macroscopically. The common classification of material in metals, semiconductor and insulators is done according to their band structure [17].

2-11-1 Absorption of laser:

The absorption phenomenon or a process in which atoms, molecules or ions enter some bulk phase gas, liquid or solid material. Since molecule undergoing absorption are taken up by the volume, not by the surface.

A more general term is sorption, which convers absorption is a condition in which something takes in another substance. The process of absorption means that a substance captures and transforms energy.

The absorbent distributes the material it captures throughout whole and adsorbent only distributes it through the surface. The absorption coefficient, which can be derived from the material dielectric function and conductivity, determines the absorption of light as a function of depth.

However, the specific mechanisms by which the absorption occurs will depend on the type of martial. In general, photons will couple into the available electronic or vibrational states in the material depending on the photon energy.

In insulators and semiconductors, the absorption of laser light predominantly occurs through resonant excitations such as transitions of valence band electrons to the condition band or within band [18.19].

2.11.2: Transmission of laser:

Transmittance is the relationship between the amount of light that was transmitted to the detector once it has passed through the sample(I) and the original amount of light(I_o).This is expressed in the following formula:

$$T = I/I_o \qquad (2.11.2.1)$$

Where I is the intensity of incident light beam and I_o is the intensity of the light coming out of source, if half the light is transmitted, we can say that the solution has 50% transmittance:

$$T\ \% = (I/I_o) \times 100\% \qquad (2.11.2.2)$$

The relationship between transmittance (T) and absorbance (A) can be expressed by the following:

$$A = \mathrm{Log}\ (I/\ T\ \ ) \qquad (2.11.2.3)$$

$$A = \mathrm{Log}\ (100/T\ [\%]) = 2 - \mathrm{Log}T\ [\%]\ [20] \qquad (2.11.2.4)$$

Chapter Three

Material and Methods

3.1 Introduction

Ultrasound plays an important role in modern technology .It is widely used in medicine and industry. This wide variety of applications motivates to do this work. The plant leaves from different trees were irradiated by laser beam. The emitted sound waves were detected by an ultrasound detector to see the frequency emitted.

3.2 Materials and Equipment:

The material used is 6 samples of different plant leaves which live under sun light and 6 samples in shadow were selected. The samples specifications are shown in table(3.1).

Table (3.1) plant type and number of samples:

Plant type	number of samples in sun	number of samples in shadow
Bougainvillea spp1	2	1
Citrus Sinesis	3	8
Canna Indica	5	4
Ixora Coccinia	7	6
Bougainvillea spp2	10	9
Citrus Paradisi	12	11

The equipments :

1. Laser source:

The laser source is continuous nitrogen laser, having power of (4.4 mW) and wave length of 450 nm.

2. Ultrasound detector:

The ultrasound detector consists of the following components:

a. Peizo electric transducer: Is a peizo electric crystal.

b. Digital processing unit:

Is a computer having a programmer that can enable to display sound spectrum on the screen

3.3 Methodology:

The sound frequency emitted by leaves was determined, the following steps were made as shown in Fig(3.1).

1. Each leaves exposed for 0.0125 seconds to laser beam.

The photons of laser were absorbed by leaves atoms which cause them to vibrate, the vibrating atoms emit ultrasound waves to the surrounding. Thus it passes through air to the detector.

2. The emitted sound and produced an electric pulse was receipted by the transducer unit.

3. The digital unit convert the suitable pulse was converted to a sound spectra relating ultrasound wave length to sound intensity by digital unit as shown in figures (4.1.), (4.2), …., and (4.24).

Fig (3.1): setup of experiment

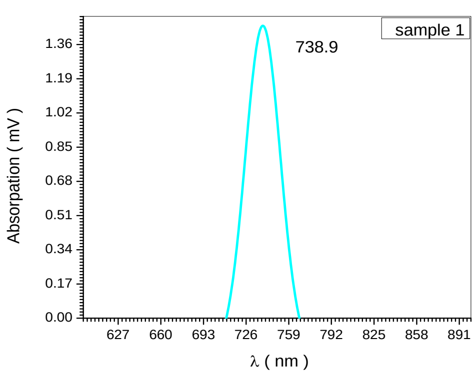
Chapter Four

Result and Discussion

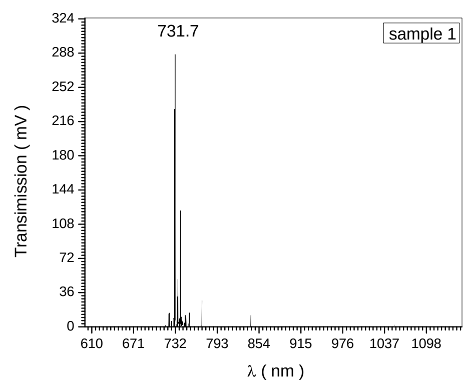
4.1 Results:

12 plants leaves samples belonging to six species namely Bougainvillea spp1, Citrus Sinesis,Canna Indica,Ixora Coccinia,Bougainvillea spp2 and Citrus Paradisi were selected and sub-catogrisel into two groups. One group was exposed to direct sun light and the second group was put in shadow.

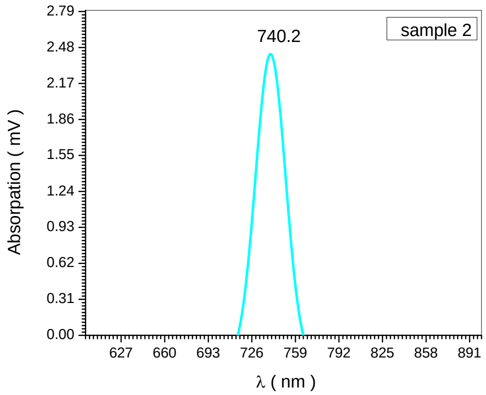
Nitrogen Laser was applied on both groups to study the plants samples abilities to generate sound wave. The results obtained from the two groups are shown in the figures below:



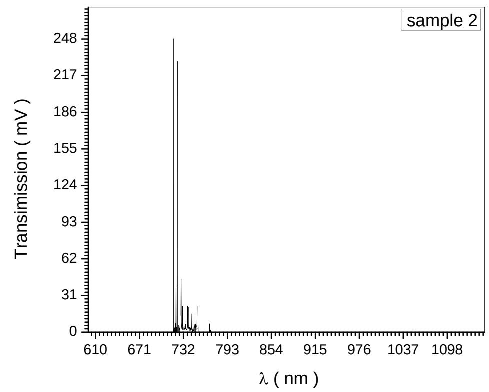
Fig(4.1 Absorption of Bougainvillea Spp1 in shadow



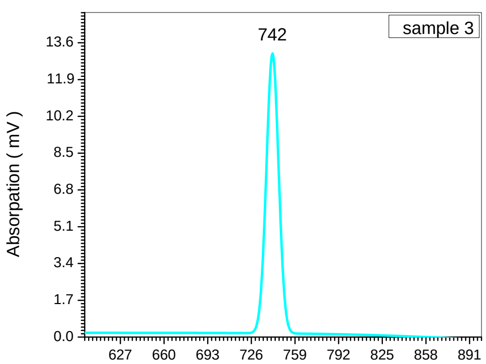
Fig(4.2) Transmission of Bougainvillea Spp1 in shadow



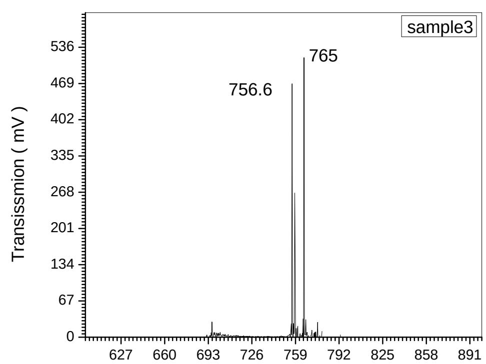
Fig(4.3) Absorption of Bougainvillea Spp1 in sun



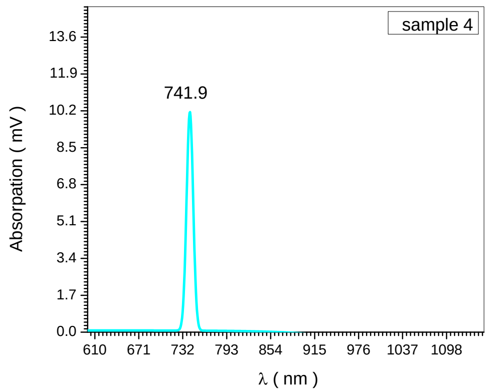
Fig(4.4) Transmission of Bougainvillea Spp1 in sun



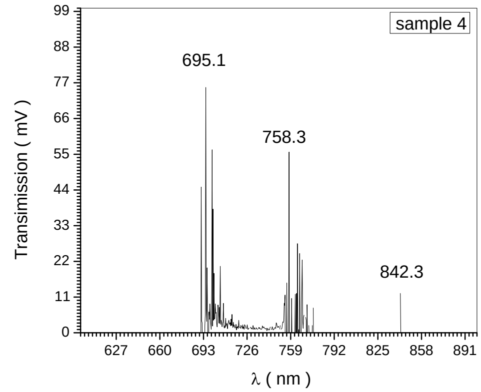
Fig(4.5) Absorption of Citrus Sinesis in sun



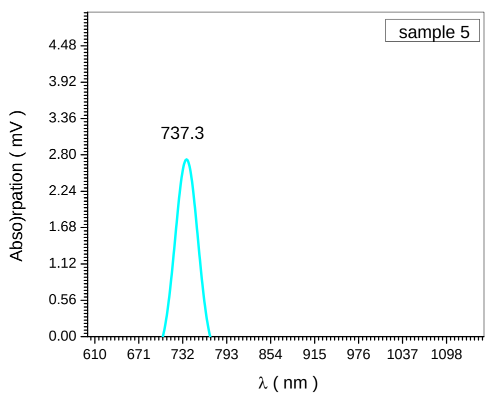
Fig(46) Transmission of Citrus Sinesis in sun



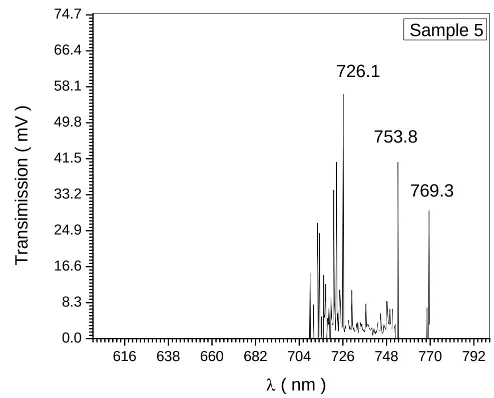
Fig(47) Absorption of Canna Indica in shadow



Fig(4.8) Transmission of Canna Indica in shadow



Fig(4.9 Absorption of Canna Indica in sun



Fig(4.10) Transmission of Canna Indica in sun

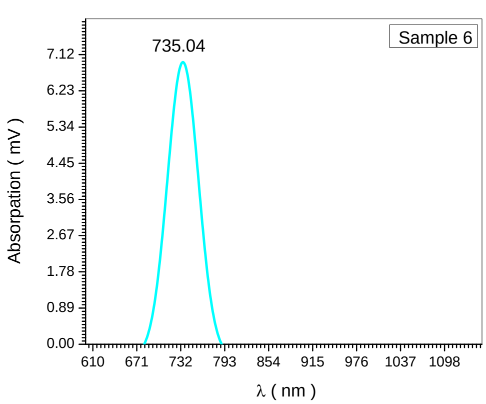


Fig (4 .11) Absorption of Ixora Coccinia in shadow

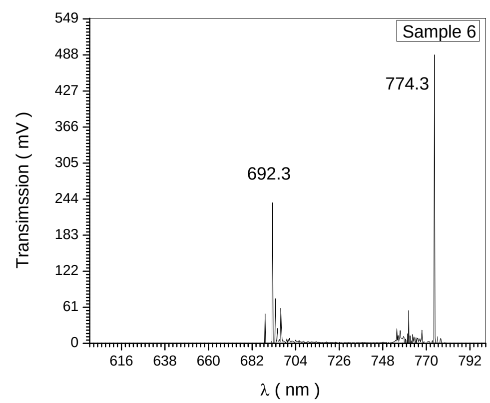


Fig (4.12) Transmission of Ixora Coccinia in shadow

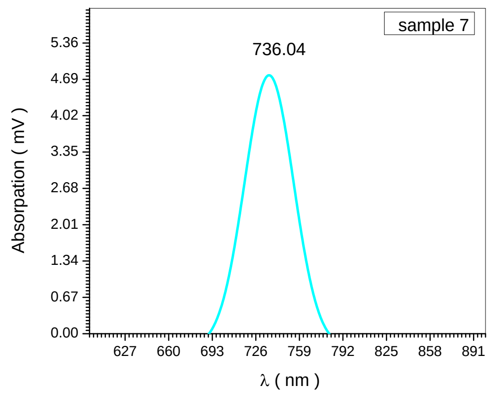


Fig (4.13) Absorption of Ixora Coccinia in sun

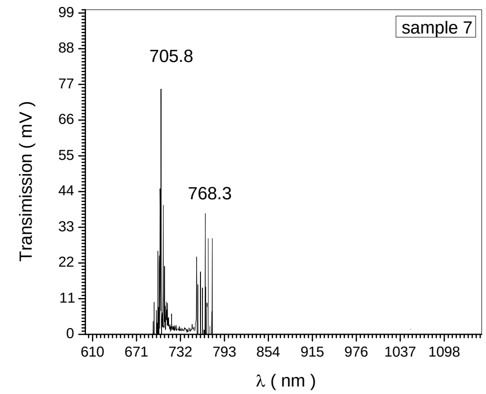


Fig (4.14) Transmission of Ixora Coccinia in sun

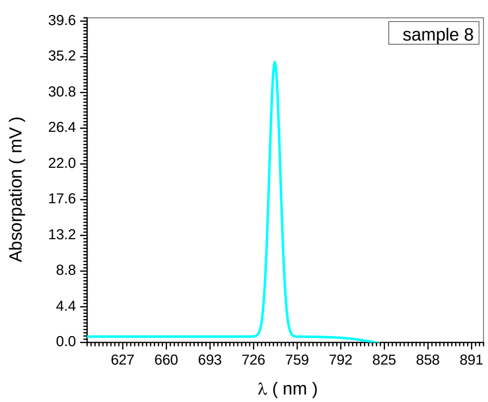


Fig (4.15) Absorption of Ixora Coccinia in shadow

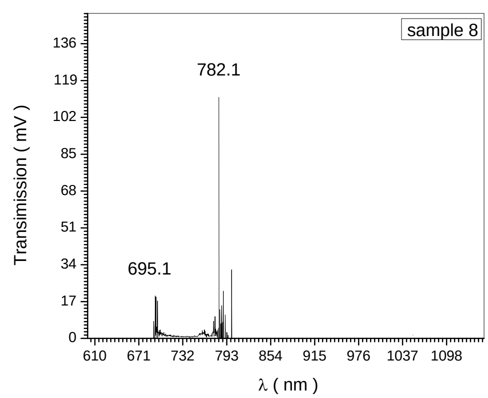


Fig (4.16) Transmission of Citrus Sinesis in shadow

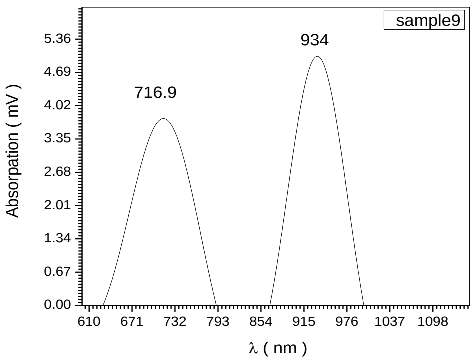


Fig (4.17) Absorption of Bougainvillea Spp2 in shadow

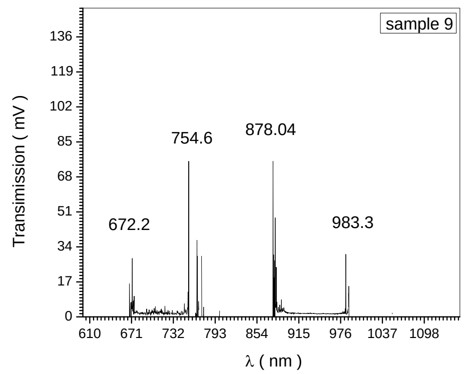


Fig (4.18) Transmission of Bougainvillea Spp2 in shadow

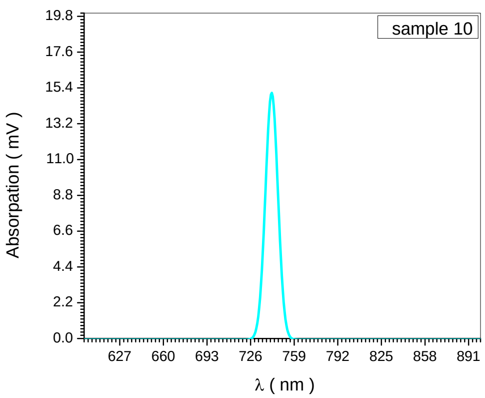


Fig (4.19) Absorption of Bougainvillea Spp2 in sun

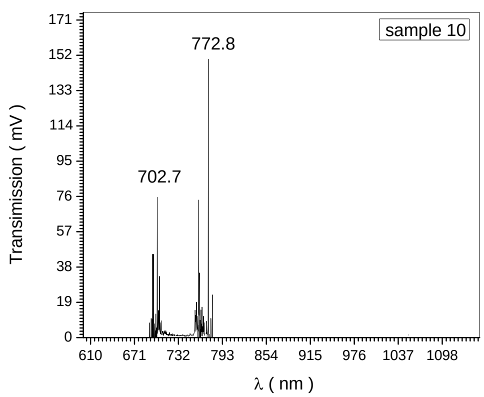
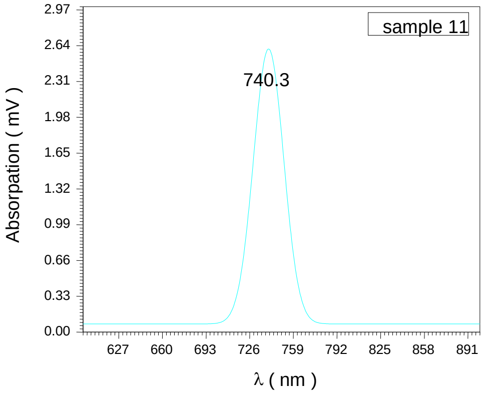


Fig (4.20) Transmission of Bougainvillea Spp2 in sun



Fig(4.21) Absorption of Citrus Paradisi in shadow

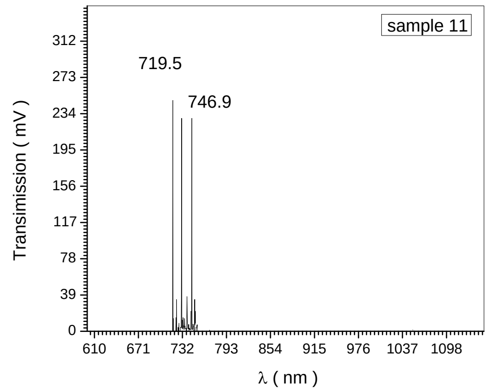


Fig (4.22) Transmission of Citrus Paradisi in shadow

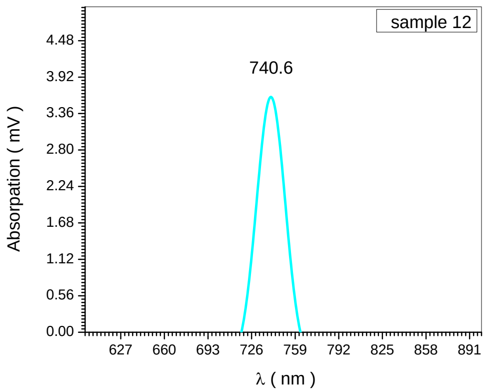


Fig (4.23) Absorption of Citrus Paradisi in sun

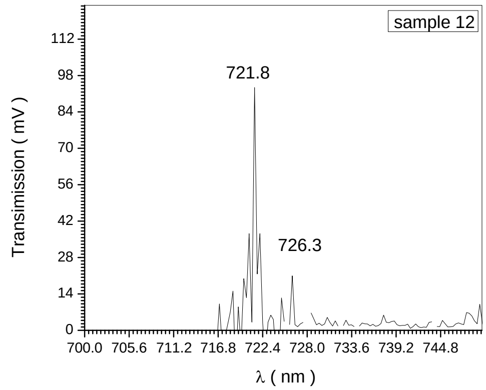


Fig (4.24) Transmission of Citrus in sun

Table (4.2) Show the absorption and transmission peaks of the samples.

Sample	Absorption Peak (nm)	Transmission Peak (nm)
1	738.9	731.7
2	740.2	717.9
3	742	756.6 - 765
4	741.9	695.1 - 758.3 - 842.3
5	737.3	726.1 - 753.8 - 769.3
6	735.04	692.3 - 774.3
7	736.04	705.8 - 768.3
8	741	695.1 - 782.1
9	716.9 - 934	672.2 - 754.6 - 878.04 - 983.3
10	702.7	702.7 - 772.8
11	740.3	719.5 - 746.9
12	740.6	721.8 - 726.3

4.2 Discussion:

The spectrum of plant leaves shows high frequency ultrasound waves produced. Fig(4.1)for Bougainvillea spp1 in shadow the frequency produced shows absorption peaks at 738.9nm.Fig(4.2)for transmission of Bougainvillea spp1 in shadow the peaks at 731.7nm.In Fig (4.3) Bougainvillea spp1 in sun light the absorption peak at 740.2nm.Fig(4.4) Bougainvillea spp1in sun light the transmission peaks at 717.9 nm . Fig(4.5) Citrus Sinesis in sun light the absorption peak at 742nm. Fig(4.6) Citrus Sinesis in sun light the transmission peaks at756.6,765nm.In Fig (4.7)Canna Indica in shadow the absorption peak at 741.9nm.In Fig (4.8)Canna Indica in shadow the transmission peaks at 695.1,758.3 and 842.3nm.Fig (4.9) Canna Indica in sun light the absorption peak at 737.3nm.Fig(4.10) Canna Indica in sun light the transmission peaks at 726.1,753.8 and 769.3nm.Fig (4.11) Ixora Coccinia in shadow the absorption peak at

737.04nm.Fig (4.12) Ixora Coccinia in shadow the transmission peaks at 692.3 and 774.3nm. Fig (4.13) Ixora Coccinia in sun light absorption peak at 736.04nm.Fig (4.14) Ixora Coccinia in sun light transmission peaks at 705.8nm and 768.3nm.Fig (4.15) Citrus Sines is in shadow absorption peak at 741.7 nm. Fig (4.16) Citrus Sines is in shadow transmission peaks at 695.1 nm and 782.1 nm. Fig (4.17) Bougainvillea spp2 in shadow absorption peak at 716.9 nm and 934 nm . Fig (4.18) Bougainvillea spp2 in shadow transmission peaks at 672.2, 754.6, 878.04and983.3nm. Fig (4.19) Bougainvillea spp2 in sun light absorption peak at 702.7 nm .Fig(4.20) Bougainvillea spp2 in sun light absorption peak at 702.7and772.8nm. Fig (4.21) Citrus Paradisi in shadow absorption peak at 740.3nm. Fig (4.22) Citrus Paradisi in shadow transmission peaks at 719.5 and 746.9nm.Fif (4.23) Citrus Paradisi in sun light absorption peak at 740.6nm. Fig (4.24) Citrus Paradisi in sun light transmission peaks at 721.8 and 726.6nm.It is very interesting to note that all these emitted sound waves are much higher than 20000Hz.

Comparison was held between the frequencies obtained by the plant lsaves in the study is shown in fig. ( ) and fig.()

The result revealed that the highest frequency in the group of plant leaves exposed to sun light was shown by Ixora Coccinia followed by Canna Indica and the lowest frequency shown by Citrus Sinesis and Bougainvillea Spp2.

For the group grown in shadow, the highest frequency was given by BougainvilleaSpp2 followed by Ixora Coccinia. The lowest frequency which showed two frequencies in shadow. Citrus Sinesis, Canna Indica and Citrus Paradisi gave almost the same frequencies in shadow.

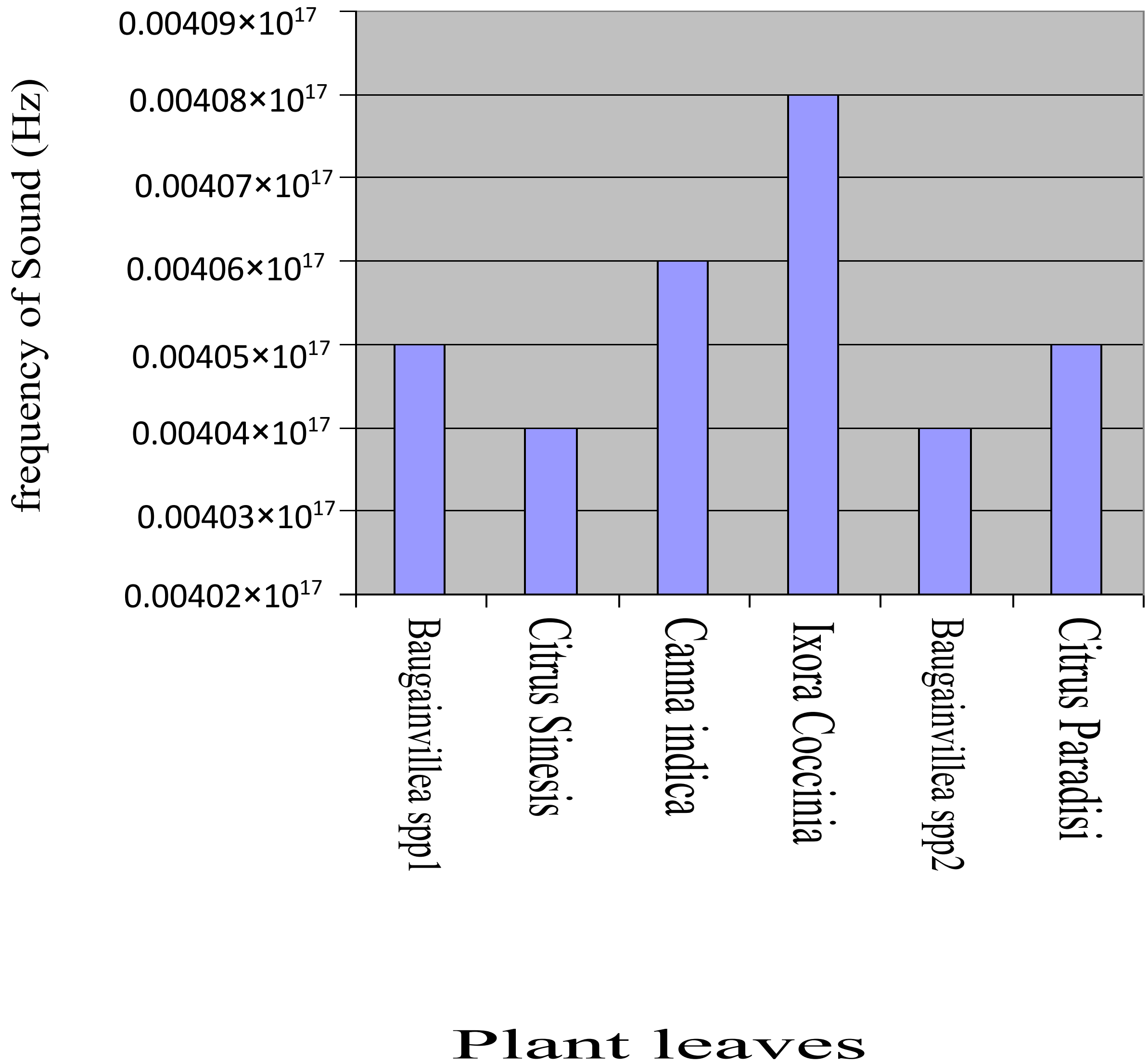


Fig (4.25)shows comparison between plant leaves in Sun and the frequencies obtained

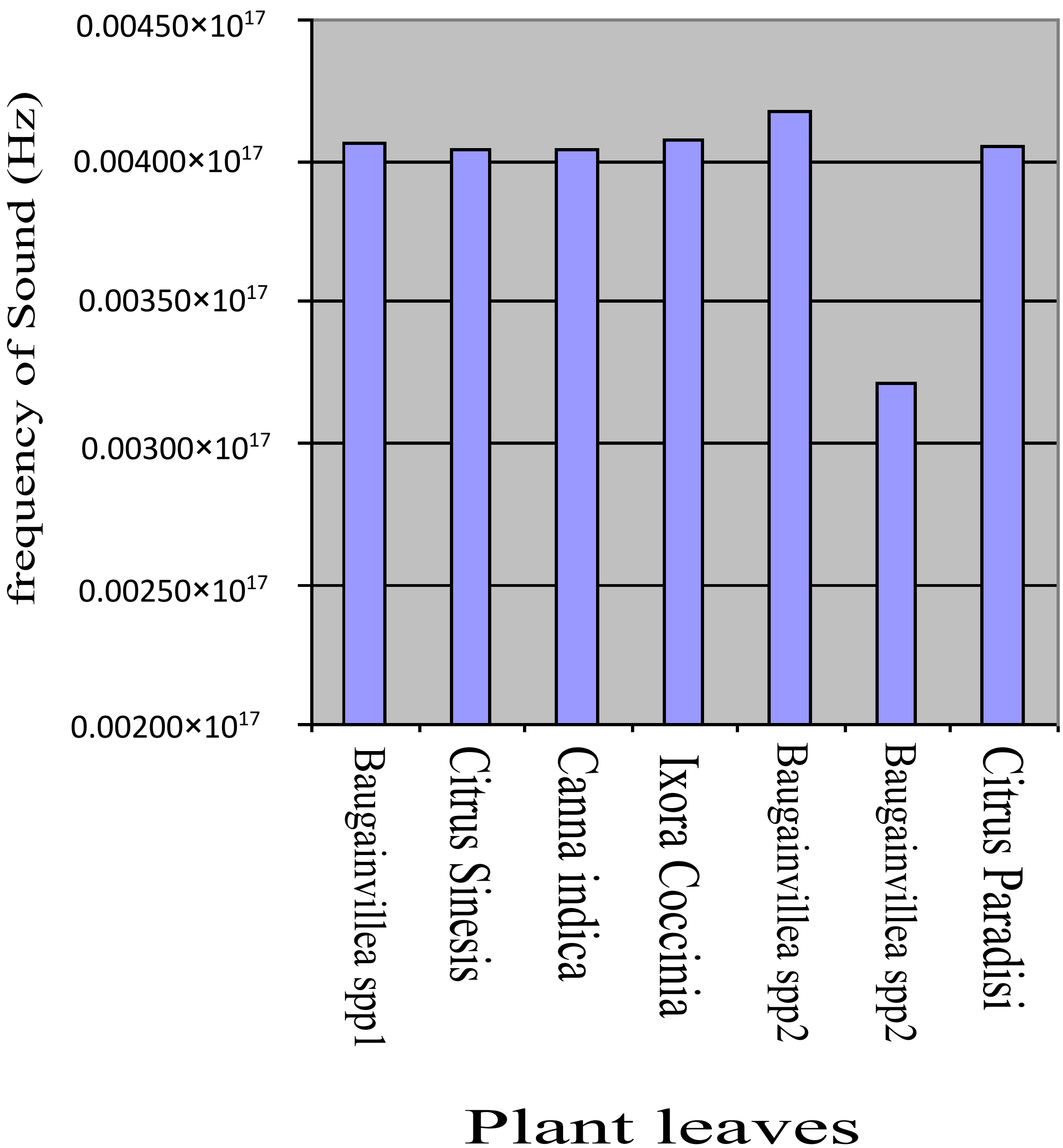


Fig (4.26)shows comparison between plant leaves in Shadow and the frequencies obtained

4.3. Conclusion:

This work shows that Nitrogen laser can cause some plant leaves to produce a high frequency ultrasound waves.

Future Work:

1. One need to see the different between sound waves produced by pulsed and continuous laser.

2. Further studies were needed to see the production of sound waves by solids, liquids and gases.

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