SOME STUDIES ON LIGHT AND ENVIRONMENT

A thesis submitted towards partial fulfilment
of the requirements for the degree of

Master of Technology (Illumination Technology and Design)

Submitted by
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CONTENTS

CHAPTER # 1

PREAMBLE

CHAPTER 1 – PREAMBLE

Light energy can be defined as a form of electromagnetic radiation which is emitted by hot objects like Sun, lamps, LASER, etc. A beam of light contains set of particles called photons. Photons corresponding to longer wavelengths, i.e., with lower frequencies carry less energy than photons from short wavelength areas. The light energy between 400 and 700nm region are visible to human eyes and it is also the range that is utilized by plants for photosynthesis.

Plants absorb the light spectrum in an almost similar range as the human eye, but unlike humans, they absorb mostly red and blue light. One of the main molecules allowing plants to absorb light energy and use that energy to transform water and carbon dioxide into oxygen and complex organic molecules is called chlorophyll and the process is known as photosynthesis. Photosynthesis can also be termed as a process in which plants containing chlorophyll convert the carbon dioxide into sugars in the presence of sunlight by a set of redox reactions. There are two main types of chlorophyll found in the plants are chlorophyll a and b, which differ from each other slightly due to light absorption curves. The small difference allows them to catch different wavelengths. Chlorophyll absorbs mainly red and blue light and reflects green wavelengths. However, there are some other accessory pigments apart from chlorophyll that are carotenoids, xanthophylls, etc. Phenolic substance that (flavonoids, anthocyanins, flavones, flavonoids, etc.) capture wavelength other than only red and blue spectrum [1].

Plant photoreceptors are usually triggered by the different range of UV radiation that earth receives from the sun. The different range of UV radiation are shown in the table below.

Table 1.1 Range of different UV radiation, visible radiation and optical radiation in tabular form

RADIATION TYPE	WAVELENGTH RANGE
OPTICAL RADIATION	100 nm – 1mm
Ultra Violet (UV) Radiation UV - C UV - B UV - A	100 nm – 380 nm 100 nm – 280 nm 280 nm – 315 nm 315 nm – 380 nm
Visible Radiation (Light)	380 nm – 780 nm

There are also other particles absorbing light known as photoreceptors. The main photo receptor groups are phytochromes, phototropins and cryptochromes. All photoreceptors capture light in different wavelength region and are responsible for different response in plants. Some of the photoreceptors are described below:

•Cryptochromes – They capture external stimuli related to light and control the internal clock of plants. They are also related to different morphological responses, such as inhibition of stem elongation, expansion of cotyledons, production of anthocyanins and photoperiodic flowering. Cryptochromes absorb UVA (ultraviolet), blue, and green wavelengths.

•Phytochromes – They are important for flowering induction and seed development. They are also useful in stem elongation and leaf expansion. They also help plants to activate shade avoidance syndromes while growing. The responses regulated by phytochromes are mediated by the ratio of surrounding red and far-red light, which affects the photo stationary state of the phytochromes molecule [1].

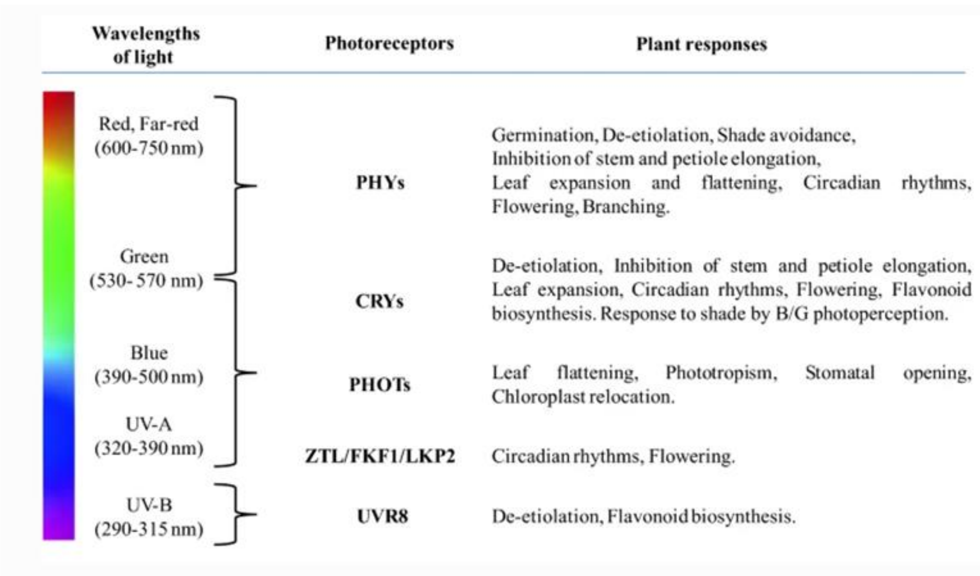

Fig 1.1 Different wavelength range and photoreceptors with plant response comparison [2].

Effect of different wavelengths on plant growth and development:

- Large dose of UV is harmful to plants, since it degrades DNA. However small dose of UV-A and UV-B is often necessary to increase the stress tolerance of plants. Usually plant grown under ultraviolet light have thick leaves and stems and short internodes.

- Blue light is perceived by the blue light photoreceptors such as phototropins and cryptochromes. Phototropin mediates stomatal regulation and plant movement towards light. Cryptochromes regulate many photomorphism mechanisms such as inhibition of stem elongation. Plants grown under blue light have short inter nodes.

- Green light is partially sensed by phototropins and cryptochromes. Green light contains valuable information about plant's surrounding, guiding the growth accordingly.

- Red light is perceived by phytochromes sense both red and far red light and are the main regulators of shade avoidance syndrome. High far red irradiation causes premature flower production in many species and stem elongation.

The quality of light is more important than the quantity of the light that is falling on the plant. A good quality light having all the necessary wavelengths that are required to trigger the photoreceptors is important for good growth of any plant. That is one of the reasons why despite having high amount of sunlight in many places decent growth of plant is not found. This has to be kept in mind while doing plantation under artificial lighting systems. While choosing artificial lamp for plantation the UV emitting content of the lamp used must be known to ensure proper growth. If artificial light is the only source of light for growing plants, the quality of light or wavelength must be considered [1].

UV radiations coming from the sun are harmful to humans, though earth atmosphere and ozone layer act as a UV barrier but with ozone layer depletion occuring at an unstoppable rate the UV radiations are causing different issue to humans. It has been studied and observed that exposure to ultraviolet (UV) radiation – from the sun, tanning beds, lamps or booths – is the main cause of skin cancer, accounting for around 86% of non-melanoma and 90% of melanoma skin cancers. In addition, excessive UV exposure can increase the risk of eye diseases, such as cataract and eye cancers.

However, UVA has a long wavelength and accounts for 95% of solar UV radiation that reaches the earth's surface, while UVB – with a middle-range wavelength – accounts for the remainder. Both UVA and UVB radiation can damage the skin by penetrating its layers and destroying cellular DNA. UVA radiation tends to penetrate deeper layers of skin, known as the dermis, aging the skin cells and causing wrinkles. UVB radiation is the main cause of skin reddening or sunburn, as it damages the outer layers of the skin, known as the epidermis [3].

Excessive UV exposure can cause genetic mutations that can lead to the development of skin cancer. The browning of the skin, or a tan, is the skin's way of trying to stop further DNA damage from occurring.

Thus, proper experimentation and observation of UV radiation that is coming from the sun to earth surface is necessary. Also, to find out how plants react with the UV radiation and whether it can provide sufficient protection to the humans. Hence, encouraging people to plant more and more trees to protect themselves from the harmful UV radiations.

CHAPTER # 2

AIMS AND OBJECTIVES OF THE STUDIES

CHAPTER 2 - AIMS AND OBJECTIVES OF THE STUDIES

Earth rotate around the sun in an elliptical path inclined in certain angles. Due to diurnal motion of earth as well as the diangle motion of the earth, the relative position of the sun and the earth seasonal variation occurs with climatic changes. In this work there was an intend to trace the diurnal as well as annual variation of sunlight upon the earth. So, in the first step of the experimentation measurement of the intensity of solar irradiance, colour of the sunlight in CCT and UV content, in various weather condition were taken.

It is a well-known fact that when a person dips inside the saline water, i.e., sea water then instantly the complexion of their skin becomes dark due to the growth of melanin in their skin which we have generally found when a person is exposed to sunlight melanin content of the skin increases due to presence of UV radiation in the sun radiation.

In the next experimental study there was an aim to try to simulate the sea water and observe that whether the salty water absorbs the UV radiation from the sunlight. Details of the experiment has been described here in after, [Chapter no. – 4, Clause- 4.2.].

It has been observed from earlier studies that colour of light likely to have certain effect on the growth rate of the plant. The same has been analysed through the experimentation upon a set of zinnia plant as illustrated here in after.

From our earlier studies it was seen that the trees are good natural device for absorption of UV, specially UV-A. It has been experimented earlier that content of UV-A is predominantly much more than that of UV-B and UV-C. Experimentation has been carried out with a set of china rose plant with different colours of petals such as red, white and sandal at various state, i.e., without flower, with only buds and at full bloom to analyse the energy requirement, absorption of UV from the atmosphere at various stages.

Thus, through the above experimentations there was an intend to compile a small fraction of experimental study on the light and environment.

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CHAPTER # 3

EXPERIMENTAL SETUP AND METHODOLOGY ADOPTED

CHAPTER -3:

EXPERIMENTAL SETUP AND METHODOLOGY ADOPTED

3.1. INSTRUMENTS USED IN THE EXPERIMENTS

3.1.1. SOLAR POWER METER

In all the experimental study **Metravi make 207 Solar Power / Sunlight Meter** was used for measuring the solar irradiance from a particular location and point at the premises of School of Illumination Science, Engineering and Design. The Solar Power Meter was positioned normally with the sunlight falling on the surface and measurements were taken. This was done to understand the solar power characteristic over the location Jadavpur, Kolkata, West Bengal.

Fig 3.1: Metravi make 207 Solar Power Meter

It was also used in the experiment where the UV value of salt water mimicking the sea water was taken for finding the exact value of solar power during that instant when the UV value reading was taken.

Solar irradiance is the power per unit area received from the Sun in the form of electromagnetic radiation as measured in the wavelength range of the measuring instrument. The solar irradiance is measured in watt per square metre (W/m^2).

A portable Pyranometer or a Solar Power Meter is a light sensor made of silicon that measures the power per area incident on the sensor. This measurement is known as the solar irradiance – “a measurement of power (rate of energy/sunlight) per unit area”.

The Solar Power Meter used to do such measurements should have high-precision, be reliable and ideally have an extendable cable so that the sunlight intensity readings can also be taken from a bit of distance, such that any shadows don’t interfere with the readings. The instrument should preferably have a rugged body so that it can be used consistently on the field. It should also be stable for long use and have a long-lasting battery. A rapid response instrument will ensure quick and efficient assessment of optimal locations and angles for solar panel placements [4].

The Metravi 207 Solar Power Meter helps to measure the sunlight intensity falling on solar panels or on any surface exposed to sunlight, using a sensitive silicon sensor.

It measures up to $1999W/m^2$ or 634BTU /(Ft^2*hr) irradiance. With high accuracy and fast Response, it also features Data Hold function. It takes direct readings and no adjustment of the instrument is needed. Measuring unit is selectable between W/m^2 and BTU/(Ft^2*hr) and it also features Max / Min value recording. It comes with a clear and bright 3-1/2 digits LCD, measurement resolution of $1W/m^2$/1 BTU (Ft^2*hr) and high accuracy of $\pm 10W/m^2$ [5].

The 207 Solar Power Meter provides a fast, accurate, handy solution for sunlight measurement, enabling solar professionals and technicians to provide exceptional services to their customers while installing and commissioning solar panel power projects. The $\pm 10\ W/m^2$ of reading ±5 digits accuracy gives the confidence that the readings are accurate for installations.

3.1.2. UV RADIOMETER

There are several radiometer models on the market that provide various types of information. A radiometer should be chosen to fit the application and the information required. Functions range from simple intensity and simple dosage to sophisticated mapping devices. Which wavelength to measure is also a matter of choice. Over 90% of the UV radiometers in market measure in the UVA spectrum (320nm-390nm). This is because the majority of the chemistry responds to this band of energy. If it is desirable to measure other parts of the UV spectrum, a radiometer is available to do so. Certain chemistry is formulated to respond to different wavelengths of light and for different applications. Radiometers are also configured for use in different applications.

This instrument was used in the experiments as an UV meter, Everfine make U20 UV radiometer comes with UV-A measuring sensor for taking record of the UV-A radiation that is coming through the atmosphere to earth surface as a part of understanding solar radiation characteristic. Thus, **Everfine make U20 UV radiometer** has been used here. This instrument was also used in the experiment where there was a need to understand the UV interaction with hibiscus plant and artificial lamp. UV-A readings of different artificial lamps using this instrument with hibiscus plants at different stages such as flowering stage, budding stage, without flower and bud stage, etc. were taken. This instrument was also used in calculating UV-A content of sea water by mimicking 1litre of tap water with 35gms of salt in it. UV-A readings were taken over the salt water tray to understand the characteristic of UV-A in sea water and over normal tap water.

This instrument has UV-A sensor which came with the company package. It can be connected with a specific usb cable given by the manufacturer and after that if we turn on the instrument with the power on/off switch then it automatically starts taking the reading of UV-A as the sensor given by the manufacturer is specifically for UV-A. There is a provision for lighting up the screen with backlight when taking readings during the dark room experiment such as while doing the hibiscus plant experiment that is conducted in the dark room as artificial light UV consumption is tested.

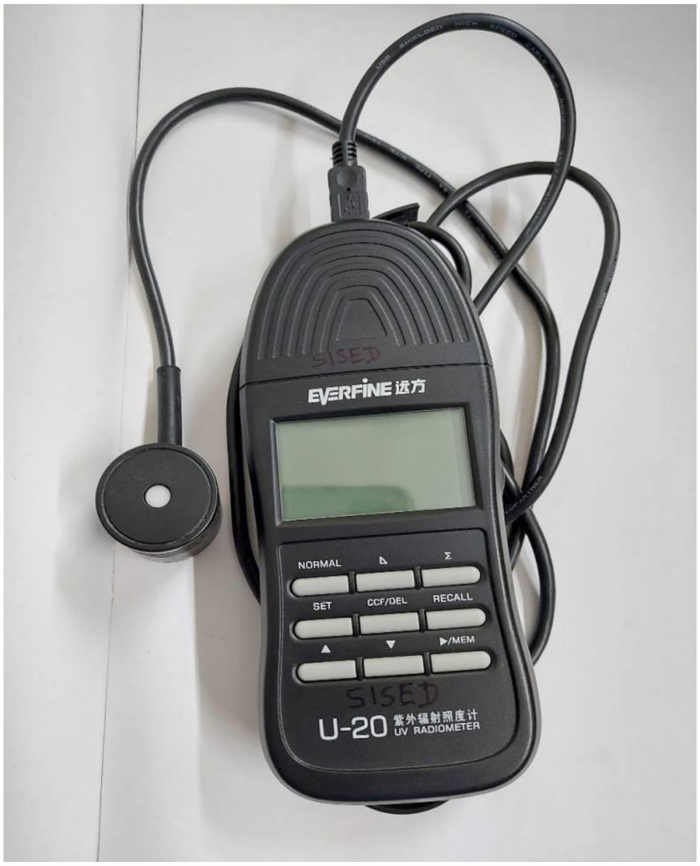

Fig 3.2 Everfine make U20 UV Radiometer

The device features compact structure, good stability and high stray light control ability. It is widely used in ultraviolet light, disinfection and sterilization, light medical treatment, aging, detection, photolithography, light curing, breeding, plant cultivation, and UV index evaluation. Users can select the corresponding UV detectors for different response wavebands according to actual application. Range: UVA sensor 320nm-390nm [6].

3.1.3. CHROMAMETER

In this experimental study **Konica Minolta CL-200A chromameter** has been used for measuring the illuminance value with unit lux and Correlated Colour Temperature (CCT) value with unit kelvin(K).

Fig3.3 Konica Minolta make Chromameter Cl-200A

The CL-200A chromameter is the successor to the CL-200. It can measure the color temperature, illuminance, chromaticity, excitation purity, and dominant wavelength of various light sources. The CL-200A was designed to be a highly effective tool for measuring the color temperature of white LEDs, a task that has been very difficult in the past. The CL-200A is able to do this due to its ability to measure the chromaticity from the phosphor and also inspect light quality output of the final assembled white LED. It can be also used to measure the illuminance and CCT values of sunlight for understanding solar radiation properties [7].

For understanding the solar characteristics, this instrument was used to take the readings of different illuminance values and different correlated color temperature values, at the instant when readings of solar irradiance value and UV-A values were taken to observe the solar characteristic during daytime.

This instrument was also used for observing the CCT value while taking readings for the salt water experiment to observe if there are any changes in the CCT value of sunlight due to salt/sea water.

3.2. METHODOLOGY ADOPTED

3.2.1. CASE STUDY - 1: TO STUDY THE CHARACTERISTIC OF SUNLIGHT ON PLANET EARTH.

The Sun is the primary source of energy to Earth with light and heat. The Sun produces immense amount of energy through thermonuclear fusion, a process by which small atoms like hydrogen fuse to form large atoms in the synthesis of Helium. When this fusion happens, the combined masses of the fusing atoms are more than the mass of the atom they form and some of this extra mass of the fusing atoms are converted to energy. Since the Sun and Earth position is not fixed due to Semi Elliptical shape of the orbit the intensity of Sun beam towards a position of earth varies with following various factors:

i) latitude and longitude of the place

ii) calendar day of year, duration of Sun light

iii) time of the day, i.e., light beam angle from the Sun

iv) angle of inclination of the plane of receipt, etc.

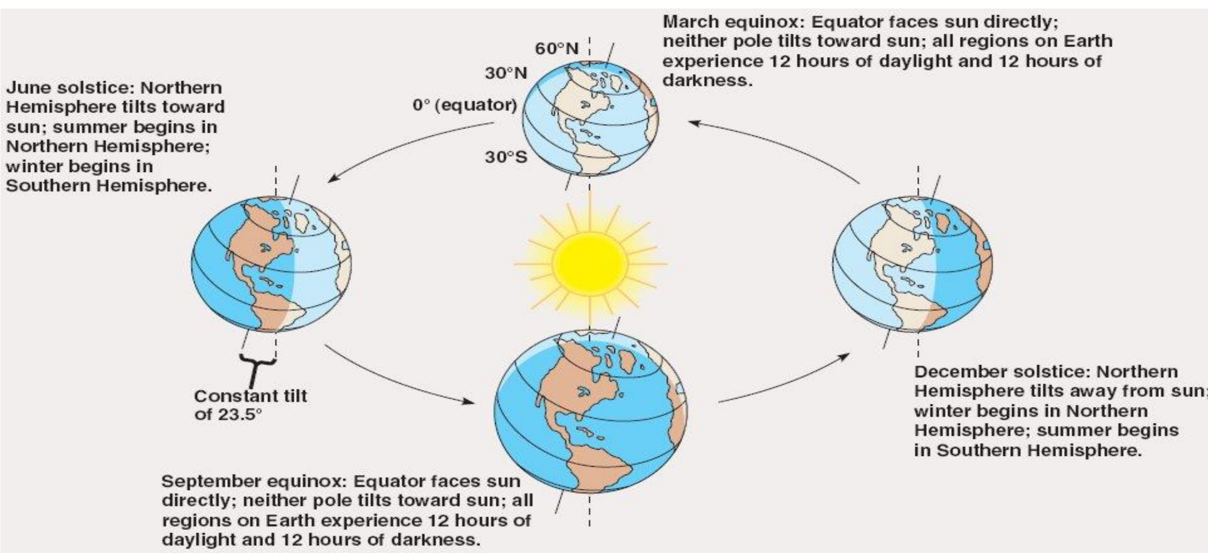

Fig 3.4: Seasonal variation of the earth and the sun due to semi elliptical orbit of the earth [8].

Space-based observations of solar irradiance started in 1978. These measurements show that the solar constant is not constant. It varies on many time scales, including the 11-year sunspot solar cycle. When going further back in time, one has to rely on irradiance reconstructions, using sunspots for the past 400 years or cosmogenic radionuclides for going back 10,000 years. Such reconstructions have been done. These studies show that in addition to the solar irradiance variation with the solar cycle (the (Schwabe) cycle), the solar activity varies with longer cycles, such as the proposed 88 year (Gleisberg cycle), 208 year (DeVries cycle) and 1,000 year (Eddy cycle).

Total Solar Irradiance (TSI) – The amount of solar radiation received at the top of Earth's atmosphere – has been measured since 1978 by a series of overlapping NASA and ESA (European) satellite experiments to be 1.361 kilowatts per square meter (kW/m^2). TSI observations are continuing today with the ACRIMSAT/ACRIM3, SOHO/VIRGO and SORCE/TIM satellite experiments. Variation of TSI has been discovered on many timescales including the solar magnetic cycle and many shorter periodic cycles. TSI provides the energy that drives Earth's climate, so continuation of the TSI time series database is critical to understanding the role of solar variability in climate change [9].

For utilization of solar energy, people are more interested in the energy received at the earth's surface than in the extra- terrestrial energy and for this reason experiment was performed on the solar characteristic of sun falling on the Jadavpur location of Kolkata city, a point in the premise of school of illumination science, engineering and design was taken and the experiment was done. The sensor of the measuring instruments was pointed perpendicular to the solar radiation falling on the earth surface and readings were taken for many days. Successive readings were taken to observe the different values of solar properties such as irradiance value, UV-A value, CCT and illuminance value for different time of the day and at different weather condition throughout the day.

3.2.2. CASE STUDY - 2: TO STUDY AND COMPARE UV-A ON NORMAL TAP WATER, SEA WATER AND EARTH SURFACE.

Everyone is exposed to UV radiation from the sun and an increasing number of people are exposed to artificial sources used in industry, commerce and recreation. The sun is by far the strongest source of ultraviolet radiation in our environment. Solar emissions include visible light, heat and ultraviolet (UV) radiation. Just as visible light consists of different colours that become apparent in a rainbow, the UV radiation spectrum is divided into three regions called UVA, UVB and UVC. As sunlight passes through the atmosphere, all UVC and most UVB is absorbed by ozone, water vapour, oxygen and carbon dioxide. UVA is not filtered as significantly by the atmosphere [10].

UV radiation from the sun radiation has always played important roles in our environment, and affects nearly all living organisms. Biological actions and reactions of many kinds have evolved to deal with it. Yet UV radiation at different wavelengths differs in its effects, and one have to live with the harmful effects as well as the helpful ones. Radiation at longer UV wavelengths of 320-400 nm, called UV-A, plays a helpful and essential role in formation of Vitamin D by the skin, and plays a harmful role in that it causes sunburn on human skin and cataracts in our eyes [11].

Since UVA mostly cause issue on human skin and eyes, it is necessary to observe and test at what location the content of UVA is most. So, in this experiment a location with normal earth surface is taken where the UVA content is measured along with the solar intensity. This experiment will mimic normal earth surface at different location and will help to understand different UVA values. Then normal tap water is taken which will mimic any freshwater bodies like pond or lake so that UVA content around them can be measured. Then experiment was finally done on salt water which is expected to mimic the sea water condition. This was done to understand the UVA level near sea sides and on sea water, so that one can observe UV condition in coastal regions.

3.2.3. CASE STUDY- 3: TO STUDY THE GROWTH CHARACTERISTIC OF ZINNIA PLANT UNDER SUNLIGHT.

The sun is a renewable energy source that plays a pivotal role in our everyday life, from warming the earth to the water cycle, it is an essential part of our daily existence. Plants need three basic things to live: sunlight, water, and carbon dioxide. Through a process called photosynthesis, the plants use the energy from the sun to convert carbon dioxide, soil nutrients, and water into food. The leaves of the plant take in the most sunlight. The broad, flattened surfaces of leaves create extensive surface area for collecting sunlight, and this is what leaves are designed to do. The stems of plants create a rigid structure to keep leaves upright and allow for the most exposure to sunlight. The cells of plants contain the green pigment chlorophyll and organelles called chloroplasts, which are key ingredients for the process of photosynthesis. Light energy is captured by chlorophyll, and this energy is used to convert carbon dioxide and water into sugars and oxygen. In other words, plants use energy they collect from the sun to produce food for themselves – and a byproduct of this process is that they create oxygen for humans and other animals to breathe [12].

Daylight has all visible spectrum and ultraviolet spectrum of wavelength in itself which help the plants to trigger its variety of photoreceptors that has individual function.

i. 280 nm UVC ultraviolet light -

The visible wavelength of 280 nm is also referred to as the UVC ultraviolet range and can be toxic to plants. If correctly used at the right levels, this light can be used to minimize the growth of bacteria or mould and can be used to manage the growth and development of different parts of the plant, such as branches and heights.

ii. 280-315 nm UVB ultraviolet light -

UVB ultraviolet light sits in the 280-315 nm and can negatively impact on plant colour.

iii. 315-400 nm UVA and near-ultraviolet light -

UVA and near ultraviolet light from 315-400 nm are considered one of the longest UV light wavelengths and it can enhance plant pigmentation, thicken leaves and may even help manage insect populations. It’s at this wavelength that chlorophyll absorption starts and light is used to manage plant architecture and long-term health.

iv. 440-500 nm Blue light

From 440-500 nm this light plays a major role in plant quality and is needed to ensure that plant development is optimal, and optimized. This light, when used in conjunction with the other wavelengths ensure that the plant’s roots are developed properly, that growth is managed correctly, and that chlorophyll absorption is maximized. At this light wavelength leafy plants really do benefit the most.

v. 510-610 nm Green light

510-610 nm, the green light, helps with photosynthesis and can help with improvements in plant size, weight and growth factors.

vi. 610-700 nm Yellow-red light

610-700 nm is considered the optimum wavelength for chlorophyll absorption, germination and flower or bud development. This wavelength is perfect for flowering and for photoperiodism. This light, when balanced with blue and green light, can translate into perfect plant growth and optimized yield.

vii. 700-800 nm Far-red light

700-800 nm increases the rate of photosynthesis and recent research has found that this can promote extension growth and has myriad benefits. This prove to be one of the most interesting wavelengths recently and can be supported by the intelligent use of LED grow lights [13].

Experiment was done to understand how a specific plant zinnia grow under direct sunlight beam which will get all the necessary wavelength of light spectrum and compare it with zinnia plant grown with diffused sunlight beam which will not get all the wavelength of light spectrum but will get mostly spectrum of light that is found after afternoon period when the sun moves toward western side. This comparison will help us better understand and prove the theories that how different spectrum of daylight can promote or effect growth of a plant.

3.2.4. CASE STUDY- 4: TO STUDY THE HIBISCUS ROSA-SINENSIS (CHINA ROSE) PLANT UV-A ABSORPTION UNDER DIFFERENT ARTIFICIAL LAMP

When one is striving for the perfect environment for growing plants, one of the main concerns is UV (ultraviolet) light. The UV radiation is found naturally in the sunlight so all plants that grow outside in the natural environment already experience its benefits. The question arises whether plants that grow indoors absorb UV light from the artificial lamps, and the answer is not as simple as yes or no. It's a more complicated issue that requires a little more in-depth knowledge and practical experiment to find out what really happens.

The most important thing to keep in mind about UV light is that there are total three different kinds of UV lights and only two are experimentally proven effective to use when growing plants:

i) UV-A and UV-B are both useful for plants. The benefits of both kinds of ultraviolet light exposure include deeper and richer plant color, increased in the nutrient content of fruits and vegetables, and strong defense system against harmful fungus. UV-A is okay in any quantity, but too much UV-B can also damage a plant's DNA.

ii) UV-C is extremely harmful to plants and even a little amount of exposure to it can permanently damage a plant's DNA.

UV-C light must be avoided at all costs -

There are no benefits at all in exposing a plant to UV-C light. UV-C radiation is completely absorbed into the atmosphere before reaching the earth surface, so therefore it is not naturally present on our planet surface. Even the smallest amount of UV-C exposure will irreparably damage the DNA of any plant.

UV-B is beneficial, but one needs to be careful -

In addition to the benefits listed above, UV-B light can also change the DNA of fungi that attack and damage or kill plants. When its DNA is altered, that prevents the fungus from spreading and hurting the plants. However, prolonged exposure to UV-B light can also alter the DNA of the plants, which is obviously problematic. UV-B light is less than 2% of the UV light that gets to the earth's surface.

UV-A exposure is great for plants with no side effects

When added during the growth cycle for plants, UV-A light can produce stronger, more plentiful plants that are able to withstand fungus and other attacks. It can also help fruits and vegetables look and taste better. UV-A light accounts for more than 98% of the UV light that reaches earth.

Plants have trichomes covering on their surfaces. Trichomes look like tiny hairs on the plant body, and they serve to reflect bad UV away from the plant. Additionally, when they are exposed to UV-A and UV-B lights, plants release a chemical component called glycosides, which can entice humans by helping the plant to produce a prettier and better-tasting fruit or vegetable. At the same time, glycosides deter insects from eating the plants [14].

In this case study therefore, experimentation was done to observe what happens to a hibiscus plant when it is exposed with UV radiation from artificial lamps. This can also show us the practical results of much discussed theory that using natural device that is plants one can eliminate harmful UV radiation coming from artificial lamps.

CHAPTER # 4
RESULTS AND ANALYSIS

CHAPTER - 4: RESULTS AND ANALYSIS

4.1. CASE STUDY 1: TO STUDY THE CHARACTERISTIC OF SUNLIGHT ON PLANET EARTH.

4.1.1. OBJECTIVE OF THE EXPERIMENT

For experimentally understanding and observing the solar characteristic of sunlight falling on Jadavpur location of Kolkata city an experimental point in the premises of school of illumination science, engineering and design was setup and the experiment was done. The sensor of the measuring instruments was aimed at perpendicular to the solar radiation falling on the earth surface and took reading for many successive days. Successive readings were taken to observe the different values of solar properties such as irradiance value, UV-A value, Correlated Colour Temperature (CCT) and illuminance value for different time of the day and at different weather condition throughout the day. One knows that understanding solar properties are very much important for people of science and engineering from different branch. For lighting engineers, it is important to understand various properties so that in future it is easy to understand and develop artificial lamps which have properties close to that of sunlight. Also, to develop different types of artificial lamp that can mimic the sunlight and can be used for growing plants where there is less or no adequate amount of sunlight. For other science branches the UV values of sunlight is important for understanding the reaction of UV with human or animal skins. Also, how a solar irradiance effects the solar panel power production and many more concepts.

4.1.2. PROCEDURE OF THE EXPERIMENT

Step 1: To locate a proper place inside the department to conduct the experiment where adequate sun radiation is available without risking the expensive instruments used for the experiment.

Step 2: Place the Metravi 207 Solar Power Meter sensor in perpendicular to sun rays falling then turn on the device and it will start taking the readings. When the reading stabilizes then press the hold key and note down the reading of Solar irradiance shown in W/m^2.

Step 3: Then place the Everfine U20 UV radiometer having UV-A sensor connected with it in that same position for measuring the UVA value. Turn on the device it will automatically start taking readings after self-calibrating, then when the reading stabilizes then note down the reading shown in $\mu W/cm^2$.

Step 4: Then place Konica Minolta Chromameter CL 200A in that same place to take the measurement of Correlated Colour Temperature (CCT) and Illuminance (lux). At first turn on the device click on the mode device till you can see Ev value which is the illuminance value and T value which is the CCT value on the screen. After the reading stabilizes click on hold button and take down the reading.

Step 5: Repeat the previous steps to take down readings of all four parameters of solar radiation throughout the day.

4.1.3. INSTRUMENTS USED FOR THE EXPERIMENT

1. Solar Power Meter: Metravi make, Model no. 207

Solar irradiance is the power per unit area received from the Sun in the form of electromagnetic radiation as measured in the wavelength range of the measuring instrument. The solar irradiance is measured in watt per square metre (W/m2). The Metravi 207 Solar Power Meter helps to measure the sunlight intensity falling on solar panels or on any surface exposed to sunlight, using a sensitive silicon sensor. It measures up to 1999W/m2 or 634BTU /(Ft2*hr) irradiance. With high accuracy and fast Response, it also features Data Hold function. It takes direct readings and no adjustment of the instrument is needed. Measuring unit is selectable between W/m2 and BTU/(Ft2*hr) and it also features Max / Min value recording. It comes with a clear and bright 3-1/2 digits LCD, measurement resolution of 1W/m2/1 BTU (Ft2*hr) and high accuracy of ±10W/m2. The 207 Solar Power Meter provides a fast, accurate, handy solution for sunlight measurement, enabling solar professionals and technicians to provide exceptional services to their customers while installing and commissioning solar panel power projects. The ±10 W/m2 of reading ±5 digits accuracy gives the confidence that the readings are accurate for installations [5].

2. UV Radiometer: Everfine make, Model no. U20

There are several radiometer models on the market that provide various types of information. A radiometer should be chosen to fit the application and the information required. Everfine U20 UV radiometer comes with UV-A measuring sensor for taking record of the UV-A radiation that is coming through the atmosphere to earth surface as a part of understanding solar radiation characteristic. The device features compact structure, good stability and high stray light control ability. It is widely used in ultraviolet light, disinfection and sterilization, light medical treatment, aging, detection, photolithography, light curing, breeding, plant cultivation, and UV index evaluation. Users can select the corresponding UV detectors for different response wavebands according to actual application. Range: SUVA sensor 320nm-390nm [6].

3. Chromameter: Konica Minolta make, Model no. CL 200A

The CL-200A chromameter is the successor to the CL-200. It can measure the color temperature, illuminance, chromaticity, excitation purity, and dominant wavelength of various light sources. The CL-200A was designed to be a highly effective tool for measuring the color temperature of white LEDs, a task that has been very difficult in the past. The CL-200A is able to do this due to its ability to measure the chromaticity from the phosphor and also inspect light quality output of the final assembled white LED. It can be also used to measure the illuminance and CCT values of sunlight for understanding solar radiation properties [7].

4.1.4. EXPERIMENTAL SETUP

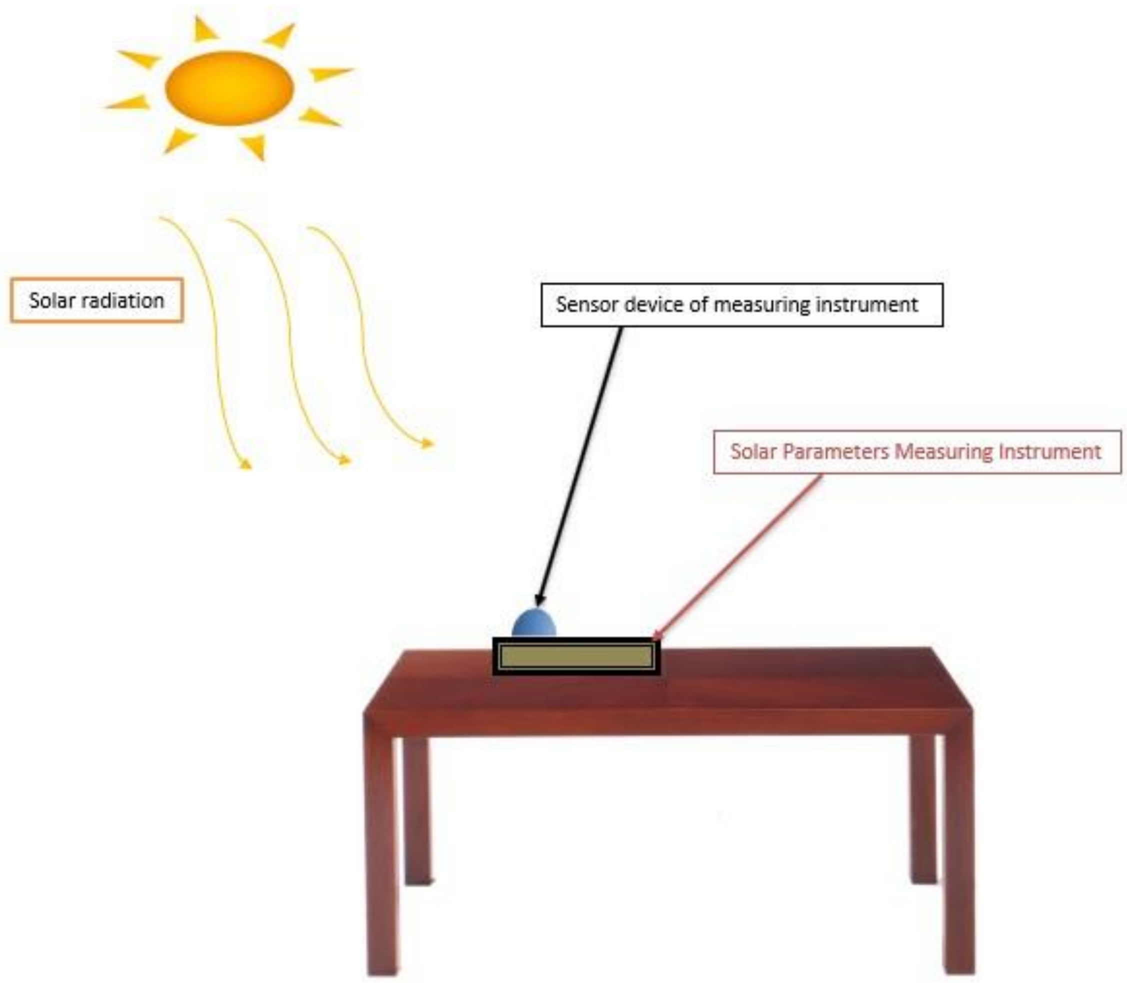

Fig 4.1 Schematic Diagram of experimental setup for measuring solar radiation.

4.1.5. OBSERVATION TABLE AND GRAPHICAL REPRESENTATION -

Table 4.1: Solar properties observation of sun- Day-1

TIME	Weather condition	CCT (K)	Solar Irradiance (W/m^2)	Illuminance (lux)	UV-A ($\mu W/cm^2$)
12:30PM	Clear Sunny	4335	382.70	22,310	773.3
1:00PM	Clear Sunny	4658	356.20	21,920	714.8
1:30PM	Clear Sunny	4986	257.90	15,990	423.1
2:00PM	Clear Sunny	4930	210.20	8,025	301.3
2:30PM	Diffused Sunlight	5212	18.60	1,821	134.2
3:00PM	Diffused Sunlight	5322	15.80	940	70.2
3:30PM	Diffused Sunlight	5503	13.54	818	61.4
4:00PM	Diffused Sunlight	5346	8.19	786	54.6
4:30PM	Evening Sky	5408	7.56	429	46.4
5:00PM	Evening Sky	5506	6.30	224	32.6

Graphical representation of solar properties observation of sun- Day-1 observation table:

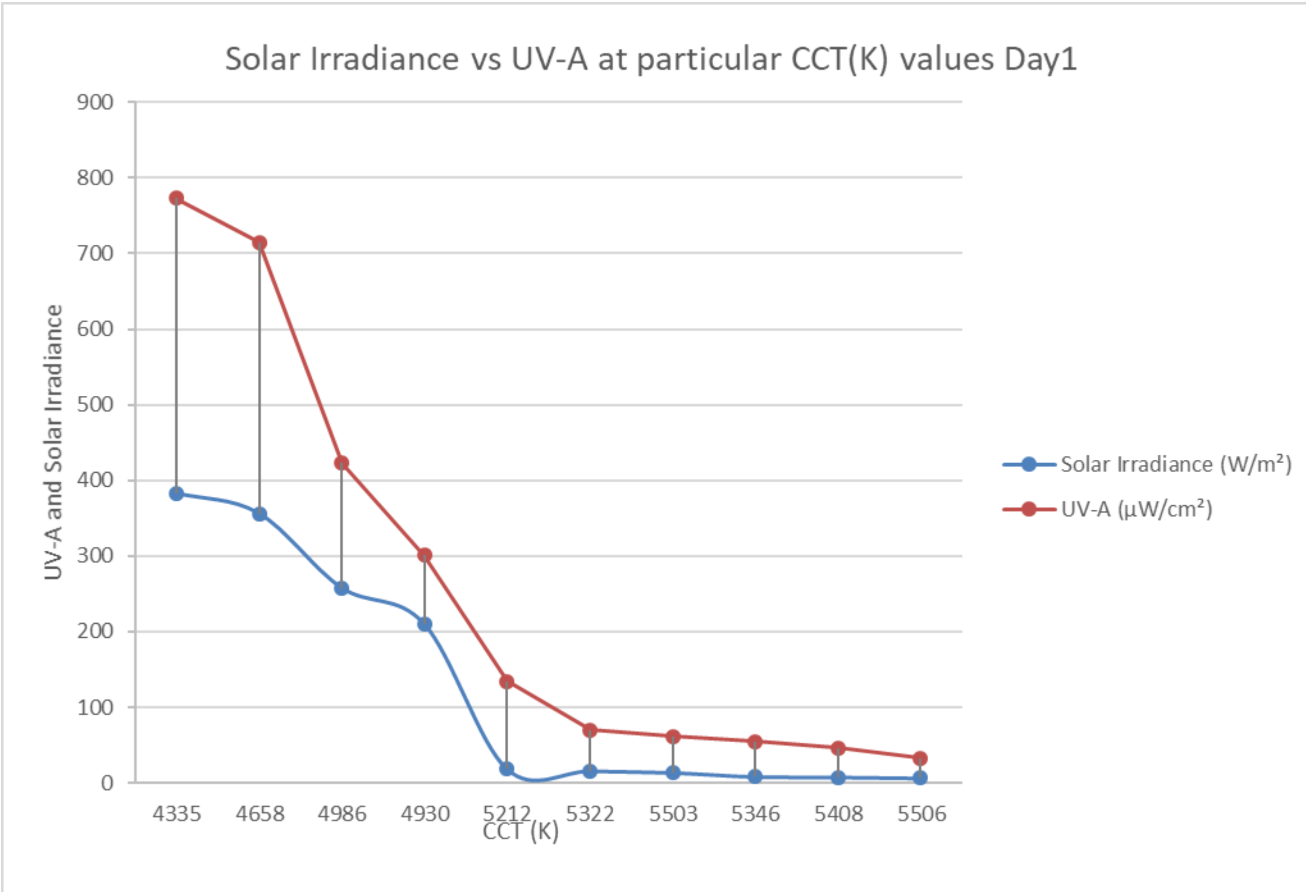

Fig 4.2 Graphical representation of comparison between Solar Irradiance values and UV-A values of a particular Day-1 observation readings at particular CCT(K) values.

Table 4.2: Solar properties observation of sun- Day-2

TIME	Weather condition	CCT (K)	Solar Radiation (W/m^2)	Illuminance (lux)	UV-A (μW/cm2)
12:30PM	Clear Sunny	3828	400.68	22,310	849.0
1:00PM	Clear Sunny	3691	338.62	21,920	670.5
1:30PM	Clear Sunny	3587	209.16	15,990	365.4
2:00PM	Clear Sunny	3717	214.20	8,025	279.8
2:30PM	Diffused Sunlight	4954	11.65	1,373	60.8
3:00PM	Diffused Sunlight	4969	10.39	940	69.9
3:30PM	Diffused Sunlight	4834	9.45	818	29.6
4:00PM	Diffused Sunlight	5023	4.41	786	14.8
4:30PM	Evening Sky	4883	3.78	429	10.6
5:00PM	Evening Sky	4920	2.20	224	10.6

Graphical representation of solar properties observation of sun- Day-2 observation table:

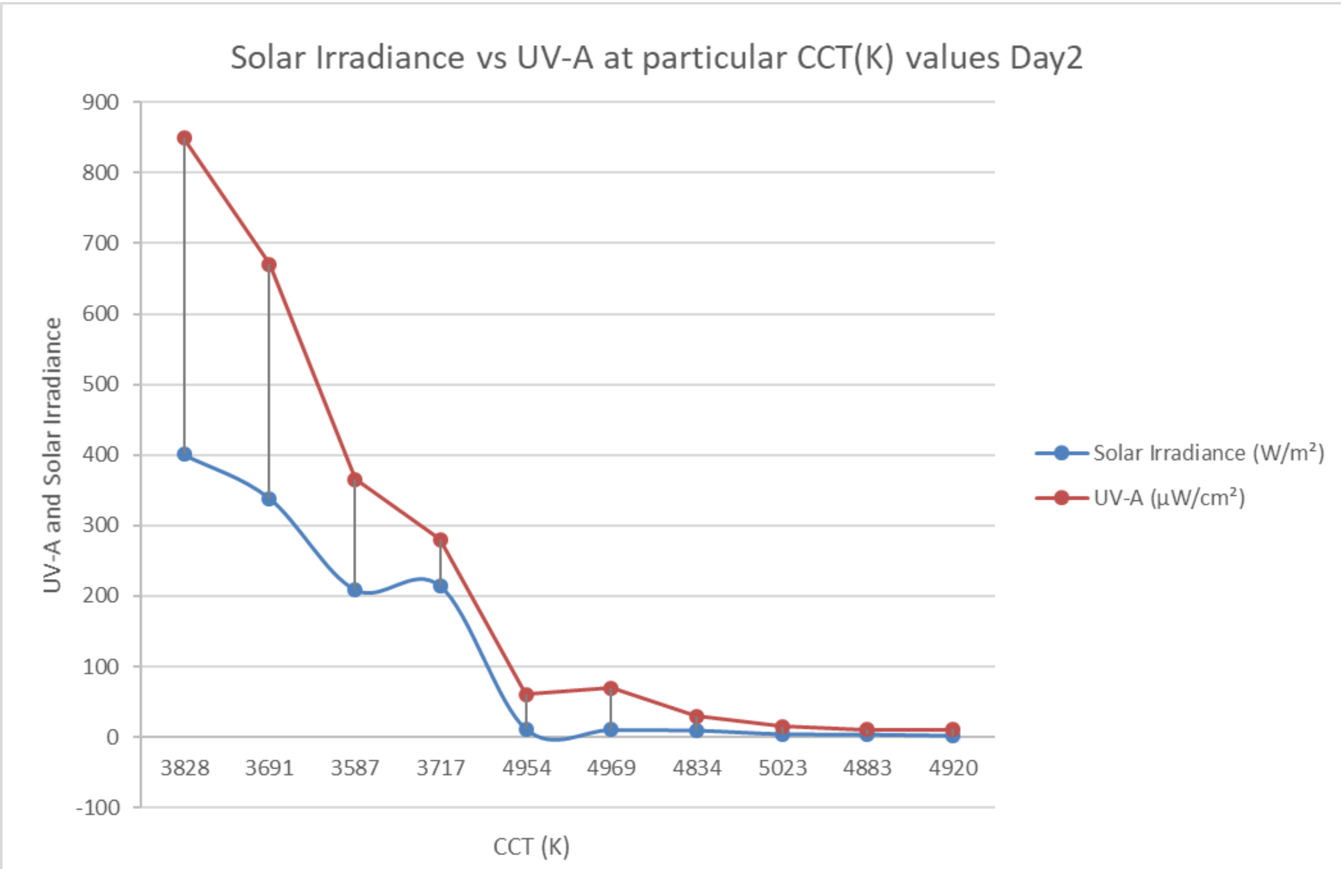

Fig 4.3 Graphical representation of comparison between Solar Irradiance values and UV-A values of a particular Day-2 observation readings at particular CCT(K) values.

Table 4.3: Solar properties observation of sun- Day-3

TIME	Weather condition	CCT (K)	Solar Irradiance (W/m^2)	Illuminance (lux)	UV-A ($\mu W/cm^2$)
12:30PM	Clear Sunny	4346	425.10	32,561	1589.2
1:00PM	Clear Sunny	4458	420.20	29,010	1577.8
1:30PM	Clear Sunny	4266	409.11	38,970	1437.8
2:00PM	Clear Sunny	4335	396.30	39,490	1562.5
2:30PM	Diffused Sunlight	5394	9.92	1,504	186.6
3:00PM	Diffused Sunlight	5053	11.65	8,777	103.6
3:30PM	Diffused Sunlight	5006	13.59	826	63.4
4:00PM	Diffused Sunlight	5002	8.50	743	44.3
4:30PM	Evening Sky	5072	5.04	428	26.9
5:00PM	Evening Sky	5089	3.40	311	12.4

Graphical representation of solar properties observation of sun- Day-3 observation table:

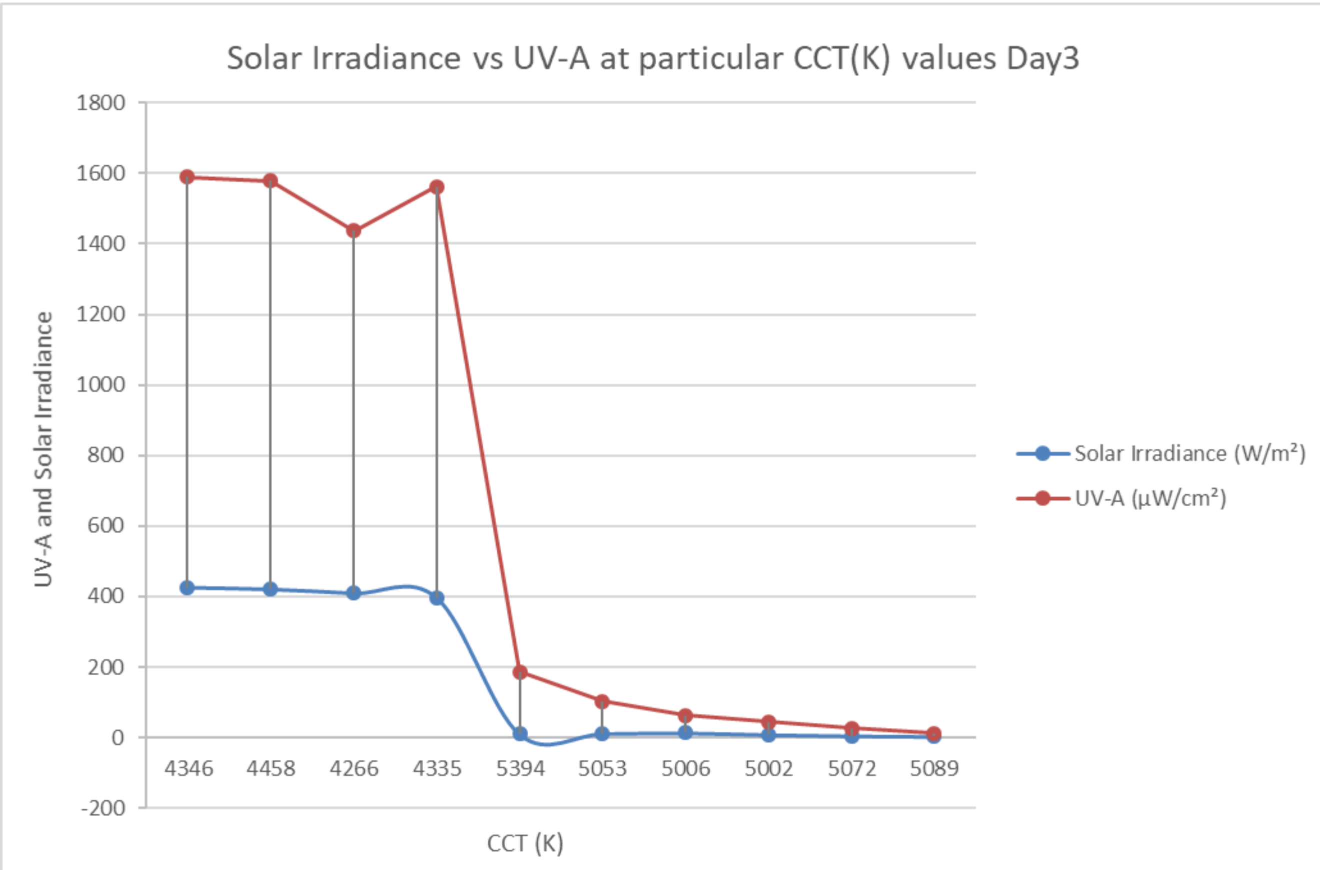

Fig 4.4 Graphical representation of comparison between Solar Irradiance values and UV-A values of a particular Day-3 observation readings at particular CCT(K) values.

Table 4.4: Solar properties observation of sun- Day-4

TIME	Weather condition	CCT (K)	Solar Irradiance (W/m^2)	Illuminance (lux)	UV-A ($\mu W/cm^2$)
12:30PM	Clear Sunny	4103	383.30	43,920	1544.5
1:00PM	Clear Sunny	4147	463.05	44,670	1488.0
1:30PM	Clear Sunny	4091	433.44	40,600	1335.0
2:00PM	Clear Sunny	4103	374.50	38,760	1271.0
2:30PM	Diffused Sunlight	5546	18.90	1,532	124.1
3:00PM	Diffused Sunlight	5537	17.01	1,454	92.3
3:30PM	Diffused Sunlight	5523	13.86	844	59.3
4:00PM	Diffused Sunlight	5454	9.45	763	43.1
4:30PM	Evening Sky	5410	7.20	547	33.1
5:00PM	Evening Sky	5442	4.90	420	15.2

Graphical representation of solar properties observation of sun- Day-4 observation table:

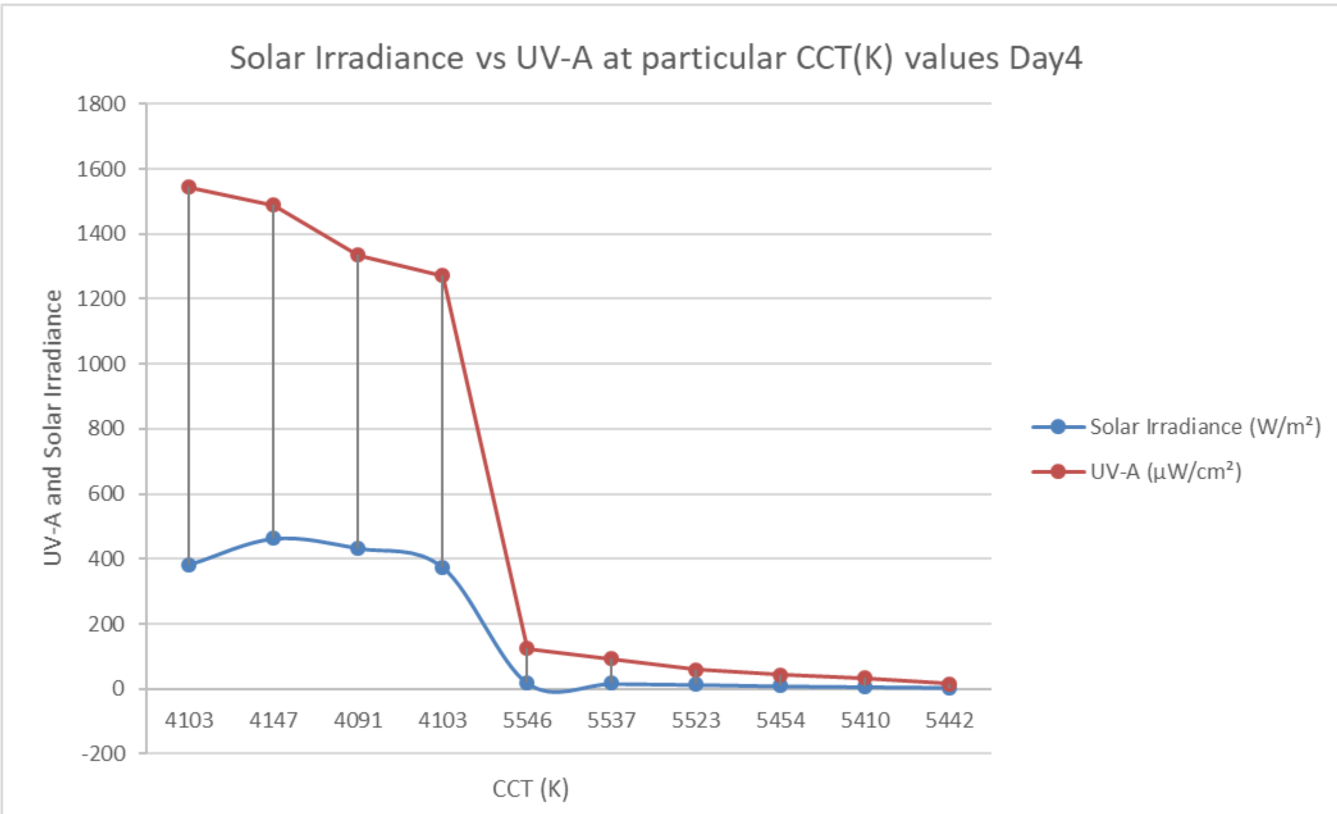

Fig 4.5 Graphical representation of comparison between Solar Irradiance values and UV-A values of a particular Day-4 observation readings at particular CCT(K) values.

Table 4.5: Solar properties observation of sun- Day-5

TIME	Weather condition	CCT (K)	Solar Irradiance (W/m²)	Illuminance (lux)	UV-A (μW/cm²)
12:30PM	Clear Sunny	4073	384.20	28,654	1487.2
1:00PM	Clear Sunny	4173	346.50	26,330	1460.4
1:30PM	Clear Sunny	4103	443.80	19,660	1501.6
2:00PM	Clear Sunny	4092	268.50	21,340	823.0
2:30PM	Diffused Sunlight	5474	20.79	1,455	110.0
3:00PM	Diffused Sunlight	5503	18.90	1,269	90.8
3:30PM	Diffused Sunlight	5401	15.75	946	65.1
4:00PM	Diffused Sunlight	5395	11.65	654	43.2
4:30PM	Evening Sky	5407	8.30	548	35.8
5:00PM	Evening Sky	5418	6.90	514	28.7

Graphical representation of solar properties observation of sun- Day-5 observation table:

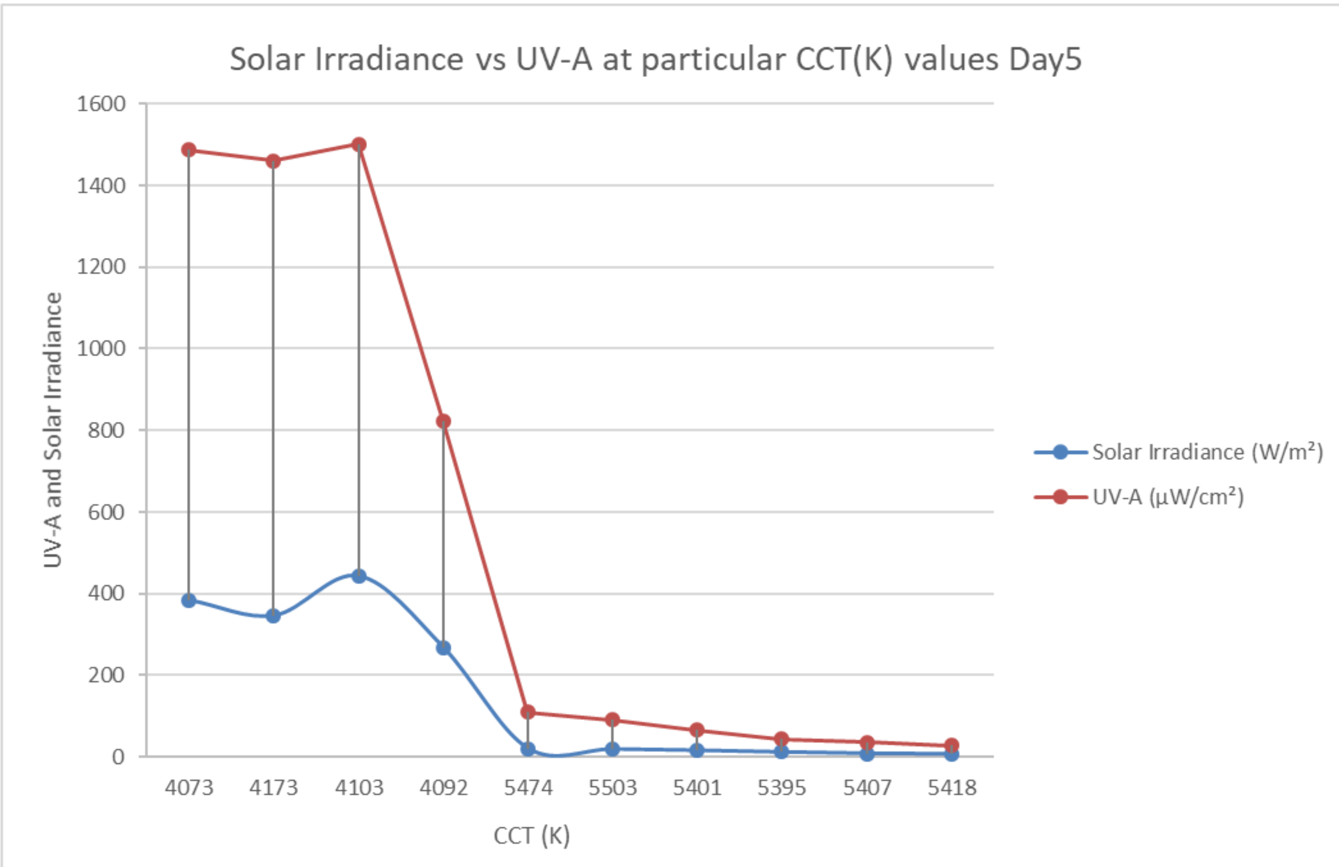

Fig 4.6 Graphical representation of comparison between Solar Irradiance values and UV-A values of a particular Day-5 observation reading at particular CCT(K) values.

Table 4.6: Solar properties observation of sun- Day-6

TIME	Weather condition	CCT (K)	Solar Irradiance (W/m^2)	Illuminance (lux)	UV-A ($\mu W/cm^2$)
12:30pm	Clear Sunny	4215	483.21	31,740	1694.5
1:00pm	Clear Sunny	4140	466.10	30,250	1722.5
1:30pm	Clear Sunny	4154	412.65	28,970	1437.8
2:00pm	Clear Sunny	4234	418.20	29,210	1281.2
2:30pm	Diffused Sunlight	5471	20.16	1,430	112.9
3:00pm	Diffused Sunlight	5364	17.16	1,180	95.9
3:30pm	Diffused Sunlight	5121	11.34	872	64.8
4:00pm	Diffused Sunlight	5265	10.08	514	41.1
4:30pm	Evening Sky	5312	9.30	484	36.3
5:00pm	Evening Sky	5388	7.80	406	28.9

Graphical representation of solar properties observation of sun- Day-6 observation table:

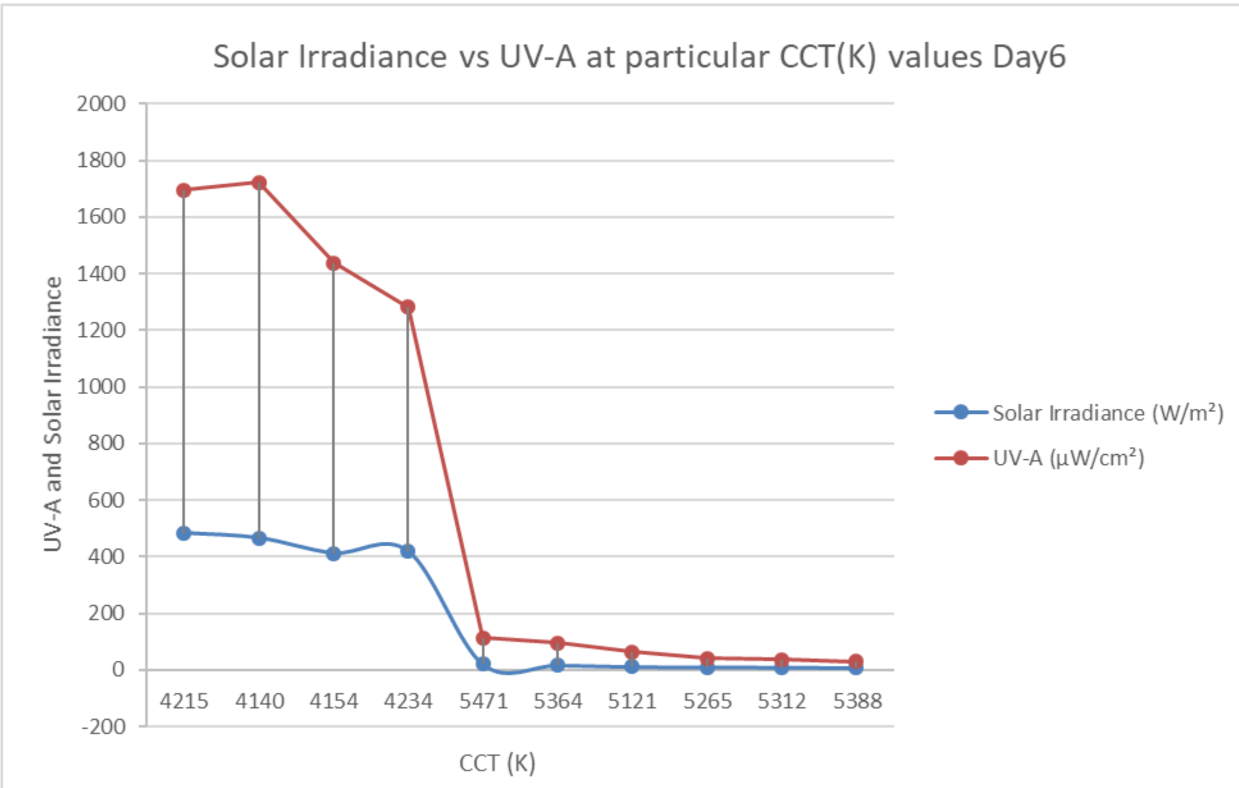

Fig 4.7 Graphical representation of comparison between Solar Irradiance values and UV-A values of a particular Day-6 observation reading at particular CCT(K) values.

Table 4.7: Solar properties observation of sun- Day-7

TIME	Weather condition	CCT (K)	Solar Irradiance (W/m^2)	Illuminance (lux)	UV-A ($\mu W/cm^2$)
12:30pm	Clear Sunny	3965	327.80	30,740	1345.1
1:00pm	Clear Sunny	4182	441.12	32,450	1451.4
1:30pm	Clear Sunny	4198	441.21	32,468	1168.0
2:00pm	Clear Sunny	4254	406.10	28,468	936.0
2:30pm	Diffused Sunlight	4321	11.60	1,526	103.0
3:00pm	Diffused Sunlight	4860	8.19	1,466	48.2
3:30pm	Diffused Sunlight	5021	11.34	1,514	57.3
4:00pm	Diffused Sunlight	5078	5.04	521	26.8
4:30pm	Evening Sky	5233	4.50	477	24.6
5:00pm	Evening Sky	5364	3.80	426	20.6

Graphical representation of solar properties observation of sun- Day-7 observation table:

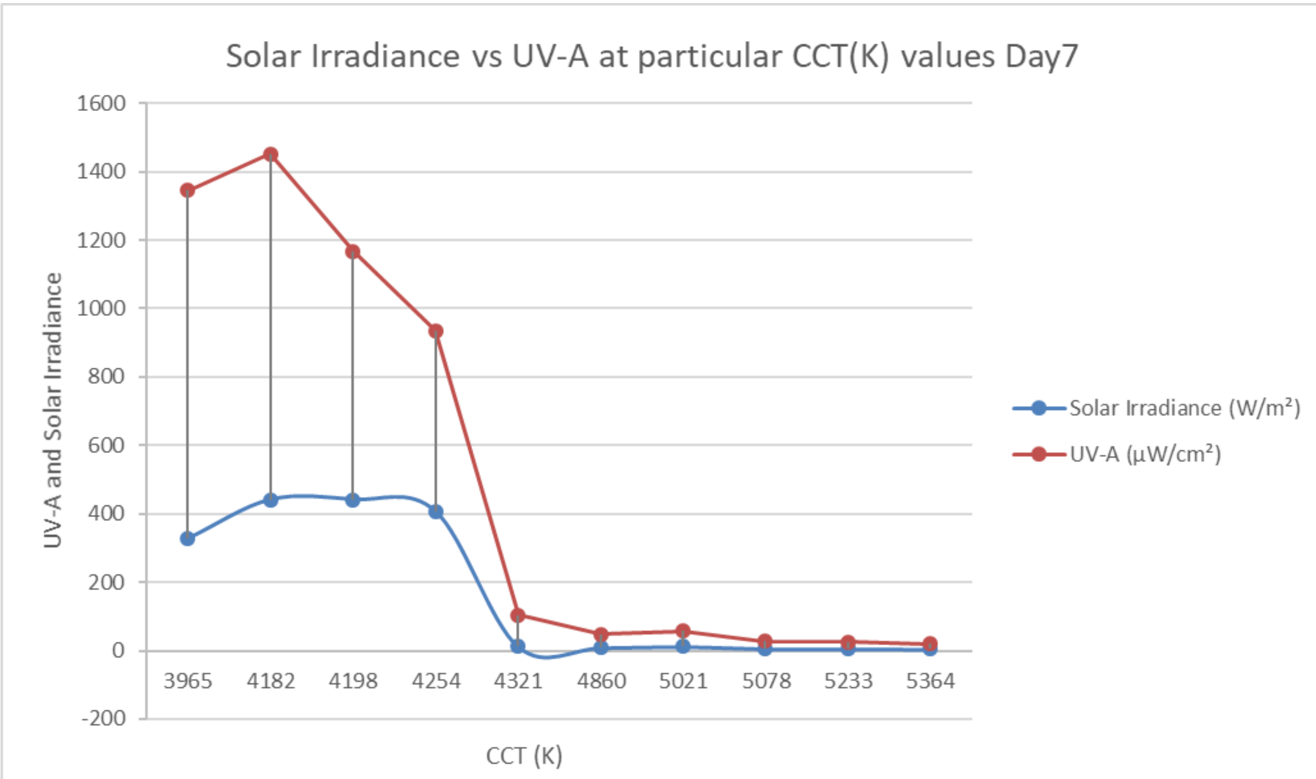

Fig 4.8 Graphical representation of comparison between Solar Irradiance values and UV-A values of a particular Day-7 observation reading at particular CCT(K) values.

Table 4.8: Solar properties observation of sun- Day-8

TIME	Weather condition	CCT (K)	Solar Irradiance (W/m^2)	Illuminance (lux)	UV-A ($\mu W/cm^2$)
12:30pm	Clear Sunny	3965	458.90	31,740	1455.6
1:00pm	Clear Sunny	4186	463.60	32,450	1643.2
1:30pm	Clear Sunny	4263	403.50	29,645	1315.1
2:00pm	Clear Sunny	4452	365.30	26,542	1108.4
2:30pm	Diffused Sunlight	4522	16.68	1,476	59.6
3:00pm	Diffused Sunlight	5013	14.49	1,452	48.9
3:30pm	Diffused Sunlight	5064	12.91	1,365	42.4
4:00pm	Diffused Sunlight	5124	11.06	623	38.7
4:30pm	Evening Sky	5221	6.20	521	33.2
5:00pm	Evening Sky	5321	2.80	421	18.6

Graphical representation of solar properties observation of sun- Day-8 observation table:

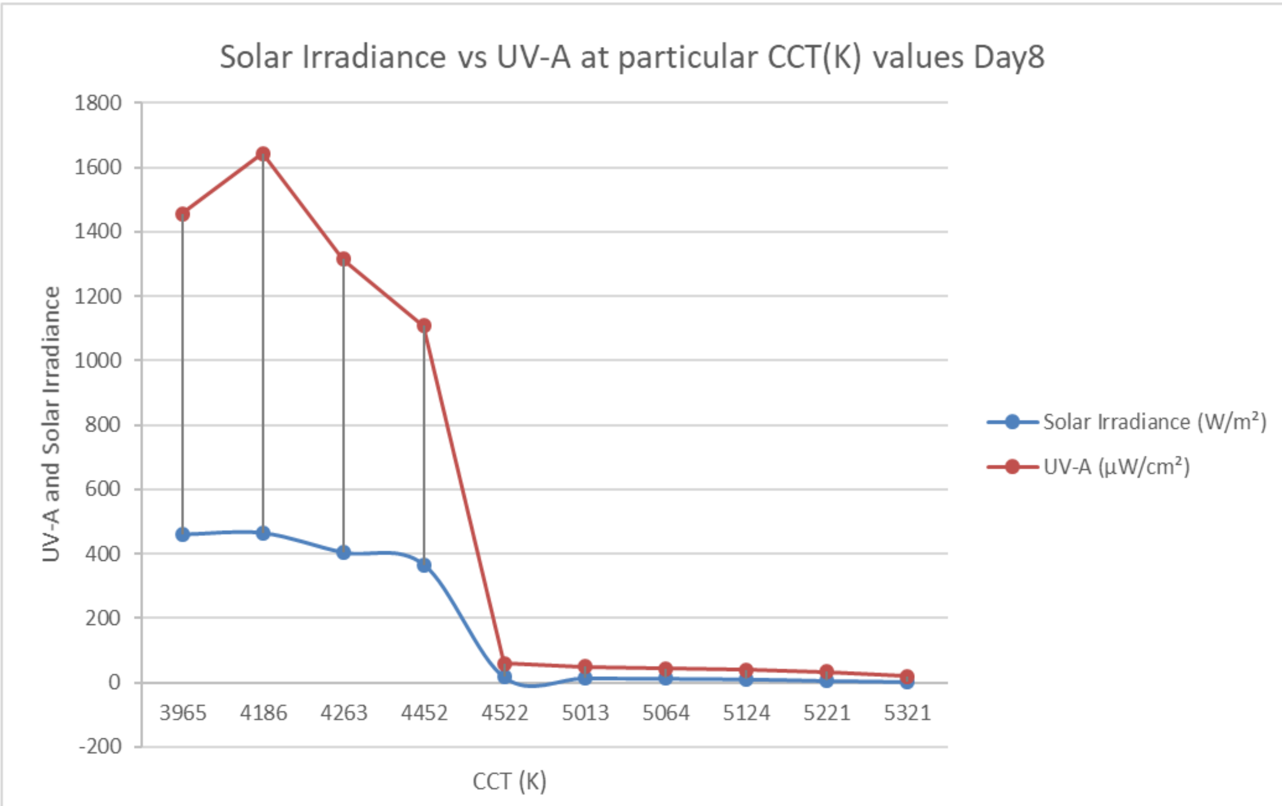

Fig 4.9 Graphical representation of comparison between Solar Irradiance values and UV-A values of a particular Day-8 observation reading at particular CCT(K) values.

Table 4.9: Solar properties observation of sun- Day-9

TIME	Weather condition	CCT (K)	Solar Irradiance (W/m^2)	Illuminance (lux)	UV-A ($\mu W/cm^2$)
12:30pm	Clear Sunny	4104	408.89	31,666	1279.9
1:00pm	Clear Sunny	4140	419.65	31,011	1411.7
1:30pm	Clear Sunny	4095	393.22	27,787	1222.9
2:00pm	Clear Sunny	4170	349.12	27,405	1037.4
2:30pm	Diffused Sunlight	5097	15.67	1,459	108.1
3:00pm	Diffused Sunlight	5186	13.97	1,366	78.5
3:30pm	Diffused Sunlight	5187	12.60	1,000	60.4
4:00pm	Diffused Sunlight	5211	8.54	674	43.6
4:30pm	Evening Sky	5243	6.48	483	38.1
5:00pm	Evening Sky	5306	4.76	368	22.6

Graphical representation of solar properties observation of sun- Day-9 observation table:

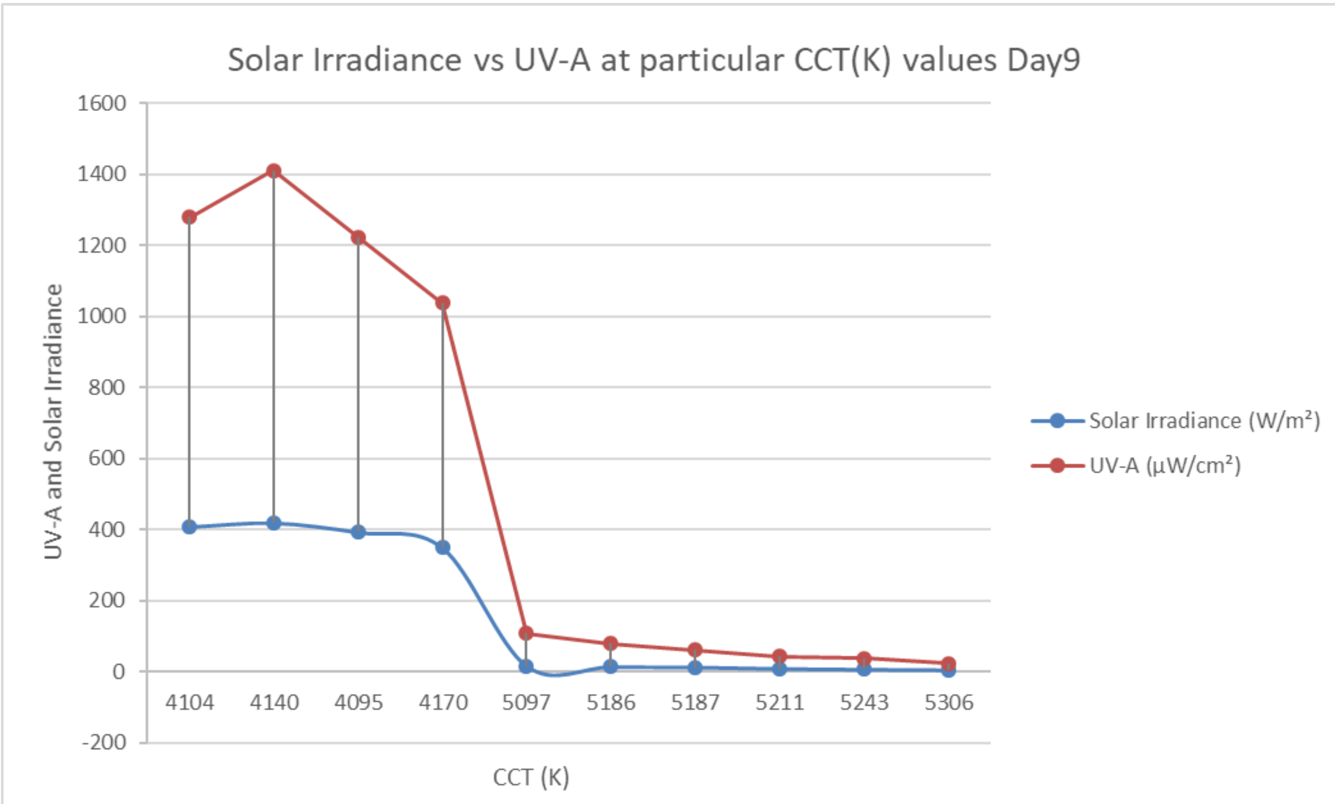

Fig 4.10 Graphical representation of comparison between Solar Irradiance values and UV-A values of a particular Day-9 observation reading at particular CCT(K) values.

Table 4.10: Solar properties observation of sun- Day-10

TIME	Weather condition	CCT (K)	Solar Irradiance (W/m^2)	Illuminance (lux)	UV-A ($\mu W/cm^2$)
12:30pm	Clear Sunny	4075	426.30	32,231	1287.2
1:00pm	Clear Sunny	4104	413.52	31,783	1453.2
1:30pm	Clear Sunny	4132	384.65	28,654	1212.3
2:00pm	Clear Sunny	4178	353.45	27,981	1026.2
2:30pm	Diffused Sunlight	5067	16.43	1,423	102.5
3:00pm	Diffused Sunlight	5179	14.23	1,375	73.7
3:30pm	Diffused Sunlight	5192	12.90	1,021	62.8
4:00pm	Diffused Sunlight	5234	8.23	645	42.4
4:30pm	Evening Sky	5289	6.37	436	37.6
5:00pm	Evening Sky	5420	4.02	353	23.2

Graphical representation of solar properties observation of sun- Day-10 observation table:

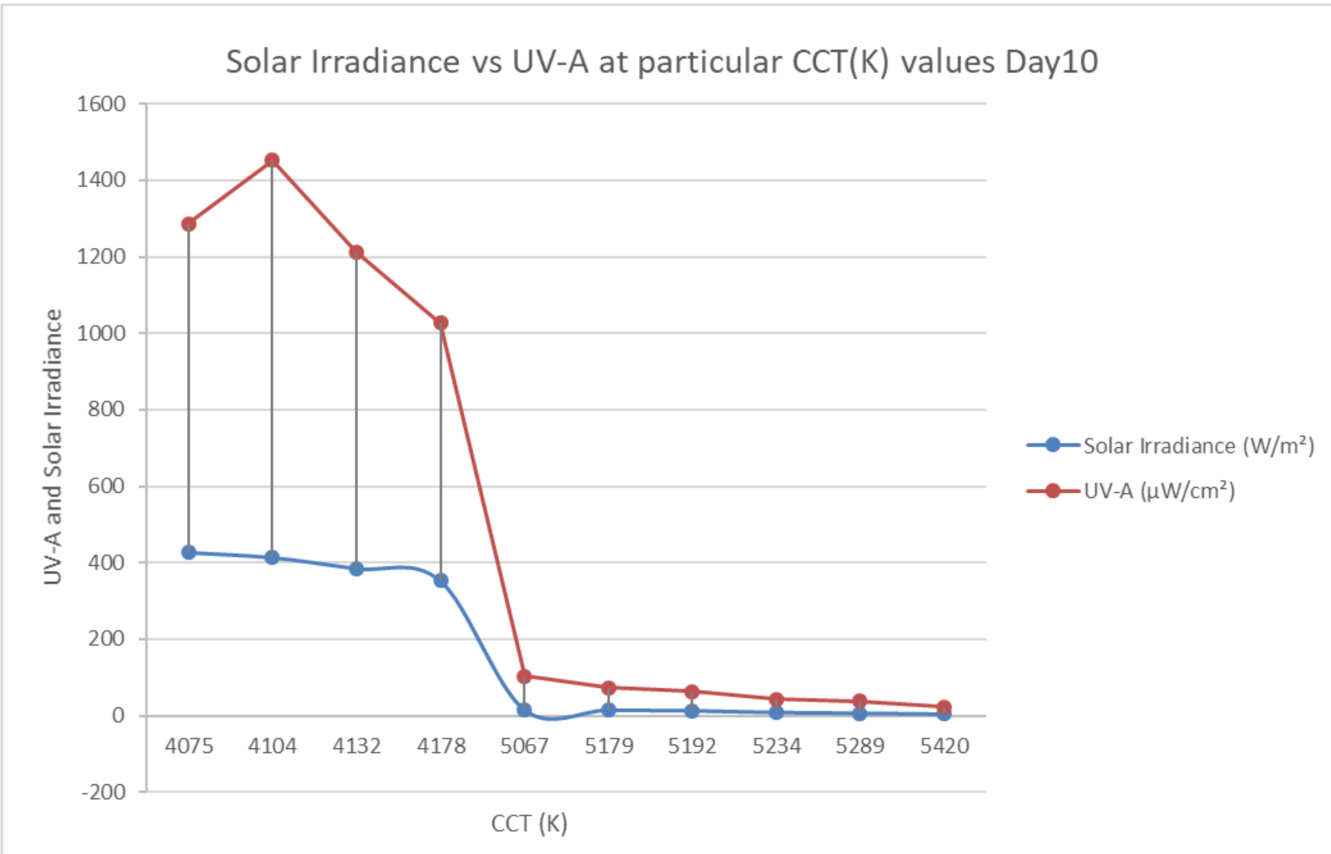

Fig 4.11 Graphical representation of comparison between Solar Irradiance values and UV-A values of a particular Day-10 observation reading at particular CCT(K) values.

4.1.6. RESULT ANALYSIS

In this experimental study readings were taken for ten successive days in the month of summer season. Observation of different solar radiation properties were taken throughout this period of time to better understand different solar parameters that is important for all living beings in planet earth. Various reading measuring the Correlated Colour Temperature (CCT) having unit Kelvin(K) were also taken. Then solar irradiance measurement reading having unit watt per meter square which is the solar power received on the earth surface per unit area were taken. Also measured illuminance value which is the total luminous flux incident on a surface, per unit area having unit lux was taken. Then UV (Ultra Violet radiation) reading specifically UV-A since that was only the sensor available at that time was also taken.

Then comparison and graphical representations of these reading were done to understand how at particular CCT value the solar irradiance and UV-A value behaves for earth surface. The observation was done during the time from afternoon till evening and the solar irradiance value at first increased to a high value of $400W/m^2$, at that time the CCT value is near to 4000K but as time passes to sunset it was observed that the solar irradiance value goes down to 5 W/m^2 and CCT value is near to 5500K. It was seen that at CCT range from 4000K-4900K during afternoon time the value of solar irradiance is very high having value of 400 W/m^2 and more. This is harmful for human bare skin but good for plants as high solar power will help plants to increase their food production. High irradiance is also good for places where solar panel is used for producing solar power.

It was observed that in CCT range from 4000K-4900K the value of UV-A is also high during afternoon time having average range of 1200-1400 $\mu W/cm^2$ which is very much harmful for human body. It was observed that with the increasing value of solar irradiance the value of UV-A also increases, i.e., when the irradiance value was 400W/m2 at that time UV-A was 1400 µW/cm2 approximately. With the range of UV-A from observation table one can guess that the overall UV radiation is also pretty high at that period of time, therefore during peak summer afternoon it is always advice to stay indoor as much as possible and if necessary use umbrella and necessary protection to protect human skin from harmful UV rays which can cause many skin diseases.

Summary – The values of solar irradiance and UV-A radiation are found to be directly proportional and both the values are highest during afternoon time and lowest in evening time. CCT values are found to be near 4000K range in afternoon and near 5500K range in evening.

4.2. CASE STUDY 2: TO STUDY AND COMPARE UV-A ON NORMAL TAP WATER, SEA WATER AND EARTH SURFACE.

4.2.1. OBJECTIVE OF THE EXPERIMENT

For experimentally understanding the UV characteristic and behavior on earth surface, in tap water and sea water we did an experiment in the premises of school of illumination science, engineering and design. UV-A readings were simultaneously taken from normal water, sea water and earth surface. Understanding the UV behavior over earth surface and comparing it with what happens with normal water and sea water is very important. Usually one has observed that fisherman who works near coastal areas are more prone to UV related skin problems and it can be well visible that their skin has more UV burn and tan than others. But if one compares them with the fisherman of the Ganges river or those fishing in other rivers they don't experience such level of skin burn or tanning due to UV rays. And those who live away from coastal areas, i.e., those in cities have lesser visible skin issues due to UV radiations. So there has to be some sort of reaction of UV with different types of water and earth surface. Experiment was done where the surface, tap water and sea water was kept in same location and UV-A value was measured along with the solar power value. So that one can understand what happens to UV-A radiation on all these three components at same solar power intensity. Here in this experiment due to unavailability of local sea water sample, sea water was experimentally created with reference taken from science papers in internet, where it was mentioned that 35gms of table salt is to be mixed with 1litre of tap water to mimic the sea water at highest approximate level. [15]

4.2.2. PROCEDURE OF THE EXPERIMENT

Step 1: To locate a proper place inside the department to conduct the experiment where adequate sun radiation is available without risking the expensive instruments used for the experiment.

Step 2: Then place the tap water preparation of 1litre quantity in a tray where sun radiation is adequate, let the sun radiation fall on the water sample for some minutes before taking the readings.

Step 3: Then place the Metravi 207 Solar Power Meter sensor in perpendicular to sun rays falling then turn on the device and it will start taking the readings. When the reading stabilizes then press the hold key and note down the reading of Solar irradiance shown in W/m^2.

Step 4: Then place the Everfine U20 UV radiometer having UV-A sensor connected with it in that same position for measuring the UVA value. Turn on the device it will automatically start taking readings after self-calibrating, then when the reading stabilizes then note down the reading shown in $\mu W/cm^2$.

Step5: Then place the sea water, i.e., the salt water preparation of 1 litre quantity in a tray where sun radiation is adequate, let the sun radiation fall on the water sample for some minutes before taking the readings.

Step 6: Then place the Metravi 207 Solar Power Meter sensor in perpendicular to sun rays falling then turn on the device and it will start taking the readings. When the reading stabilizes then press the hold key and note down the reading of Solar irradiance shown in W/m^2.

Step 7: Then place the Everfine U20 UV radiometer having UV-A sensor connected with it in that same position for measuring the UVA value. Turn on the device it will automatically start taking readings after self-calibrating, then when the reading stabilizes then note down the reading shown in $\mu W/cm^2$.

Step 8: Then at the same position take readings when the sun radiation falls on normal earth surface. Point the sensor perpendicular to the sun radiation and follow step 6 & 7.

Step 9: Note down all the readings, keeping the solar power intensity same note down the UV-A values for different situation.

4.2.3. INSTRUMENTS USED FOR THE EXPERIMENT

1. Solar Power Meter: Metravi make, Model no. 207

Solar irradiance is the power per unit area received from the Sun in the form of electromagnetic radiation as measured in the wavelength range of the measuring instrument. The solar irradiance is measured in watt per square metre (W/m2). The Metravi 207 Solar Power Meter helps to measure the sunlight intensity falling on solar panels or on any surface exposed to sunlight, using a sensitive silicon sensor. It measures up to 1999W/m2 or 634BTU /(Ft2*hr) irradiance. With high accuracy and fast Response, it also features Data Hold function. It takes direct readings and no adjustment of the instrument is needed. Measuring unit is selectable between W/m2 and BTU/(Ft2*hr) and it also features Max / Min value recording. It comes with a clear and bright 3-1/2 digits LCD, measurement resolution of 1W/m2/1 BTU (Ft2*hr) and high accuracy of ±10W/m2. The 207 Solar Power Meter provides a fast, accurate, handy solution for sunlight measurement, enabling solar professionals and technicians to provide exceptional services to their customers while installing and commissioning solar panel power projects. The ±10 W/m2 of reading ±5 digits accuracy gives the confidence that the readings are accurate for installations [5].

2. UV Radiometer: Everfine make, Model no. U20

There are several radiometer models on the market that provide various types of information. A radiometer should be chosen to fit the application and the information required. Everfine U20 UV radiometer comes with UV-A measuring sensor for taking record of the UV-A radiation that is coming through the atmosphere to earth surface as a part of understanding solar radiation characteristic. The device features compact structure, good stability and high stray light control ability. It is widely used in ultraviolet light, disinfection and sterilization, light medical treatment, aging, detection, photolithography, light curing, breeding, plant cultivation, and UV index evaluation. Users can select the corresponding UV detectors for different response wavebands according to actual application. Range: SUVA sensor 320nm-390nm [6].

4.2.4. EXPERIMENTAL SETUP

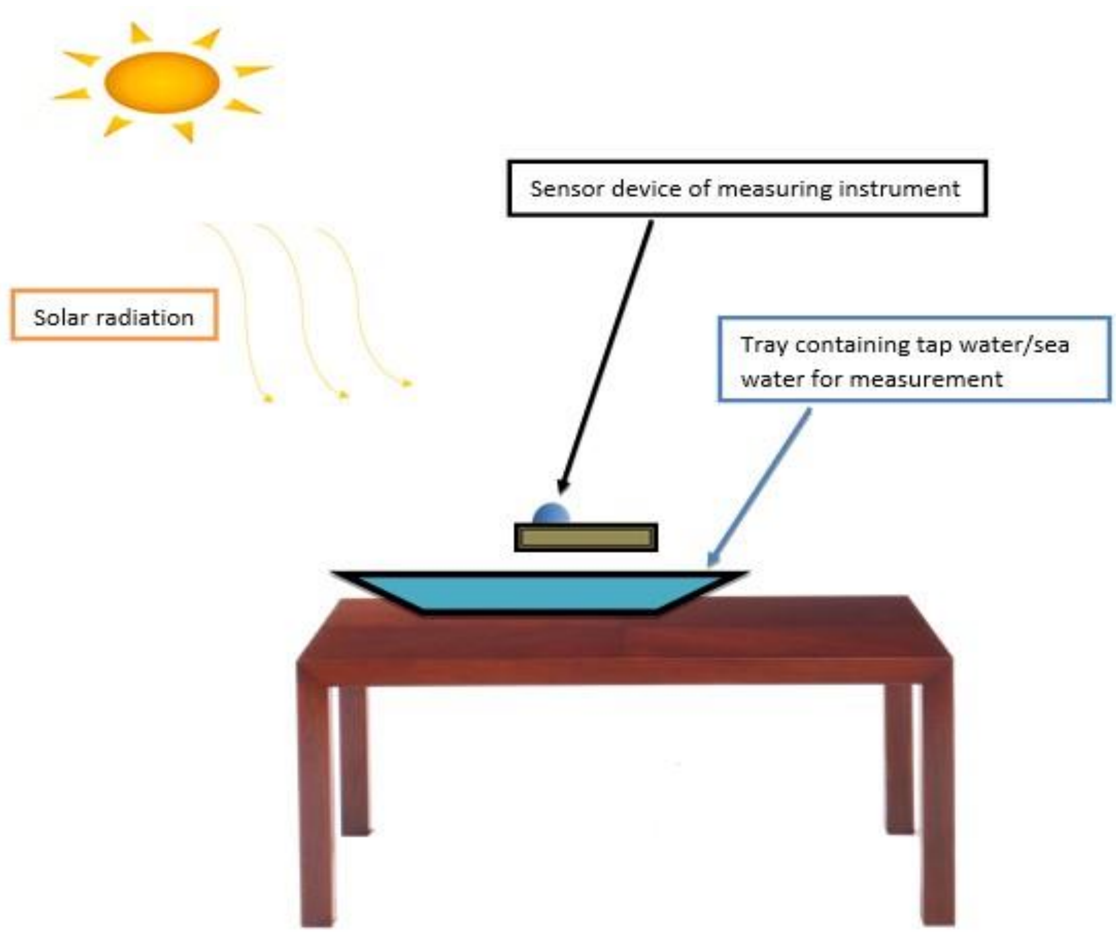

Fig 4.12: Schematic diagram of experimental setup for measuring UV-A properties on normal water, sea water and earth surface

4.2.5. OBSERVATION TABLE AND GRAPHICAL REPRESENTATION

Table 4.11: Experimental Table for UV-A comparison on Earth surface, normal water and sea water.

Sl.No.	Solar Irradiance (W/m^2)	UV-A ($\mu W/cm^2$) on Earth Surface	UV-A ($\mu W/cm^2$) on Normal Water	UV-A (µW/cm2) on Sea Water
1	401.4	1467.40	1386.2	1104.4
2	357.8	1411.10	1346.4	1047.0
3	348.7	1222.95	1168.2	922.4
4	290.2	1037.70	936.2	532.3
5	25.9	108.14	70.2	22.4
6	10.8	78.51	48.2	12.4
7	7.9	60.40	37.6	8.0
8	5.9	43.20	32.1	5.7
9	4.7	38.14	24.6	3.9
10	2.1	21.30	16.3	0.8

Graphical representation of UV-A comparison on Earth surface, normal water and sea water observation table:

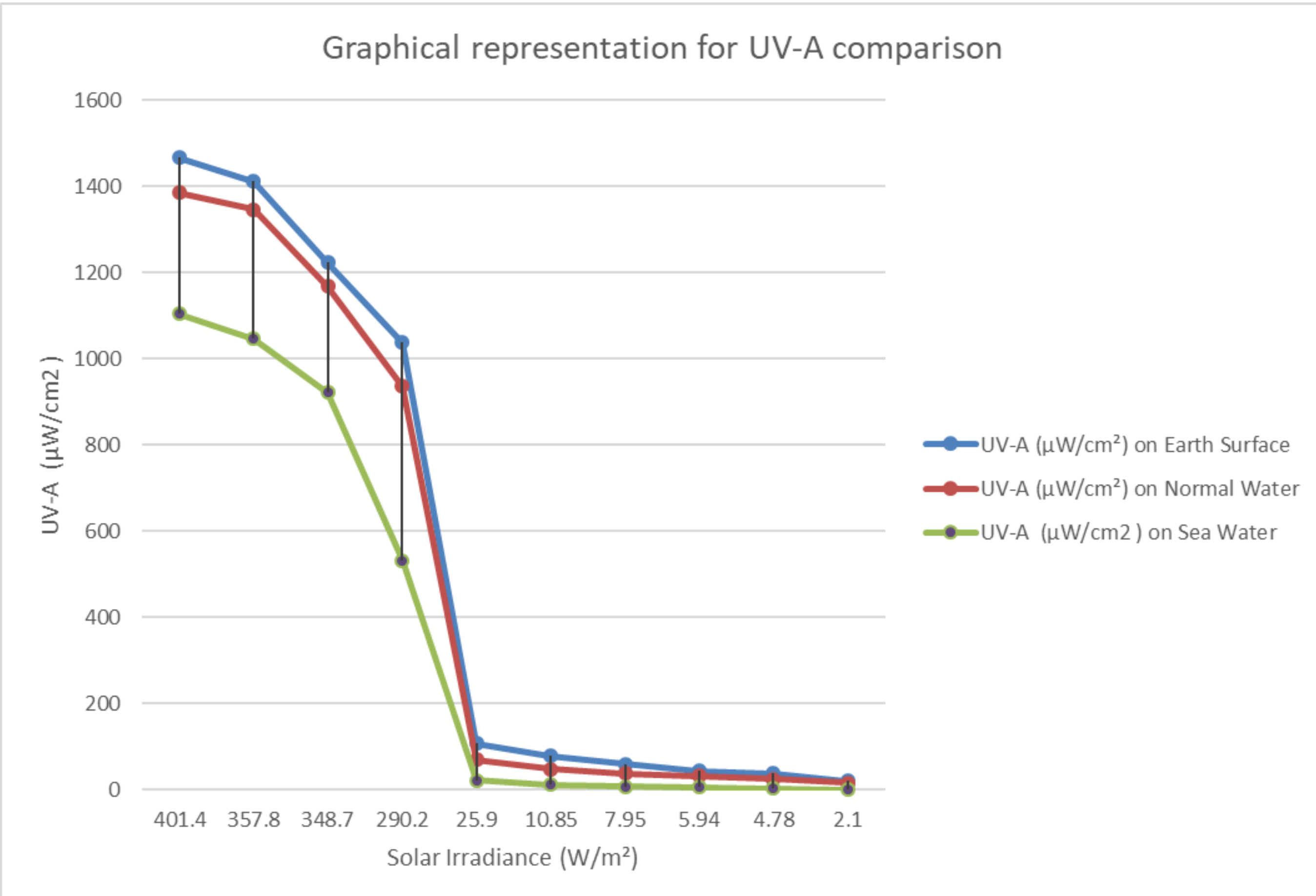

Fig 4.13: Graphical representation of comparison between UV-A falling on earth surface, on normal water and on sea water at particular solar irradiance values.

4.2.6. RESULT ANALYSIS

It can be observed from the graphical representation that the curve of the UV-A value of earth surface is higher than that of both normal water and sea water. So, it can be understood that earth surface has a low tendency to absorb all the UV radiation coming from the sun comparing with normal water and sea water. This comparison is purely relative in nature. Now if one wants to understand what happens to UV radiation in between freshwater body areas and sea water coastal areas, it can be observed from the graph that areas near to freshwater bodies will tend to absorb less UV radiation from sun than that in coastal sea side areas.

Now if we consider a particular solar irradiance value from the observation table say 400 W/m^2 at that value the UV-A content shown over the freshwater was 1386.2 $\mu W/cm^2$ and over sea/salt water it was 1104.4 $\mu W/cm^2$. It can be clearly observed both from observation table and graphical representation that the sea water/salt water have absorbed the most amount of UV-A radiation as the measurements were taken in same location point in same time and at particular solar intensity values. This proves the theoretical concept that people of science often tell that near coastal area and in sea water the UV absorption rate is very high.

So, it can be said that people living near coastal areas or people who work in sea are more prone to harmful UV radiation and because of this their skin gets more burn and tan. This is a relative comparison as people living near freshwater bodies may also get effected by the UV radiations but that is relatively less than that of coastal areas. This experimental result is very important and in future researcher needs to do testing near coastal areas to find the actual values of UV radiations and to estimate how much damage it is doing to human skin and health. Assessment is also needed in the villages that are close to sea to check the UV levels and to plant necessary number of trees with big leaves beside the houses to reduce the overall UV radiations. This result and analysis are only a basic part and more experiments and research is needed according to the geographical locations and necessary actions needs to be taken.

Summary – Ultraviolet radiation content was experimentally found to be lowest over sea/salt water when compared with freshwater. Therefore, sea/salt water can absorb the maximum amount of UV radiation than freshwater.

4.3. CASE STUDY - 3: TO STUDY THE GROWTH CHARACTERISTIC OF ZINNIA PLANT UNDER SUNLIGHT.

4.3.1. OBJECTIVE OF THE EXPERIMENT

To study the growth rate of zinnia plant under sunlight and to observe how solar parameters and radiation effects growth rate of the plant under natural situation. Plants always absorb the light spectrum in an almost similar range as the human eye, they absorb the best red and best blue light. Chlorophyll is a photoreceptor that absorbs mainly red and blue light and reflects green wavelengths, there are also other particles absorbing light known as photoreceptors. The main photoreceptor groups are phytochromes, phototropins and cryptochromes. All photoreceptors capture light in different wavelength region and are responsible for different response in plants. So, this behaviour of the photoreceptors needs to be understood. Which wavelength of light triggers what function of a plant is very important knowledge if someone wants to grow a particular plant for some important reason. It is also important so that when researchers develop artificial plant grow light they have the proper knowledge that which wavelength of light triggers what response and accordingly the artificial light could be designed. Since sun have all the light spectrum in itself so studying a plant growth under direct sunlight and diffused sunlight will tell us how growth rate can vary, how flowering condition is affected, how big are the leaves, etc. and also knowledge such as which spectrum of light trigger flowering, etc.

4.3.2. PROCEDURE OF THE EXPERIMENT

Step 1: To locate a proper place outside near home area where proper sunlight is available, so that the plant gets adequate amount of direct sunlight and the plant can be maintained and looked after.

Step 2: To plant the zinnia plant in seedling stage in a rectangular tub so that atleast six plant seedling can be planted for better comparative observation.

Step 3: The zinnia seedlings were planted with atleast 10cm of gap between them to reduce shading in between them during growth.

Step 4: There was a wooden partition given in between them in the tub to differentiate the plants that will grow under direct sunlight radiation and those which will grow under diffused sunlight radiation. There were three plants that received direct sun beam radiation and other three received diffused sun beam radiation.

Step 5: A reference point was set in the soil of the tub and with a measurement tape the growth measurements were taken for several days till the plant grew from seedling to flowering plant and its growth rate was zero percentage.

4.3.3. INSTRUMENTS USED FOR THE EXPERIMENT

1. Measuring tape –

Use any normal measuring tapes in the market for measuring the growth of the zinnia plants.

4.3.4. EXPERIMENTAL SETUP

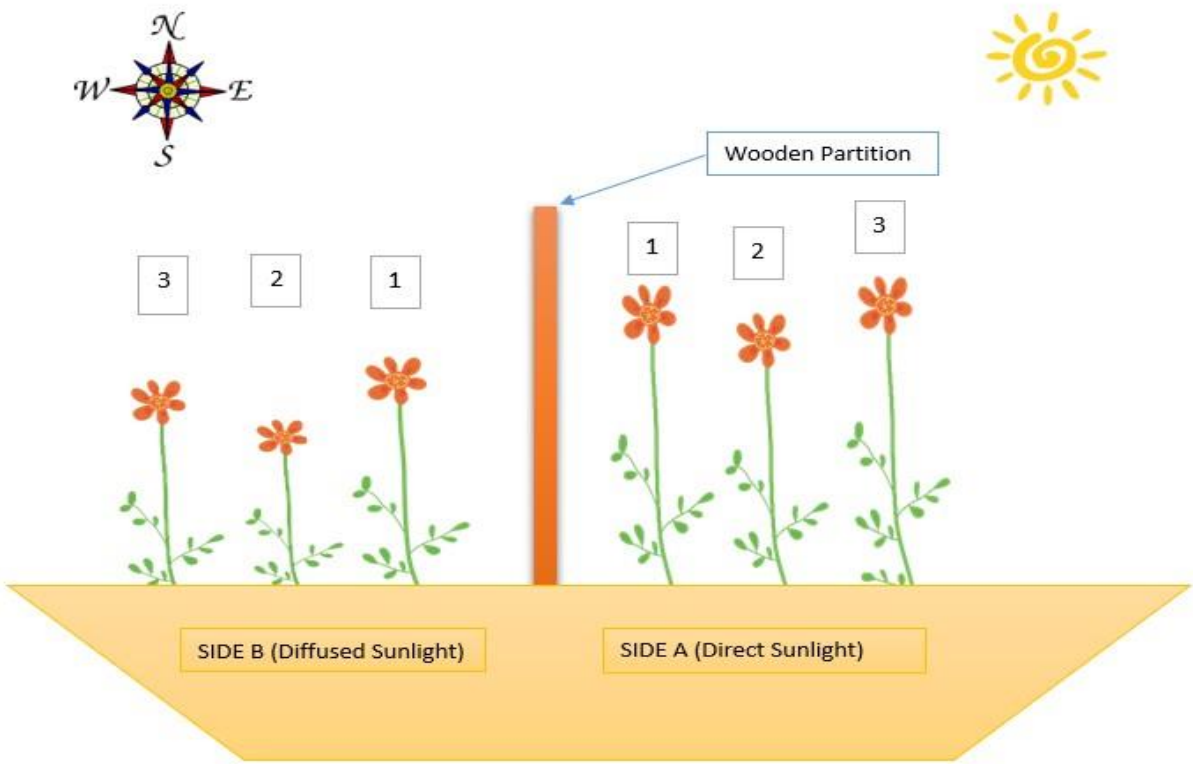

Fig 3.14 Schematic diagram of Experimental setup for measuring the growth rate of zinnia plant under direct sunlight and diffused sunlight.

Fig 3.15 Actual experimental setup for measuring the growth rate characteristic of zinnia plant

4.3.5. OBSERVATION TABLE AND GRAPHICAL REPRESENTATION

Side A (Under Direct Sun)							
Day count	Average Sunshine W/m2	Plant 1 (cm)	Plant 1 Growth rate w.r.t previous (%)	Plant 2 (cm)	Plant 2 Growth rate w.r.t previous (%)	Plant 3 (cm)	Plant 3 Growth rate w.r.t previous (%)
0	439.5	13	0	11	0	14	0
1	428.0	22	69.23	17	54.55	23	64.28
2	432.0	36	63.64	25	47.05	35	52.17
3	408.0	44	22.22	34	36.10	45	28.57
4	412.0	56	27.27	42	23.52	49	8.89
5	457.0	62	10.71	43	2.38	50	2.04
6	478.0	64	3.22	44	2.32	51	2.00
7	449.0	65	1.56	45	2.23	52	1.96

Table 4.13: Zinnia plant growth measurement observation under diffused sunlight beam radiation.

Side B (Under Diffused Sun)							
Day count	Average Sunshine W/m2	Plant 1 (cm)	Plant 1 Growth rate w.r.t previous (%)	Plant 2 (cm)	Plant 2 Growth rate w.r.t previous (%)	Plant 3 (cm)	Plant 3 Growth rate w.r.t previous (%)
0	439.5	14.0	0.00	11.0	0.00	11.0	0.00
1	428.0	17.0	21.43	15.0	36.36	13.0	18.18
2	432.0	26.0	52.94	21.0	40.00	16.0	23.08
3	408.0	31.0	19.23	27.0	28.57	20.0	25.00
4	412.0	38.0	22.58	32.5	20.37	21.0	5.00
5	457.0	41.5	9.21	33.0	1.54	21.5	2.38
6	478.0	43.0	3.61	33.5	1.52	22.0	2.33
7	449.0	43.5	1.16	34.0	1.49	22.5	2.27

Table 4.14: Zinnia plant 1 comparison observation table for direct and diffused sunlight beam.

		DIRECT SUNLIGHT		DIFFUSED SUNLIGHT	
Day count	Average Sunshine W/m2	Plant 1 (cm)	Plant 1 Growth rate w.r.t previous (%)	Plant 1 (cm)	Plant 1 Growth rate w.r.t previous (%)
0	439.5	13	0	14.0	0.00
1	428.0	22	69.23	17.0	21.43
2	432.0	36	63.64	26.0	52.94
3	408.0	44	22.22	31.0	19.23
4	412.0	56	27.27	38.0	22.58
5	457.0	62	10.71	41.5	9.21
6	478.0	64	3.23	43.0	3.61
7	449.0	65	1.56	43.5	1.16

Table 4.15: Zinnia plant 2 comparison observation table for direct and diffused sunlight beam.

		DIRECT SUNLIGHT		DIFFUSED SUNLIGHT	
Day count	Average Sunshine W/m2	Plant 2 (cm)	Plant 2 Growth rate w.r.t previous (%)	Plant 2 (cm)	Plant 2 Growth rate w.r.t previous (%)
0	439.5	11	0	11.0	0.00
1	428.0	17	54.55	15.0	36.36
2	432.0	25	47.06	21.0	40.00
3	408.0	34	36.00	27.0	28.57
4	412.0	42	23.53	32.5	20.37
5	457.0	43	2.38	33.0	1.54
6	478.0	44	2.33	33.5	1.52
7	449.0	45	2.27	34.0	1.49

Table 4.16: Zinnia plant 3 comparison observation table for direct and diffused sunlight beam.

		DIRECT SUNLIGHT		DIFFUSED SUNLIGHT	
Day count	Average Sunshine W/m2	Plant 3 (cm)	Plant 3 Growth rate w.r.t previous (%)	Plant 3 (cm)	Plant 3 Growth rate w.r.t previous (%)
0	439.5	14	0.00	11.0	0.00
1	428.0	23	64.29	13.0	18.18
2	432.0	35	52.17	16.0	23.08
3	408.0	45	28.57	20.0	25.00
4	412.0	49	8.89	21.0	5.00
5	457.0	50	2.04	21.5	2.38
6	478.0	51	2.00	22.0	2.33
7	449.0	52	1.96	22.5	2.27

Graphical representation of comparison of growth rate with days count for zinnia plant 1 under direct sunlight beam and diffused sunlight beam:

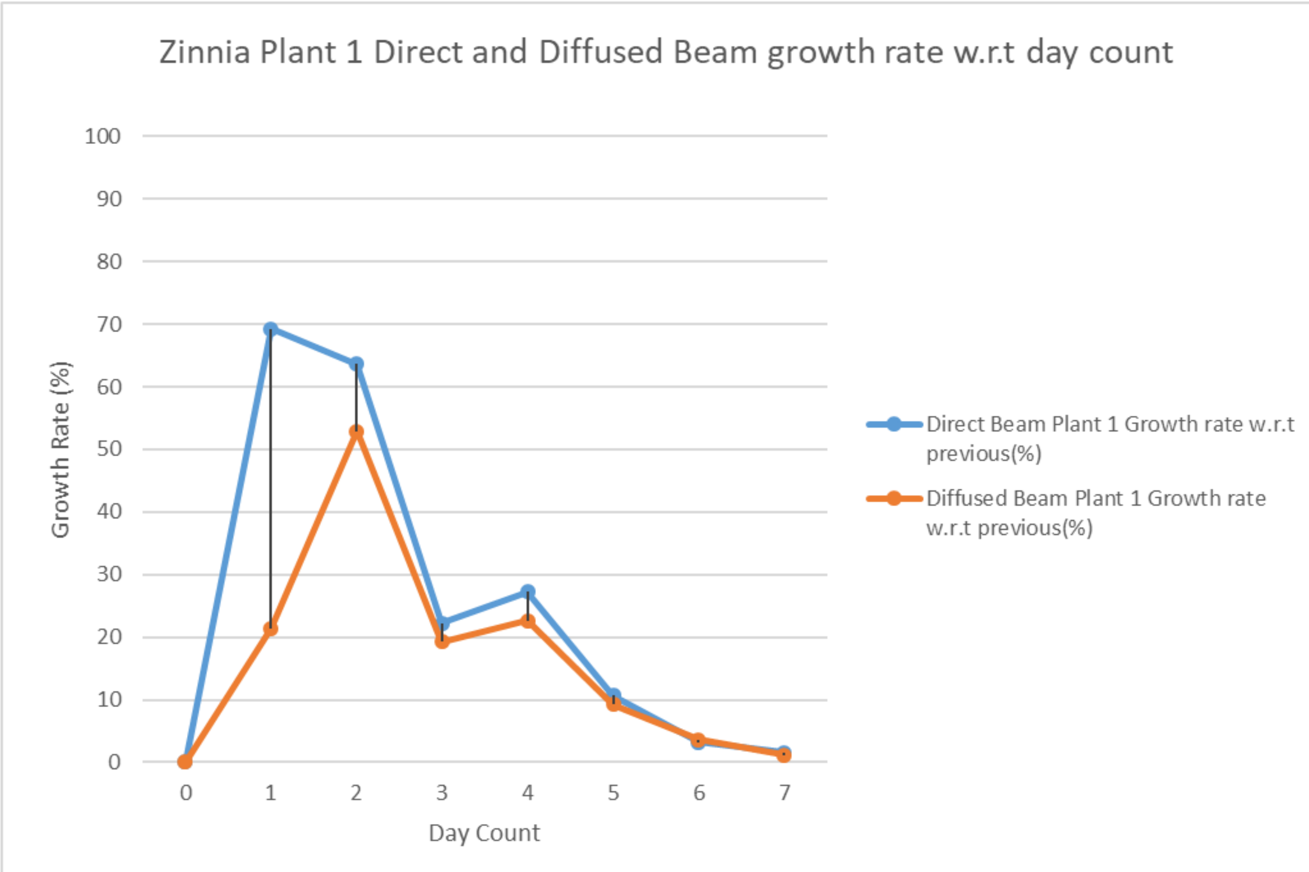

Fig 4.15 Graphical representation comparison of growth rate with days count for zinnia plant 1 under direct sunlight beam and diffused sunlight beam.

Graphical representation of comparison of growth rate with days count for zinnia plant 2 under direct sunlight beam and diffused sunlight beam:

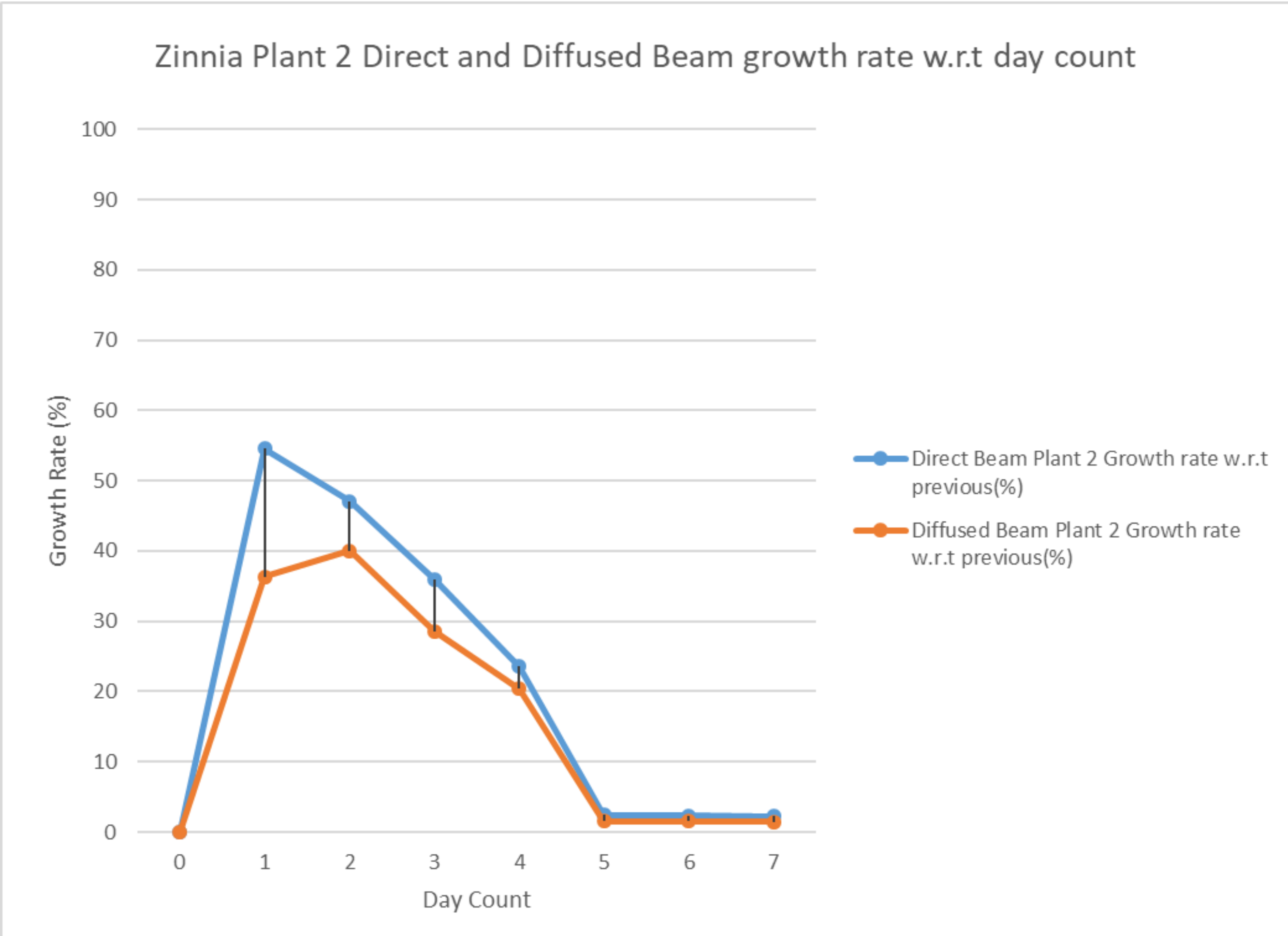

Fig 4.16 Graphical representation comparison of growth rate with days count for zinnia plant 2 under direct sunlight beam and diffused sunlight beam.

Graphical representation of comparison of growth rate with days count for zinnia plant 3 under direct sunlight beam and diffused sunlight beam:

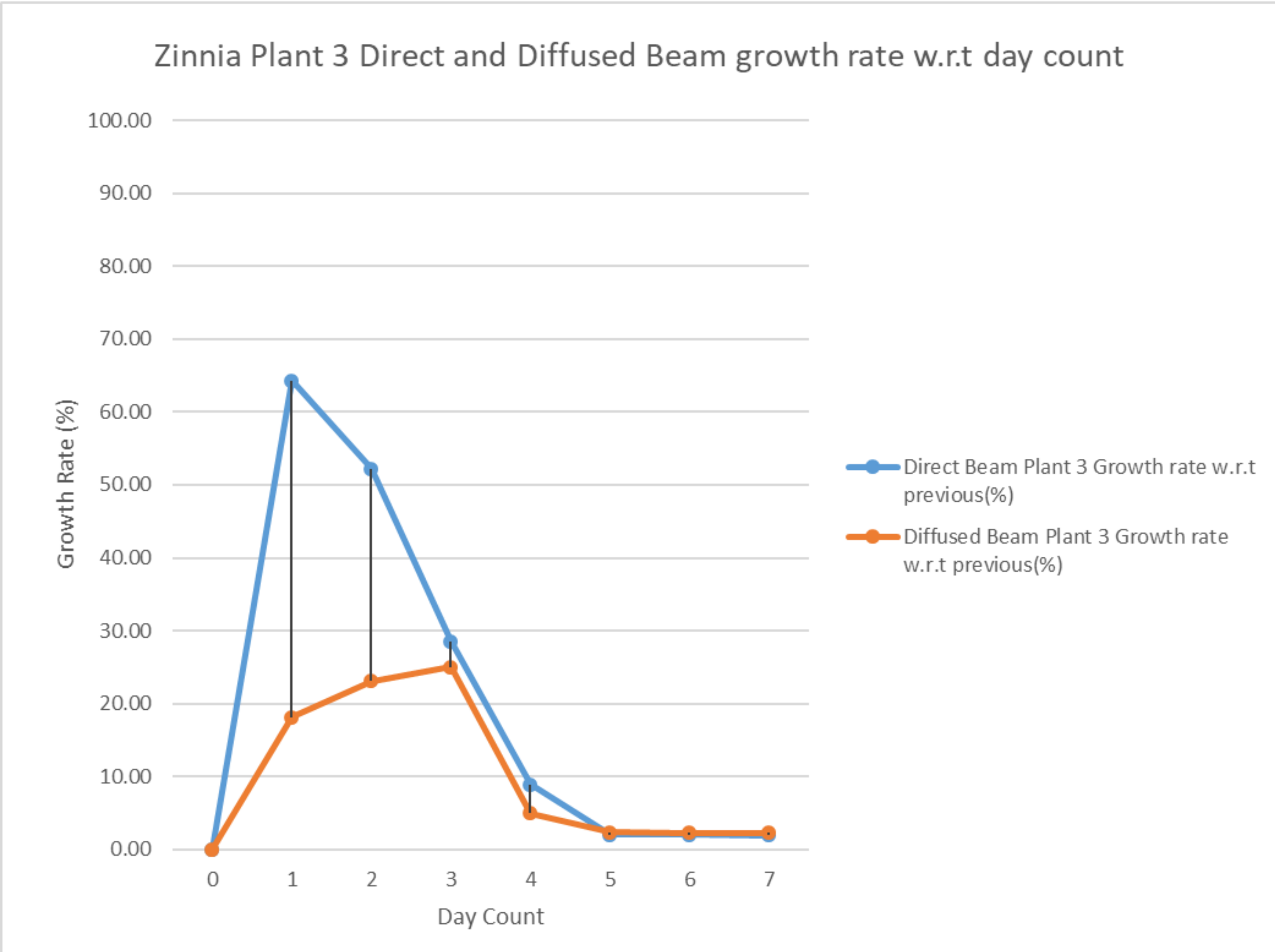

Fig 4.17 Graphical representation comparison of growth rate with days count for zinnia plant 3 under direct sunlight beam and diffused sunlight beam.

4.3.6 RESULT ANALYSIS

This experiment was conducted in a rectangular plant tub and zinnia plant were planted on it. Three plants were planted on each side of the tub which was separated with a wooden partition. The wooden partition provided the plants with diffused sunlight. The growth of the plants was observed for over a period of one month till the flower blooms fully and the plant shades its leaf. For four weeks growth readings were taken twice a week accounting to eight sets of reading. Measurement tape was used and readings were noted down.

In the first case it was observed that the plants receiving direct sun beam were growing faster initially than those receiving diffused beam. If we see the observation table the Plant1 on the direct sun beam side had an initial growth rate of 69% whereas on the diffused beam side the growth rate was only 21%. This trend was maintained throughout the experiment.

The plants receiving direct beams grew taller than those receiving diffused sun beams. The plants with diffused sun beams had retarded growth rate also their overall growth was less than those receiving direct sun beam. Both the set of plants had budding period at same week and also started giving flowers at the same time despite of there growth difference. It can be said from above observation that flower bloom timing of a plant does not depend upon direct sunlight but the growth of a plant is totally depended on the amount of sunlight beam it receives.

It was also observed that when the budding started to occur the growth rate of both the set of plants suddenly dropped. And after the flowering condition of the plant, its growth rate totally saturated and finally stopped after few days. This also shows us that the flowers while blooming takes up the maximum amount of energy present inside a plant to itself, thus despite of receiving direct sun beam or diffused sun beam the growth of the plant stops suddenly.

Summary – The sunlight has direct effect on the growth of the plant experimented, though the amount of intensity of the sun receiving by the plant does not have any direct effect on the flowering phenomenon of the plant. Flowering is mostly dependent on the quality and spectrum of light the plant receives, in this case both plants received similar wavelength spectrum light so flowering occurred in same time.

4.4. CASE STUDY 4: TO STUDY THE HIBISCUS ROSA-SINENSIS (CHINA ROSE) PLANT UV-A ABSORPTION UNDER DIFFERENT ARTIFICIAL LAMP

4.4.1. OBJECTIVE OF THE EXPERIMENT

To study the UV absorption characteristic of Hibiscus rosa-sinensis plant under artificial lamp this experiment was conducted inside the premises of school of illumination science, engineering and design. The main objective is to understand and observe how UV radiation specifically UV-A emitting from different artificial lamp is absorbed by the plant. Hibiscus is a pretty common Indian household plant as in most of the houses its flower is required for religious purpose, so almost every Indian house have a chance to have atleast one hibiscus plant. Now from the experiment conducted if it can be observed that this plant is good for UV absorption then it can be further suggested that this plant can be kept indoor near artificial lamps which may help to absorb the harmful UV and also those lamps can help them to grow as we know that UV spectrum have a power to trigger some photoreceptors of a plant. This experiment will also help us to understand how different stages of a plant absorbs UV radiation, as this experiment was conducted in stages where at first the plant had no flower or bud in it and UV readings were taken, then the plant had only bud when again UV readings were taken and then the plant with flowers were taken for the experiment and UV radiation readings were taken. This experiment will also help us to understand how plants can act as a natural device in absorbing UV radiation from artificial lamps.

4.4.2. PROCEDURE OF THE EXPERIMENT

Step 1: Collect market available lamp which are used for Indoor lighting environment like: Compact Fluorescent lamps and Incandescent lamps.

Step 2: Now secure and position the lamp with holder arrangement in the room where experiment will be done. Dark room is preferred for lighting experiments but if that is not available any room can be used with all lights turned off and windows also closed so no external light comes in. This may have minute errors in the readings.

Step 3: For this experiment small plant tub is used where hibiscus plant is grown and these tubs needs to be placed safely beside the lamp and holder system so that the UV rays emitting from the artificial light can react with the plant system for experiment.

Step 4: From the centre of the lamp a grid is consider perpendicular to it. From there a measuring tape is held, then at every one-inch grid difference from the centre of the lamp UV-A measurements were taken and observed.

Step 5: For UV-A measurements, Everfine U20 UV radiometer was used throughout the experiment, it has a special feature of backlight so even in dark room taking readings were not an issue.

Step 6: UV measurements were taken for every hibiscus plant of red, white and sandal colour flowers. Measurements were taken with no plant, plant with flower only, without flower and bud and with bud only. Artificial lamps available were changed accordingly and measurements were taken.

4.4.3. INSTRUMENTS USED FOR THE EXPERIMENT

1. UV Radiometer: Everfine make, Model no. U20

There are several radiometer models on the market that provide various types of information. A radiometer should be chosen to fit the application and the information required. Everfine U20 UV radiometer comes with UV-A measuring sensor for taking record of the UV-A radiation that is coming through the atmosphere to earth surface as a part of understanding solar radiation characteristic. The device features compact structure, good stability and high stray light control ability. It is widely used in ultraviolet light, disinfection and sterilization, light medical treatment, aging, detection, photolithography, light curing, breeding, plant cultivation, and UV index evaluation. Users can select the corresponding UV detectors for different response wavebands according to actual application. Range: SUVA sensor 320nm-390nm [6].

2. Measuring tape:

Use any normal measuring tapes in the market for measuring the grid distance. It is used to place the UV sensor at exact grid point to take accurate readings.

3. Lamp and lamp holder:

Philips 100Watt Incandescent lamp with 2700K CCT B22 is used in the experiment with holder. Also, Philips 14W CFL cool daylight 6500K B22 lamp is used in the experiment with holder suitable with it.

4.4.4. EXPERIMENTAL SETUP

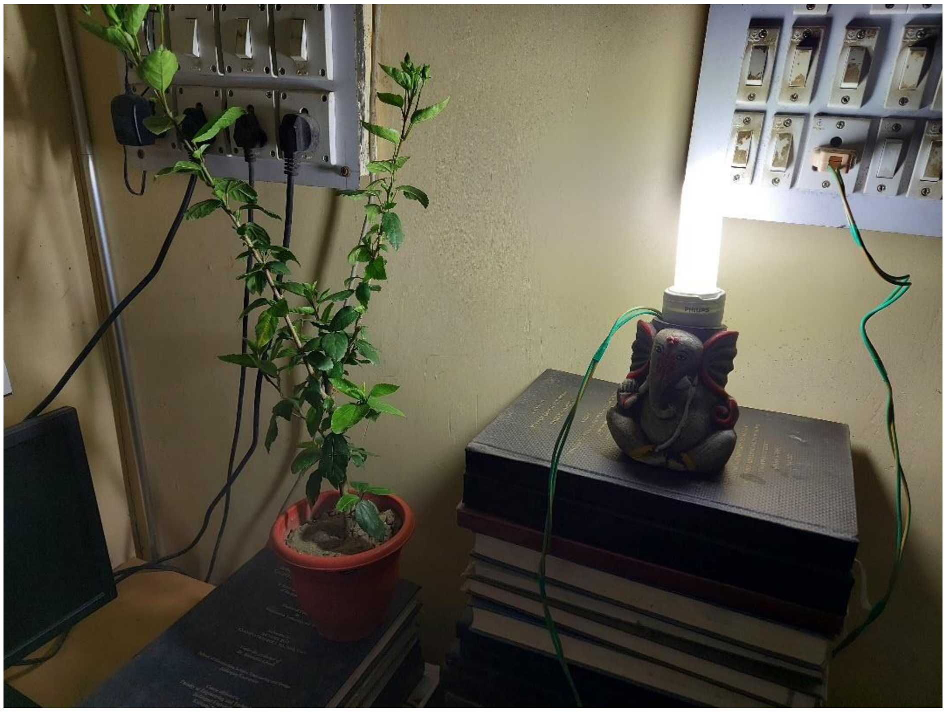

Fig 4.18 CFL lamp UV-A absorption is being tested for hibiscus plant with buds only.

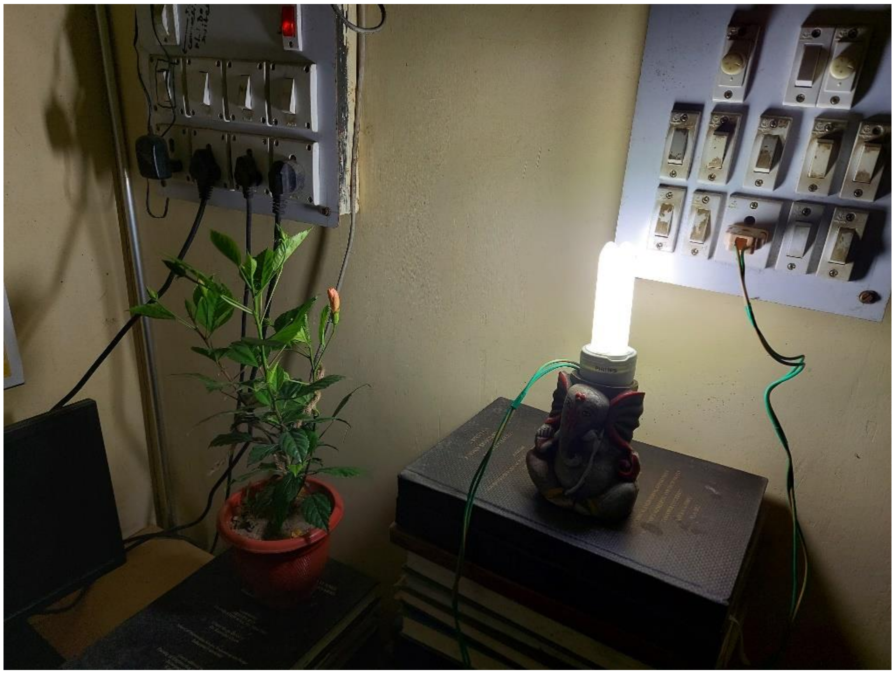

Fig 4.19 CFL lamp UV-A absorption is being tested for hibiscus plant without flower and bud.

Fig 4.20 Incandescent lamp UV-A absorption is being tested for hibiscus plant with flowers only.

NOTE: Due to sudden fire incident, our laboratory had been destroyed.
The experiments have been carried out in teacher's chamber with makeshift set up.

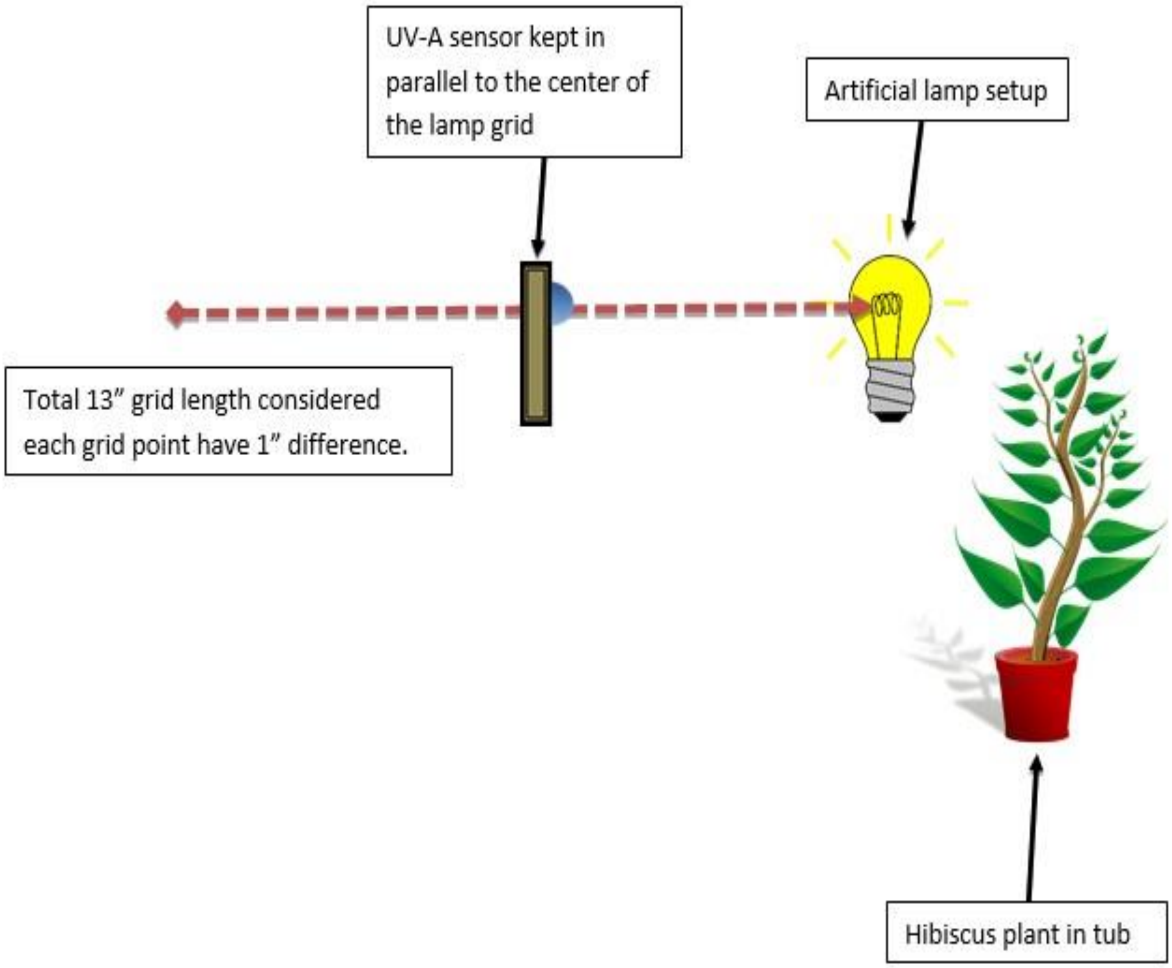

Fig 4.21 Schematic diagram of experimental setup with hibiscus plant and artificial lamp for measuring UV-A radiation.

4.4.5. OBSERVATION TABLE AND GRAPHICAL REPRESENTATION

Table 4.17 Tabular representation comparison of UV-A absorption of hibiscus plant under different condition (Red Hibiscus plant, CFL 6500K):

Distance	Without Plant (UV-A in μW/cm²)	**Red Hibiscus Plant** (UV-A in μW/cm²)		
		No Bud & Flower	*With Bud only*	*With Flower*
2"	184.0	147.3	148.2	149.0
3"	89.0	68.3	69.2	70.5
4"	72.2	49.2	50.0	50.6
5"	42.3	26.3	27.1	29.0
6"	24.1	14.4	15.0	16.0
7"	18.9	10.8	11.2	12.0
8"	11.1	5.0	5.2	6.0
9"	5.2	2.0	3.5	4.0
10"	2.3	0.5	0.6	1.0
11"	0.0	0.0	0.0	0.0
12"	0.0	0.0	0.0	0.0
13"	0.0	0.0	0.0	0.0

Graphical representation comparison of UV-A for red hibiscus rosa-sinensis plant under different condition for CFL 6500K artificial light source:

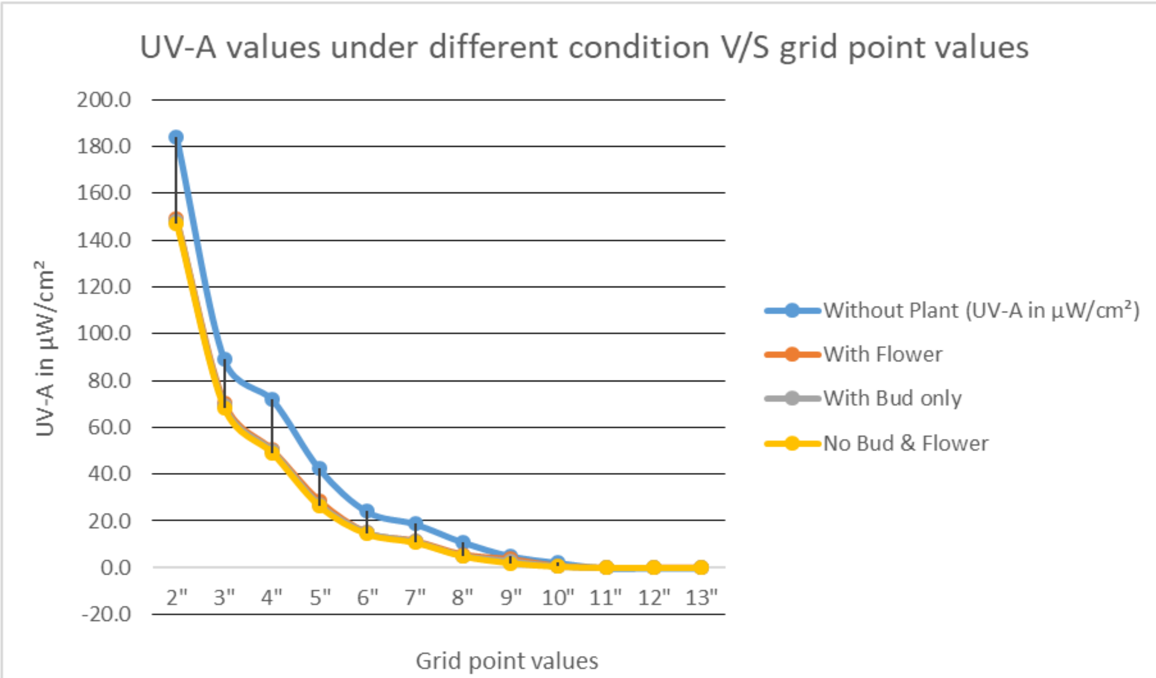

Fig 4.22 Graphical representation comparison of UV-A for red hibiscus rosa-sinensis plant using CFL 6500K artificial lamp.

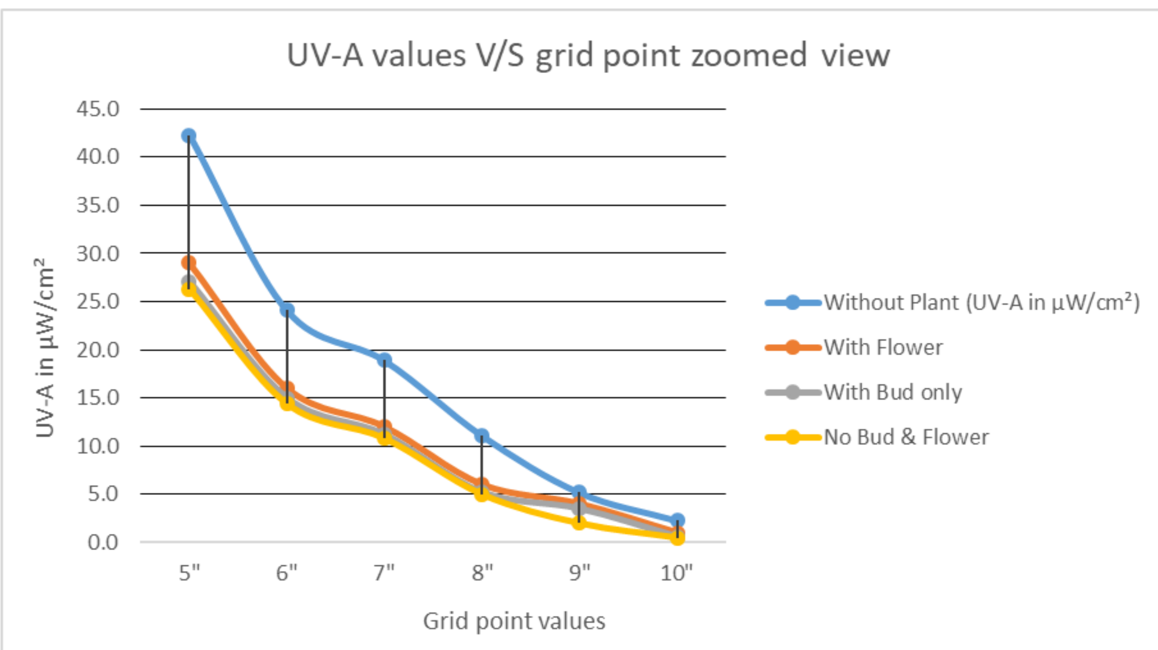

Fig 4.23 Zoomed view of the above UV-A vs grid point graphical representation for better understanding. *Note – grid point values from 5” to 10” are taken along with their UV-A readings.

Table 4.18 Tabular representation comparison of UV-A absorption of hibiscus plant under different condition (Sandal Hibiscus plant, CFL 6500K)

Distance	Without Plant (UV-A in μW/cm²)	Sandal Hibiscus (UV-A in μW/cm²)		
		No Bud & Flower	*With Bud only*	*With Flower*
2"	184.0	160.8	164.0	166.3
3"	89.0	71.0	71.7	72.8
4"	72.2	48.6	51.8	52.1
5"	42.3	24.0	25.1	27.6
6"	24.1	14.3	15.1	17.8
7"	18.9	7.4	7.9	11.5
8"	11.1	4.5	4.6	5.7
9"	5.2	2.1	2.3	3.7
10"	2.3	0.4	0.5	0.9
11"	0.0	0.0	0.0	0.0
12"	0.0	0.0	0.0	0.0
13"	0.0	0.0	0.0	0.0

Graphical representation comparison of UV-A for sandal hibiscus rosa-sinensis plant under different condition for CFL 6500K artificial light source:

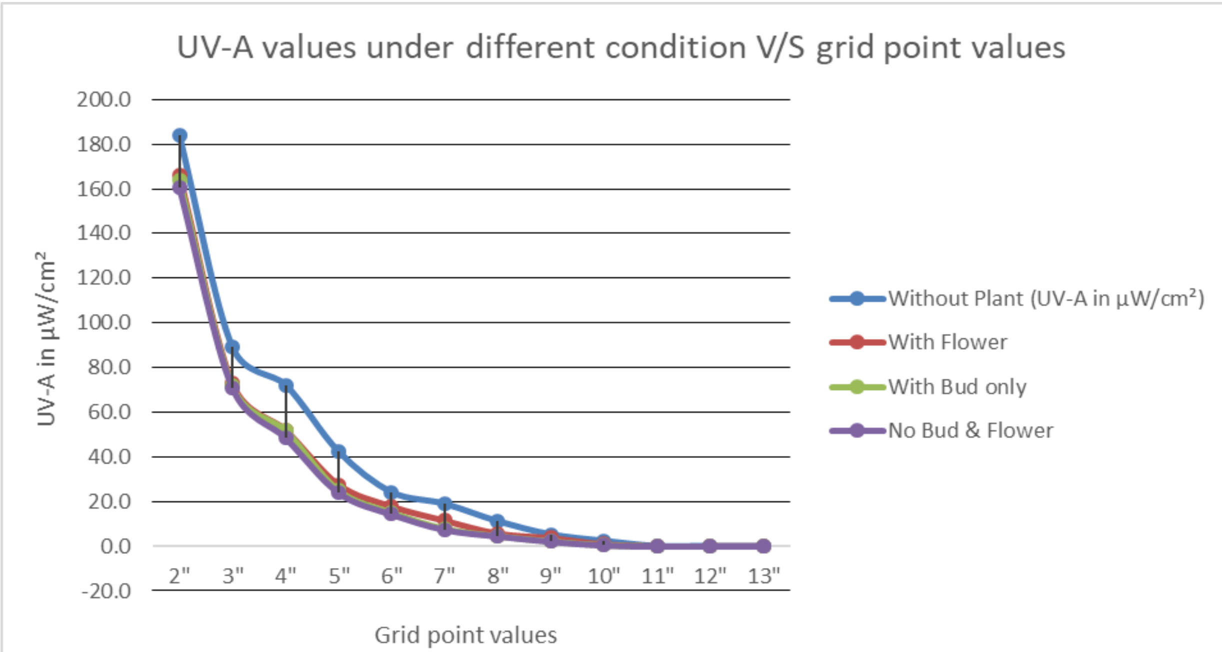

Fig 4.24 Graphical representation comparison of UV-A for sandal hibiscus rosa-sinensis plant using CFL 6500K artificial lamp.

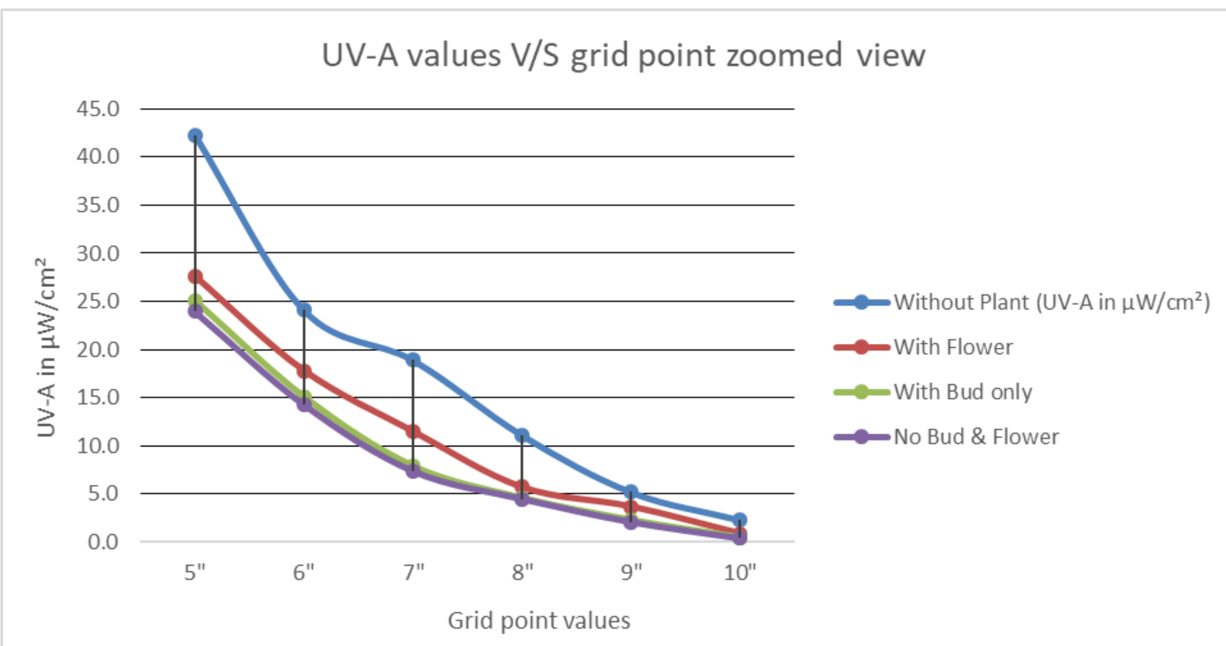

Fig 4.25 Zoomed view of the above UV-A vs grid point graphical representation for better understanding. *Note – grid point values from 5” to 10” are taken along with their UV-A readings.

Table 4.19 Tabular representation comparison of UV-A absorption of hibiscus plant under different condition (White Hibiscus plant, CFL 6500K)

Distance	Without Plant (UV-A in µW/cm²)	**White Hibiscus (UV-A in µW/cm²)**		
		No Bud & Flower	*With Bud only*	*With Flower*
2"	184.0	181.0	182.4	183.1
3"	89.0	72.4	73.1	74.2
4"	72.2	43.1	44.3	46.2
5"	42.3	24.2	24.8	29.7
6"	24.1	17.8	18.2	18.5
7"	18.9	11.2	13.2	14.1
8"	11.1	5.3	5.5	6.5
9"	5.2	2.5	3.4	4.9
10"	2.3	0.6	0.8	1.7
11"	0.0	0.0	0.0	0.2
12"	0.0	0.0	0.0	0.0
13"	0.0	0.0	0.0	0.0

Graphical representation comparison of UV-A for white hibiscus rosa-sinensis plant under different condition for CFL 6500K artificial light source:

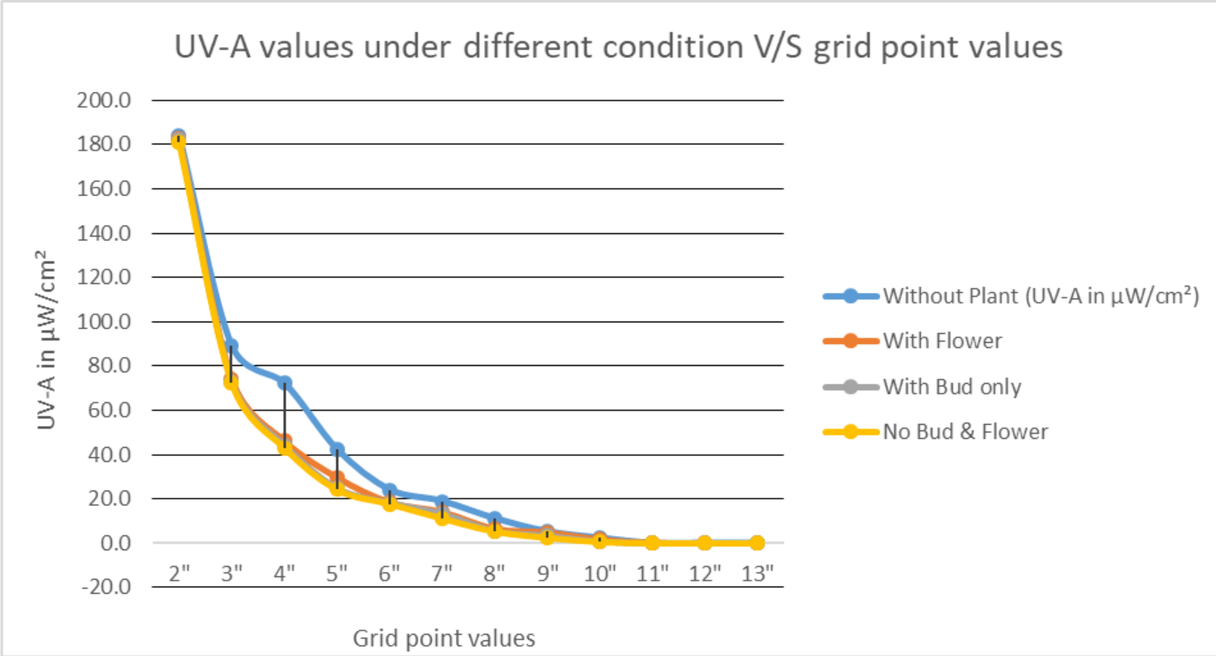

Fig 4.26 Graphical representation comparison of UV-A for white hibiscus rosa-sinensis plant using CFL 6500K artificial lamp.

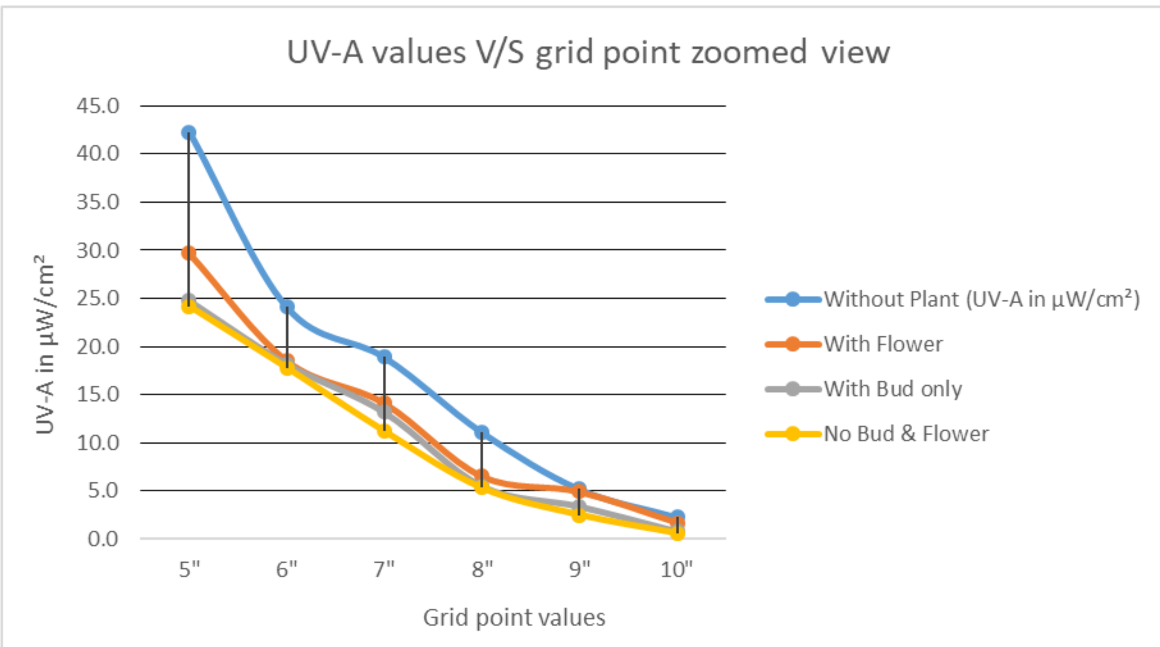

Fig 4.27 Zoomed view of the above UV-A vs grid point graphical representation for better understanding. *Note – grid point values from 5” to 10” are taken along with their UV-A readings.

Table 4.20 Tabular representation comparison of UV-A absorption of hibiscus plant under different condition (Red Hibiscus plant, Incandescent lamp 2700K):

Distance	Without Plant	**Red Hibiscus** (UV-A in μW/cm²)		
		No Bud & Flower	*With Bud only*	*With Flower*
2"	189.0	139.1	140.5	142.3
3"	96.0	88.6	89.1	90.7
4"	71.4	55.4	57.2	58.5
5"	48.6	34.6	35.4	36.8
6"	33.1	27.1	28.9	30.2
7"	21.4	16.8	17.7	18.2
8"	14.2	11.6	12.1	12.8
9"	12.1	7.5	8.0	8.6
10"	6.5	6.0	6.7	7.0
11"	5.0	1.8	2.6	3.0
12"	1.3	0.3	0.6	0.8
13"	0.0	0	0	0.0

Graphical representation comparison of UV-A for red hibiscus rosa-sinensis plant under different condition for Incandescent 2700K artificial light source:

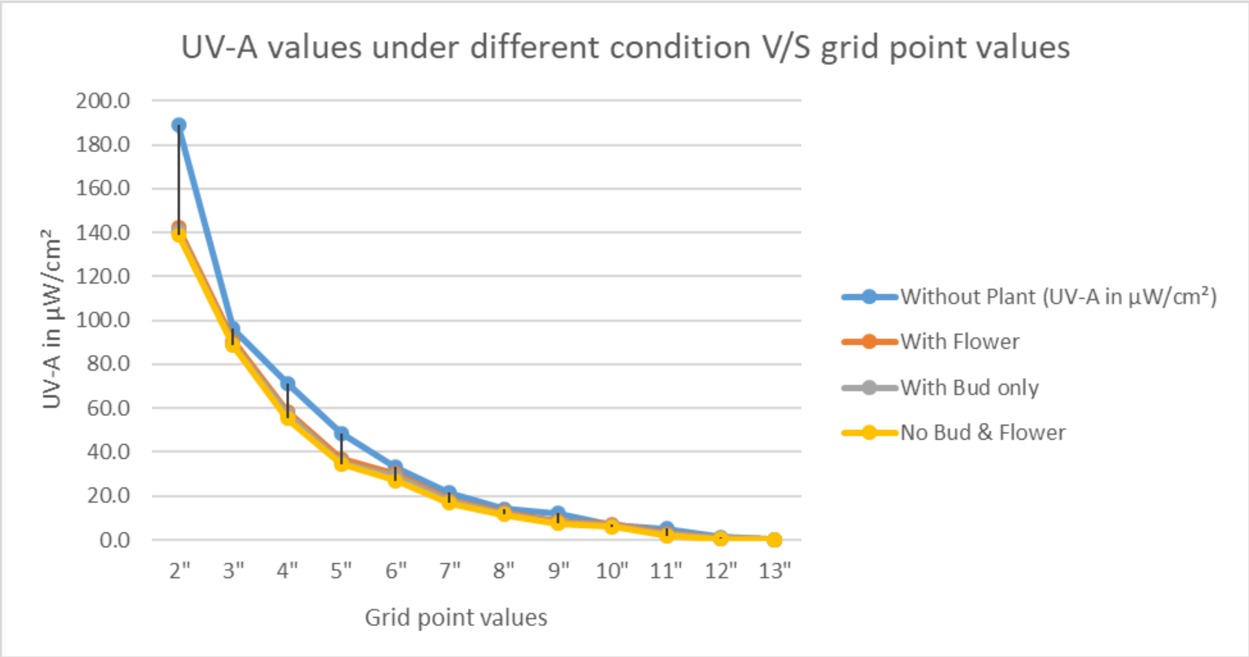

Fig 4.28 Graphical representation comparison of UV-A for red hibiscus rosa-sinensis plant using Incandescent 2700K artificial lamp.

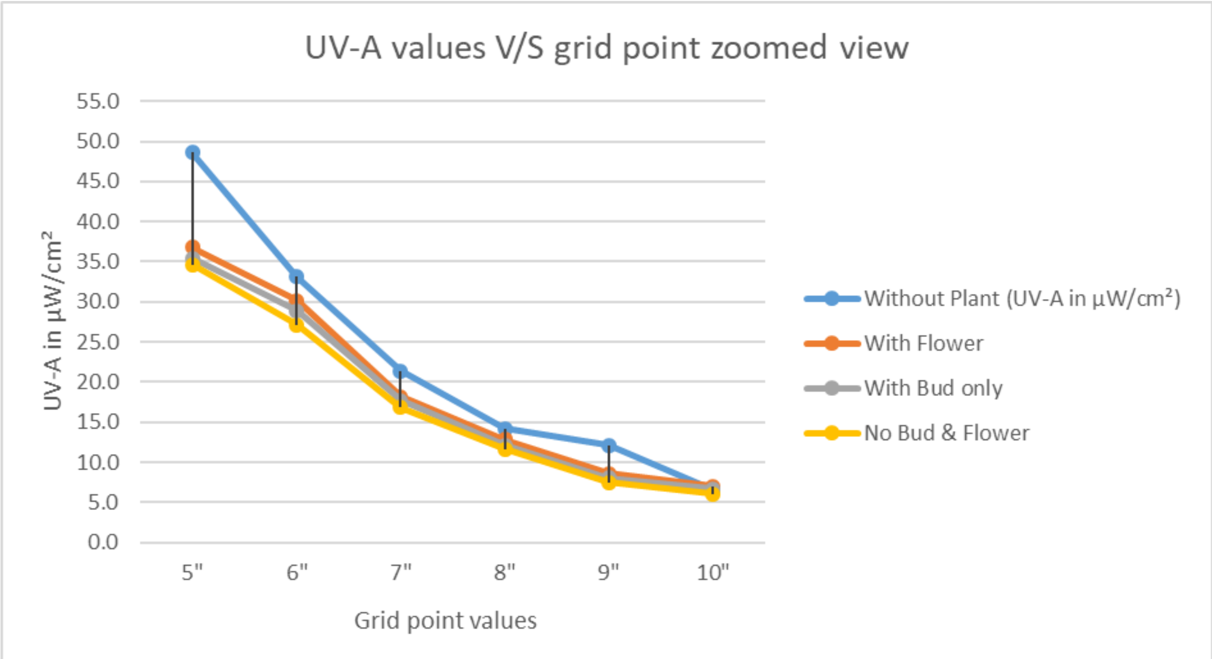

Fig 4.29 Zoomed view of the above UV-A vs grid point graphical representation for better understanding. *Note – grid point values from 5” to 10” are taken along with their UV-A readings.

Table 4.21 Tabular representation comparison of UV-A absorption of hibiscus plant under different condition (Sandal Hibiscus plant, Incandescent lamp 2700K)

Distance	Without Plant (UV-A in µW/cm²)	**Sandal Hibiscus** (UV-A in µW/cm²)		
		No Bud & Flower	*With Bud only*	*With Flower*
2"	189.0	165.1	167.5	168.5
3"	96.0	86.2	87.5	88.2
4"	71.4	59.3	60.1	62.3
5"	48.6	36.8	37.7	38.1
6"	33.1	29.6	30.5	31.4
7"	21.4	19.1	19.6	21.0
8"	14.2	13.8	14.5	15.3
9"	12.1	9.8	9.7	10.1
10"	6.5	5.7	6.0	6.2
11"	5.0	2.8	3.1	3.3
12"	1.3	0.4	0.8	1.0
13"	0.0	0	0.0	0

Graphical representation comparison of UV-A for sandal hibiscus rosa-sinensis plant under different condition for Incandescent 2700K artificial light source:

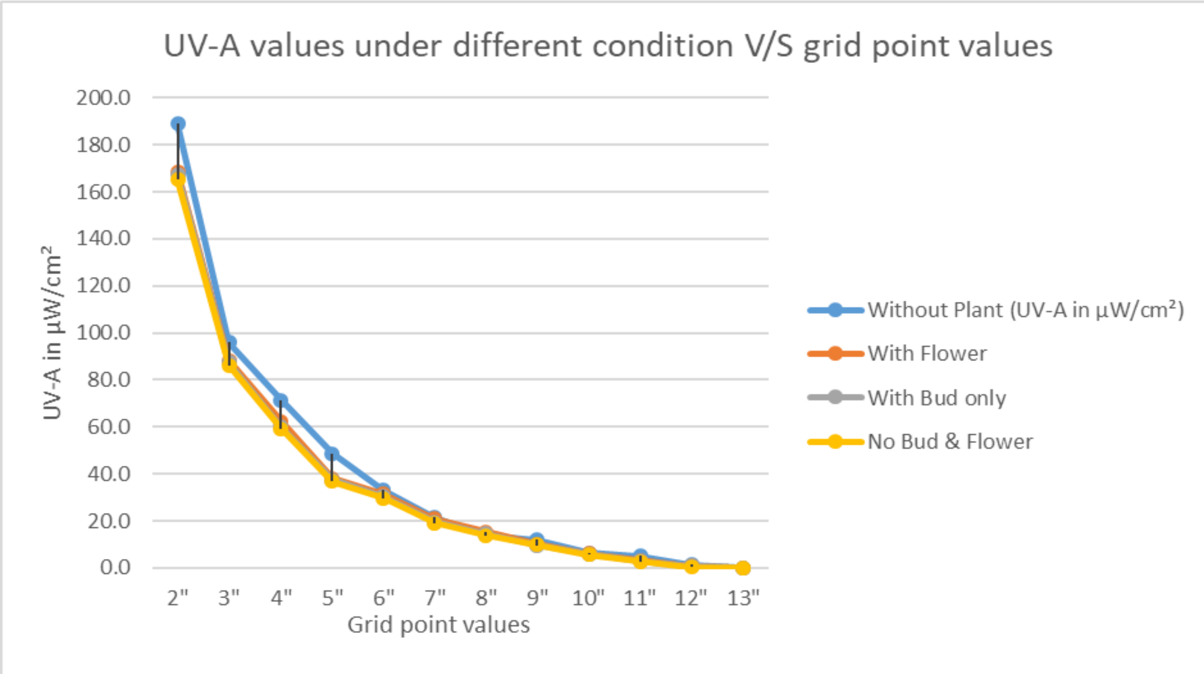

Fig 4.30 Graphical representation comparison of UV-A for sandal hibiscus rosa-sinensis plant using Incandescent 2700K artificial lamp.

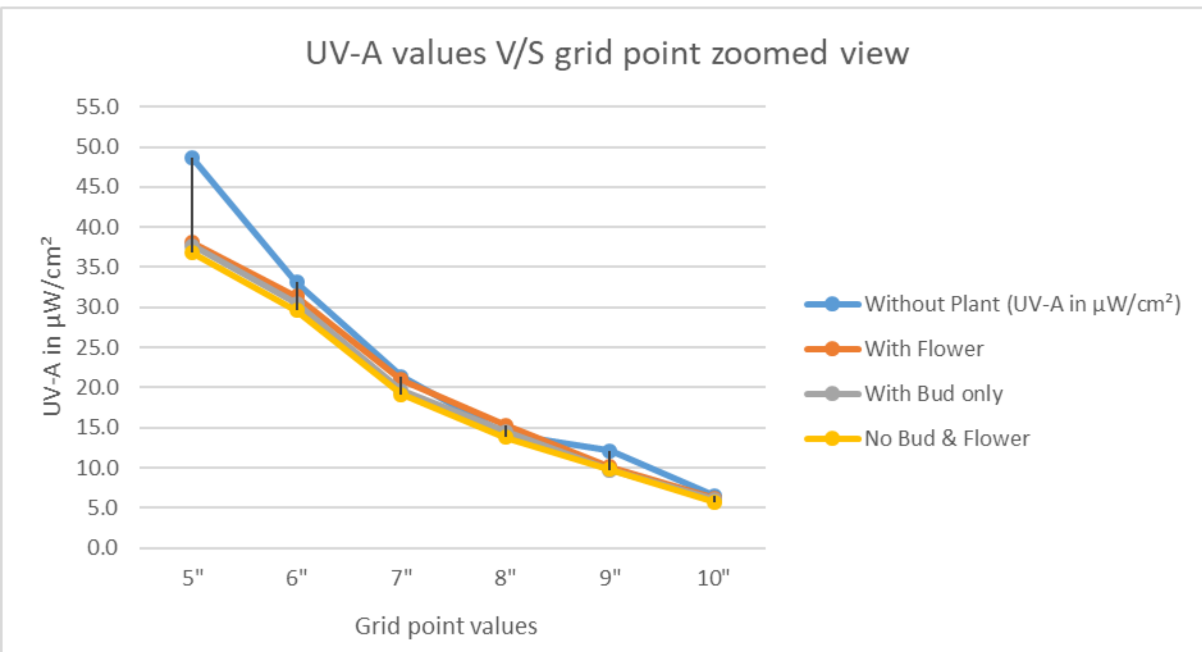

Fig 4.31 Zoomed view of the above UV-A vs grid point graphical representation for better understanding. *Note – grid point values from 5" to 10" are taken along with their UV-A readings.

Table 4.22 Tabular representation comparison of UV-A absorption of hibiscus plant under different condition (White Hibiscus plant, Incandescent lamp 2700K)

Distance	Without Plant (UV-A in μW/cm²)	**White Hibiscus** (UV-A in μW/cm²)		
		No Bud & Flower	*With Bud only*	*With Flower*
2"	189.0	173.0	177.0	179.2
3"	96.0	93.0	96.8	100.3
4"	71.4	59.5	57.9	59.6
5"	48.6	42.4	39.2	41.8
6"	33.1	32.4	26.7	30.9
7"	21.4	20.2	22.3	24.0
8"	14.2	14.3	15.5	15.7
9"	12.1	10.4	9.6	10.1
10"	6.5	6.3	6.4	6.5
11"	5.0	3.3	3.0	4.4
12"	1.3	0.9	1.0	1.2
13"	0.0	0.0	0.0	0.2

Graphical representation comparison of UV-A for white hibiscus rosa-sinensis plant under different condition for Incandescent 2700K artificial light source:

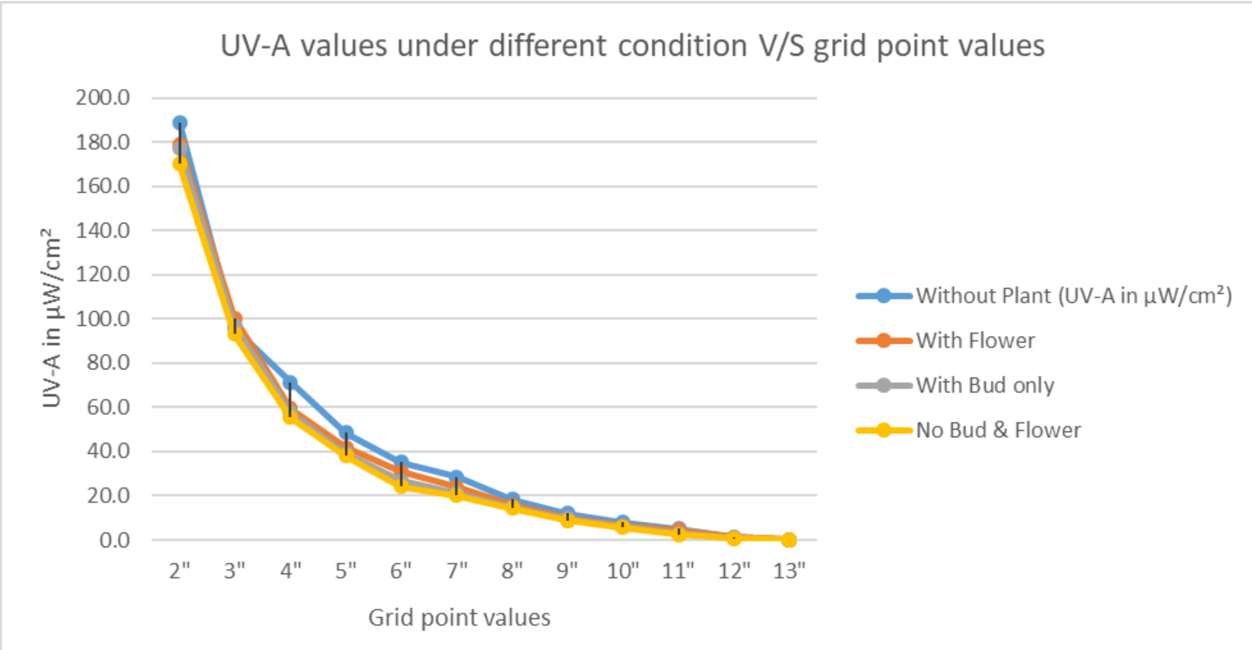

Fig 4.32 Graphical representation comparison of UV-A for white hibiscus rosa-sinensis plant using Incandescent 2700K artificial lamp.

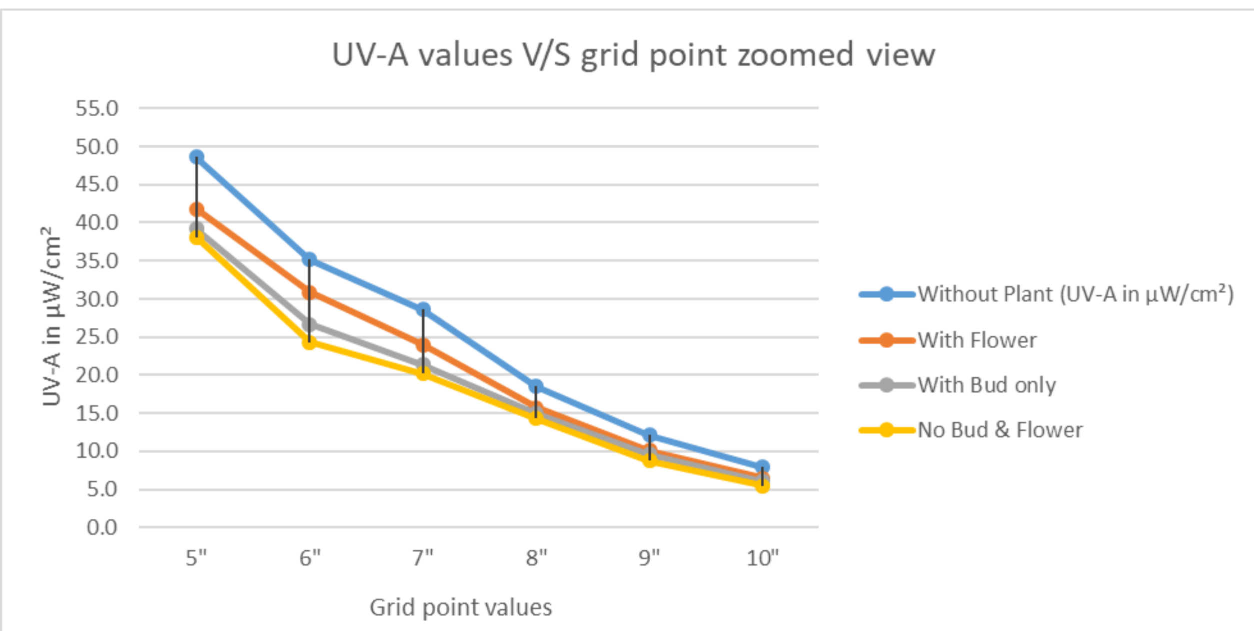

Fig 4.33 Zoomed view of the above UV-A vs grid point graphical representation for better understanding. *Note – grid point values from 5” to 10” are taken along with their UV-A readings.

Table 4.22 Tabular representation comparison of UV-A for different colour hibiscus rosa-sinensis plant under budding condition using Incandescent lamp 2700K

Distance	UV-A content in µW/cm²		
	Red flower bud only	*Sandal flower bud only*	*White flower bud only*
2"	140.5	167.5	177.0
3"	85.4	87.5	96.8
4"	57.2	60.1	64.4
5"	35.4	37.7	39.2
6"	28.9	30.5	34.5
7"	17.7	19.6	21.4
8"	12.1	14.0	15.0
9"	8.0	9.7	10.8
10"	6.7	7.2	8.4
11"	2.6	3.1	3.8
12"	0.6	0.8	1.0
13"	0	0.0	0.0

Graphical representation comparison of UV-A for different colour hibiscus rosa-sinensis plant under budding condition for Incandescent 2700K artificial light source:

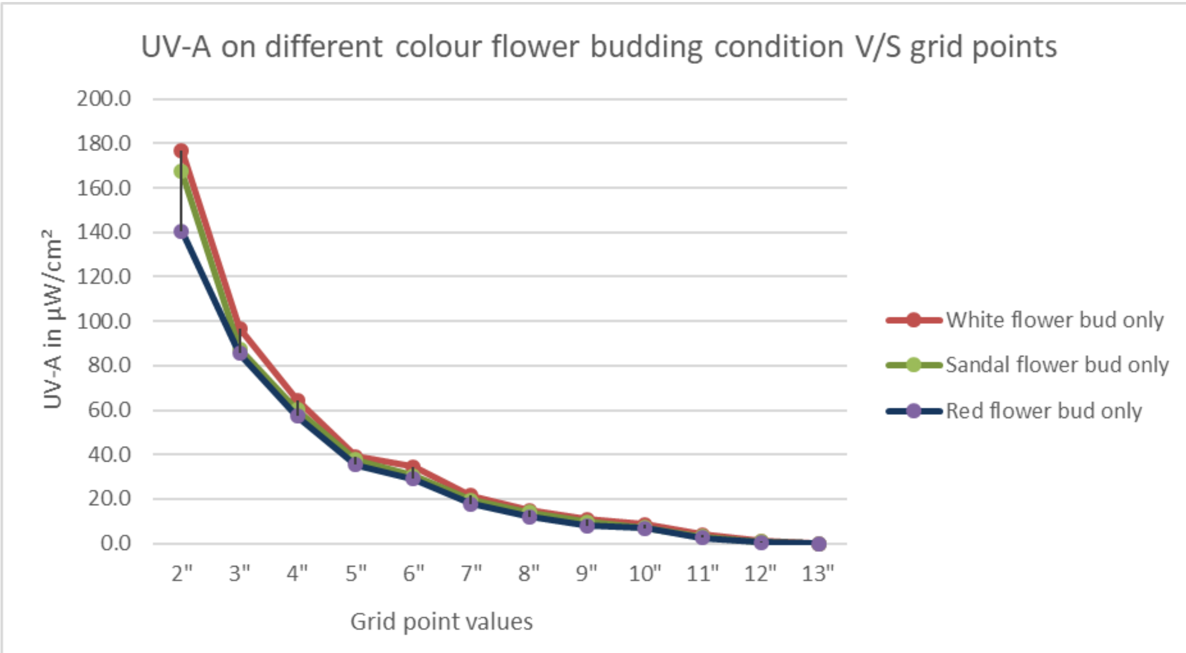

Fig 4.34 Graphical representation comparison of UV-A for different colour hibiscus rosa-sinensis plant under budding condition using Incandescent 2700K artificial lamp.

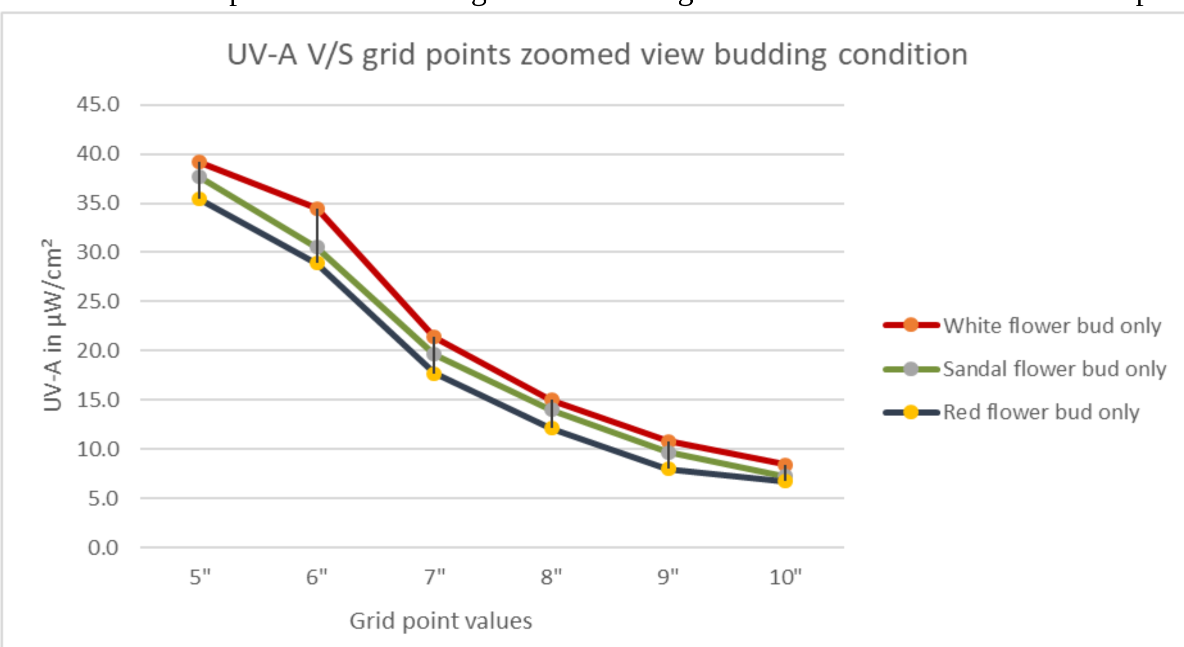

Fig 4.35 Zoomed view of the above UV-A vs grid point graphical representation for better understanding. *Note – grid point values from 5" to 10" are taken along with their UV-A readings.

Table 4.23 Tabular representation comparison of UV-A for different colour hibiscus rosa-sinensis plant under budding condition using CFL lamp 6500K.

Distance	UV-A content in μW/cm²		
	Red flower bud only	*Sandal flower bud only*	*White flower bud only*
2"	148.2	164.0	182.4
3"	69.2	71.7	73.1
4"	50.0	51.8	55.3
5"	27.1	29.4	32.4
6"	15.0	16.1	18.2
7"	11.2	12.2	13.5
8"	5.2	5.5	6.9
9"	3.5	4.3	5.7
10"	0.4	0.9	1.2
11"	0.0	0.0	0.0
12"	0.0	0.0	0.0
13"	0.0	0.0	0.0

Graphical representation comparison of UV-A for different colour hibiscus rosa-sinensis plant under budding condition for CFL 6500K artificial light source:

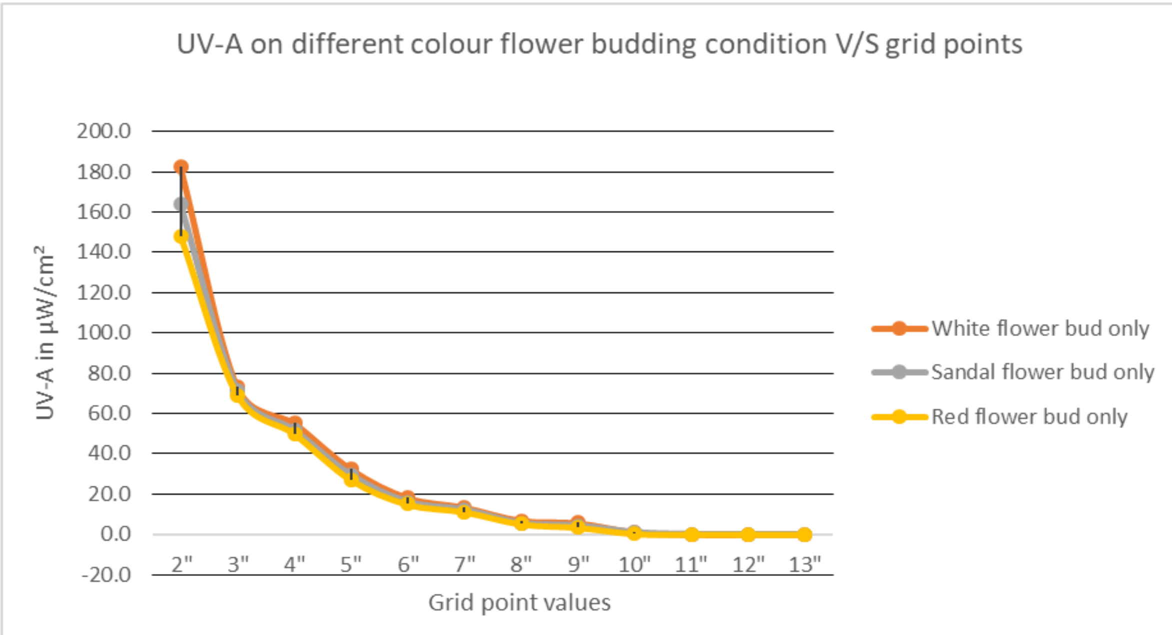

Fig 4.36 Graphical representation comparison of UV-A for different colour hibiscus rosa-sinensis plant under budding condition using CFL 6500K artificial lamp.

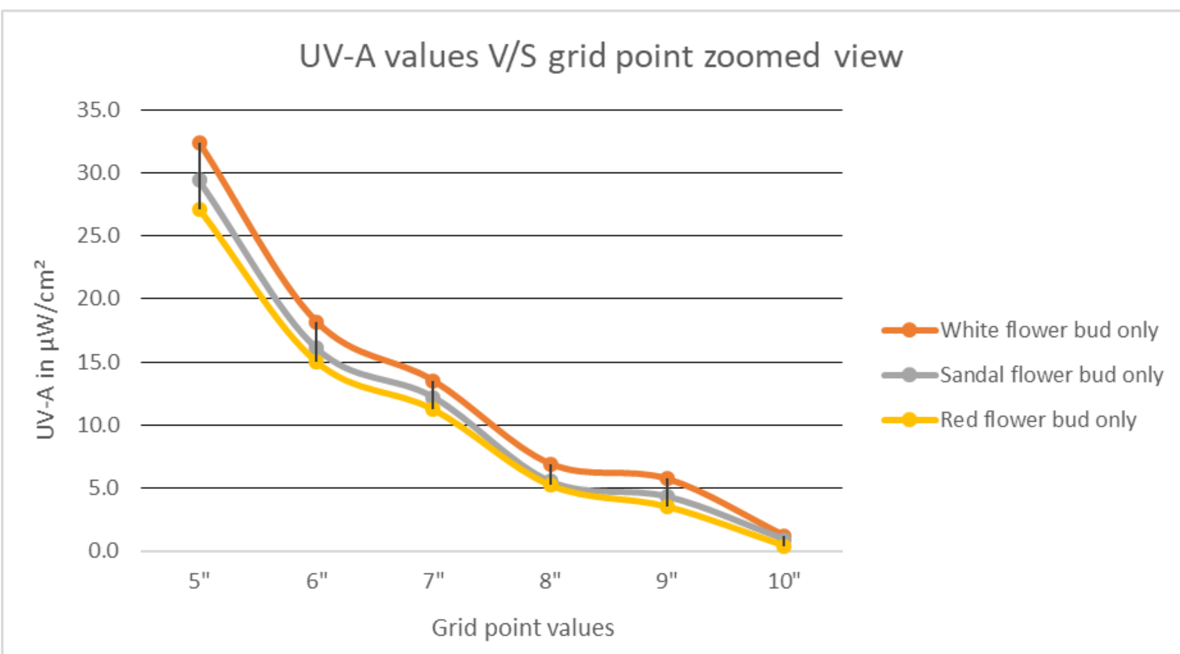

Fig 4.37 Zoomed view of the above UV-A vs grid point graphical representation for better understanding. *Note – grid point values from 5" to 10" are taken along with their UV-A readings.

4.4.6. RESULT ANALYSIS

From this experiment it can be observed from the graphical representation of plants of all colour that without hibiscus plant the UV radiation from both the CFL and Incandescent lamp was higher than when the plants were placed in front of the lamps. The UV content was comparably lowest when placed near the red hibiscus plant than white or sandal colour flower plant. This proves that the red hibiscus plant will absorb highest value of UV radiation than other colour flower plant of hibiscus family.

Now if one considers the red hibiscus plant only it can be observed that when there is no flower or bud that is the plant is in the producing state it is absorbing more UV radiation for its own production mechanism. Then when it is in the budding stage the UV absorbing is little less and it is lowest when the plant is not in the producing state that is when there are flowers in the hibiscus plant. This gives conclusion that plants with more green leaves have greater power in absorbing UV radiation than flowering plants.

Comparison was also done with three different colour plants at their budding stages and it was found that the plant with red bud absorbed the maximum amount of UV content and plant with white bud reflected the maximum amount of UV content among them. Also, it was understood from the observation table of this experiment that as the distance increase from the centre of the lamp the value of UV radiation reduces, so it should be kept in mind the lamps should not be installed close to human body to avoid direct UV radiation effect even if it is low value. It may be one of the reasons why people who study at night under table lamp which is close to face tends to have eye issues. Finally, conclusion can be drawn that plants can be used as natural device for reducing UV radiation coming from artificial lamps.

Summary – Plants with big green leaves can be used as a natural device to reduce UV radiation inside rooms where artificial lamps are used. Plants with red flowers can also be used as they have most UV absorption tendency than other colour flowers.

CHAPTER #5

SUMMARY, CONCLUSION AND PROPOSAL FOR FUTURE STUDY

CHAPTER 5 - SUMMARY, CONCLUSION AND PROPOSAL FOR FUTURE STUDY

From the above experiments conducted many important results were concluded. In the first case study where, different properties of sunlight were measured and different observations were found out. It was observed that in CCT range 4000K-4900K range the value of UV-A is high during the afternoon time having average range of 1200-1400 $\mu W/cm^2$ which is very much harmful for human body. It was also observed that with the increasing value of solar irradiance the value of UV-A also increases, i.e., when one got the irradiance value $400 W/m^2$ at that time UV-A was 1400 $\mu W/cm^2$ approximately.

In the next case study, different readings of UV-A value were taken for freshwater (tap water), sea water (salt water) and earth surface. It was found out comparing the graphical trend of fresh water and sea water that the sea water tends to absorb more UV content than freshwater which is a significant result. This proves the theoretical concept that people of science often tell that near coastal area and in sea water the UV absorption rate is very high. So, it can be concluded that people living near coastal areas or people who work in sea are more prone to harmful UV radiation and because of this melanin formation in their skin is more.

In the third case study one tried to understand the growth rate condition of a certain plant when it is placed under direct sun beam and under diffused sun beam. It was observed that the plants receiving direct sun beam were growing faster initially than those receiving diffused beam. It was observed that flower bloom timing of a plant does not depend upon direct sunlight but the longitudinal growth of a plant is totally depended on the amount of sunlight beam it receives. It was also observed that the flowers while blooming takes up the maximum amount of energy from itself, thus despite of receiving direct sun beam or diffused sun beam the growth of the plant stops suddenly after flower blooms.

In the fourth and final case study one tried to experimentally observe how plants can act as a natural device in absorbing UV radiation from artificial lamps. Three coloured flower plants red, sandal and white in three conditions, no flower and bud, bud only and flower only condition were used and observed how UV-A is absorbed on all these conditions. It was observed that red hibiscus plant absorbs highest value of UV radiation than other colour flower plant of hibiscus family. Now if one considers the red hibiscus plant only it can be observed that when there is no flower or bud that is the plant is in the producing state it is absorbing more UV radiation for its own production mechanism. This gives conclusion that plants with more green leaves have greater power in absorbing UV radiation than flowering plants. It was found that the plant with red flower bud absorbed the most UV content and the white flower bud reflected the most UV content. Also, it was understood from the observation table of this experiment that as the distance increase from the center of the lamp the value of UV radiation decreases, so it should be kept in mind the lamps should not be installed close to human body to avoid direct UV radiation effect even if it is low value.

Future scope –

i) The experiment for understanding the characteristic of solar radiation will have to be conducted on open field and according to a geographical location where obstruction is negligible which was not possible due to the safety and security of the measuring device. Also, in future this experiment should be conducted throughout a year for 12hrs and 365 days by covering all seasonal variation for getting an extended amount of data for greater realization.

ii) For freshwater and seawater UV absorption experiment, in future researcher needs to do testing near coastal areas free from obstacles to find the actual values of UV radiations and to estimate how much damage it is doing to human skin and health. In future assessment will be needed in the villages that are close to sea to check the UV levels and to plant necessary number of trees with big leaves beside the houses to reduce the overall UV radiations. Due to

iii) For the growth rate experiment in future more plants should be tested using the methodology of direct sunbeam growth and diffused sunbeam growth to understand how plant will react when there is low sunlight so that necessary actions can be taken to ensure the production rate does not fall.

iv) From the experiment conducted with hibiscus plant it was seen that it can be used as a natural device for UV radiation absorption that are coming from artificial lamps. In future several other leafy plants with less maintenance requirement can be tested for different household lamps to check how they absorb UV radiation and further recommend them in a standardized list as a natural UV reduction tool.

v) Due to a sudden incident which led to heavy damage in our laboratory the device that could measure all the three UV – A, B and C component was lost. So, all the experiments conducted one could only measure the UV-A content in a simple instrument which can only measure UVA. In future when the UV-A, B and C measuring device will be available to use one could further investigate the result and get further observations.

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