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Investigating Ultra Violet (UV) Strength against Different Level of Altitude using New Environmental Data Management System

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***Abstract*—**This paper presents the investigation results of UV measurement at different level of altitudes and the development of a new portable instrument for measuring UV. The rapid growth of industrial sectors in developing countries including Malaysia, brings not only income to the nation, but also causes pollution in various forms. Air pollution is one of the significant contributors to global warming by depleting the Ozone layer, which would reduce the filtration of UV rays. Long duration of exposure to high to UV rays has many devastating health effects to mankind directly or indirectly through destruction of the natural resources. This study aimed to show correlation between UV and altitudes which indirectly can help predict Ozone depletion. An instrument had been designed to measure and monitors the level of UV. The instrument comprises of two main blocks namely data logger and Graphic User Interface (GUI). Three sensors were used in the data logger to detect changes in the temperature, humidity and ultraviolet. The system has undergone experimental measurement to capture data at two different conditions; industrial area and high attitude area. The performance of the instrument showed consistency in the data captured and the results of the experiment drew a significantly high reading of UV at high altitudes.

***Keywords*—**Ozone Layer, Monitoring, Global Warming, Measurement, Ultraviolet

I. Introduction

THIS paper discusses the phenomena of UV's strength against different level of altitude. Ultra Violet (UV) is a combination of three wavelengths namely UVA, UVB and UVC. 97 % of the UV's strength emitted by the Sun has been filtered while it passes through the Ozone layer. Air pollution has significant contribution towards global warming through Ozone depletion. The emission of toxic gas from industries such as CFC thins the Ozone layer slowly and allows more UV rays to reach the earth. Therefore, apart from monitoring the quality of air in the environment, it is also important to measure and monitor the level of UV. It is generally known that the quality of air differs at different altitudes, which would also give different readings of UV. Based on this, an instrument to measure and monitor UV was designed and using EDM system, several experiments were conducted to measure the UV strength at different altitude. The result of the analysis showed significant correlation between UV and altitude.The measurement exercise was done using a new portable data management system which was designed for logistic convenience, affordable and is user friendly for use by environmental activist, students, housewife, NGO and small enterprise.

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The system consists of two main components, data logger and data interpreter. The next section of this paper highlights the formation of Ozone layer and the damaging process that create Ozone holes. Section IV describes the development of the measurement system and followed by measurement result carried out at Genting Highland. The final section overview the significant findings of the measurement results towards interpreting the level of UV against different level of altitude.

II. Ozone Layer

The formation of Ozone layer involves three forms (or allotropes) of oxygen or known as ozone-oxygen cycle: oxygen atoms (O or atomic oxygen), oxygen gas (O2 or diatomic oxygen), and ozone gas (O3 or tri-atomic oxygen). The Ozone layer is formed in the stratosphere when oxygen molecules photolyzes after absorbing an ultraviolet photon whose wavelength is shorter than 240 nm. This converts a single O2 into two atomic oxygen ions.

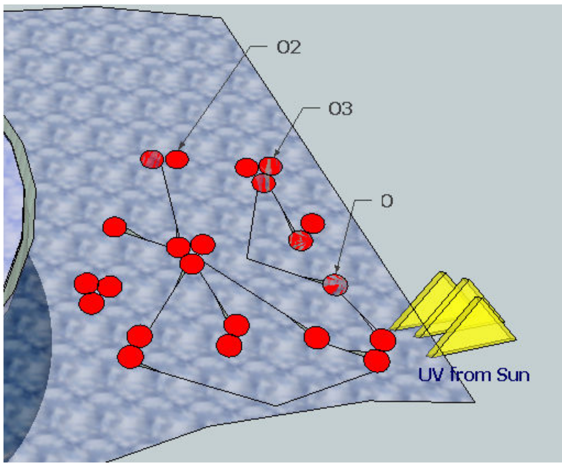

Fig. 1 Illustration of Ozone Layer from Three Forms or Allotropes

The atomic oxygen ions then combine with separate O2 molecules to create two O3 molecules. These ozone molecules absorb UV light between 310 and 200 nm, following which ozone splits into a molecule of O2 and an oxygen atom. The oxygen atom then joins up with an oxygen molecule to regenerate ozone. This is a chain process which terminates when an oxygen atom "recombines" with an ozone molecule to make two O2 molecules

$$O + O_3 \rightarrow 2\,O_2$$

Ozone Hole is form when the foreign particles break the chain of Allotropes. One of the polluted gases that could destroy the Ozone is chlorofluorocarbons (CFCs), which at the time were widely used as refrigerants, in aerosol sprays, and in manufacturing plastic foams. CFC molecules are inert in the troposphere, so they are transported to the stratosphere, where they photolyze and release chlorine (Cl) atoms. Chlorine atoms cause catalytic ozone loss by cycling with ClO. The formation of Ozone layer is disturbed when the existence of the Chlorine (Cl) atom stop the formation of O3.The process of damaging is illustrated as shown in Figure 2 [6].

III. Environment Data Management System

A project had been initiated to develop a low cost instrument for measuring level of UV. The instrument is very useful for any user to monitor the quality of UV daily and yearly. High UV due to Ozone effect is very slow and we could not justify the effect within few days or even few months. Monitoring technique is the most efficient way to differentiate the effect by comparing the present data with the backdated data. Correlation was carried out to calculate the percentage of difference within few months. The instrument comprised several components which are illustrated as shown in Figure 3.

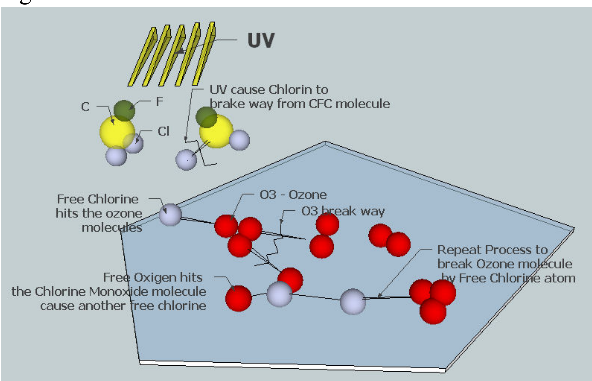

Fig. 2 The Cycle Process of Damaging Allotropes by CFC at Stratosphere Layer

The first component is data logger. The function of the data logger was to measure the UV and store the data. Periodically the saved data is transmitted through ZeeBee transmitter to the EDM. The data analyser which is called as Environment Data Management (EDM) is to interpret the measured data for analyzing the level of UV. EDM is a Web-based software which allow the results to be accessed by user throughout the world.

IV. Data Logger Algorithm

The measuring system, data logger comprises of three components namely the sensor (Pyranometer), Real-Time Clock (RTC) and the measuring algorithm. The UV sensor, Pyranometer is a device that sensitive to ultra-violet of type A. There are two functions of Pyranometer in the system. First is to measure daily UV for environment monitoring and second to locate the position of the sun.

The complete measuring algorithm flow chart is illustrated in Figure 4. The algorithm was executed and the first event took place was the initialization of all the constants, counters and interrupts which include RTC. During this stage there were few important constants that were required to be set-up such as RTC Time, time interval and etc. The next event was the set-up mode for the LCD display.

The user can opt to select two-mode display namely temperature, or Real Time and Date. Once selected the data was displayed while the system continued logging the data. The third event was the data logging process. The data was logged within the time interval of 15 sec to 30 min depending on the user's requirement. There were two locations used as data storage, internal RAM and EEPROM. The total capacity for the two data storages was 2 K which was good enough to store 4 days data for the time interval of 30 min. Once the storages were full, the user was required to transfer the raw data into MMC.

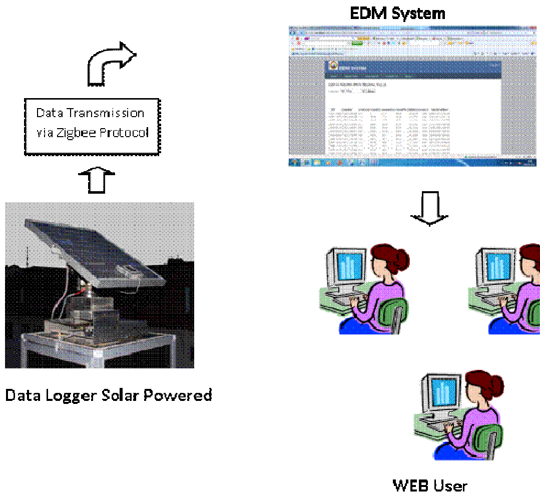

Fig. 3 System Configuration

The data is automatically converted into ASCII before it is saved in the MMC. After the whole process is completed the program is back to the logging mode to capture new data. Time interval for data logging is varied which is depending on the application of the data logger. The range of interval is stored in set_measure register. The operation for triggering is done by loading the value for hours and minutes register from RTC and compare the value with set_measure reg.

V. Measurement Methodology

Scientifically the strength of UV is higher for several factors such as higher altitude, open area such as seaside and weather. Weather is the main cause influential the level of UV daily. Raining, cloudy, high humidity may block the UV from heating the earth. As a result the chances being exposed for high UV in this region are very small this would be approximately 40 % of the day time or from the time between 11.00 am till 2.00 pm daily.

The next factor which may cause high UV is high altitude. There are several places in Malaysia with high population and high altitude geographically such as Cameron Highlands, Genting Highlands and Fraser Hill. This factor had initiated an investigation to study the correlation between UV and altitude. The investigation of UV took place to measure the value of UV at different levels within the same day. The comparison is made to study at which level the UV is high and generalize whether the altitude cause a high reading of UV.

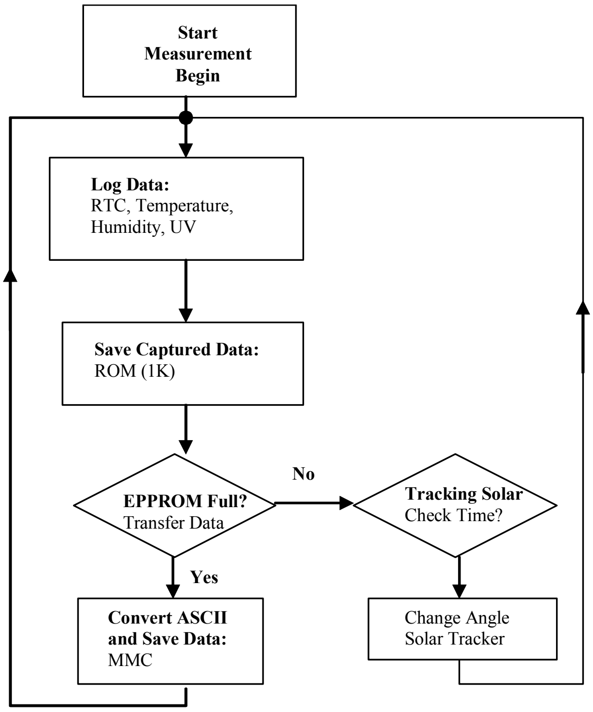

Fig. 4 Algorithm Flow Chart

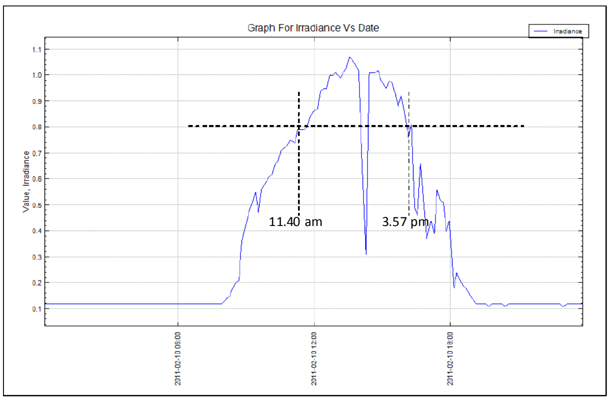

Fig. 5 Effective Time Zone

In the measurement process there are few assumptions being applied to justify the significant of the measurement. First the duration of the measurement for the different levels must be done within 11.00 am until 2.00 pm which is later known as Effective Time Zone (ETZ). This range would give the highest value of UV and the factor of low value due to time is low. Next the measurement is carried out for two days to ensure the pattern of the reading is same and consistent. The process of measurement is using Environment Monitoring System (EDM) and a UV sensor Pyranometer. The EDM is also configured to log few other parameters which are temperature and humidity. The measuring time interval for this particular exercise was set to 2 min/log. Once the measurement has been completed the data is saved in the PC and EDM will analyse the data to plot the result in the graph form.

Effective Time Zone (ETZ) is an assumption used to pursue for the measurement methodology. The ETZ has been obtained through daily measurement graph as shown in Figure 5. This exercise was done purposely for determining the duration of charging hours for Solar Panel [4]. Daily charging time is offset by the intensity of sun. Sun intensity is changing against time. Solar photovoltaic generates charge power when the voltage output is higher than the voltage of the batteries. It has been observed that the cross line or known as productive charge time as shown in Figure 5 is the effective duration of charging time when the daytime is fully bright.

VI. Measurement Results

Genting Highlands – 29 June 2011 and 6 July 2011

Target location for the measurement was Genting Highlands. Genting Highlands is a tourist location and surrounded by heavy green jungle. Along the road from the bottom level to the top level there are few spot locations for measuring the UV.

The spot locations were identified based on level and the measurement was carried out within the ETZ. The summary of the spot location is summarized in Table 1.

TABLE I
SPOT LOCATION FOR UV MEASUREMENT

No	Location	Altitude Level, m
1	Rawang	400
2	Batang Kali	450
3	Awana	1200
4	Genting 1	1800
5	Genting 2	2000

The graph of Figure 6 (a) and 6 (b) show the peak value of UV for all the spot locations. The two days measurement has slightly different value but in general the pattern is approximately similar. The peak value of UV at 400 m above sea level is 1.02 kw/m^2 while on the second day the UV reading is low due to the weather was cloudy in the morning. It was slowly changed to light sunny at noon. The reading is slightly higher at 1200 m (Awana) and 1800 (Genting 1) for both graph with recoded reading 1.2 kw/m^2 and 0.9 kw/m^2 respectively.

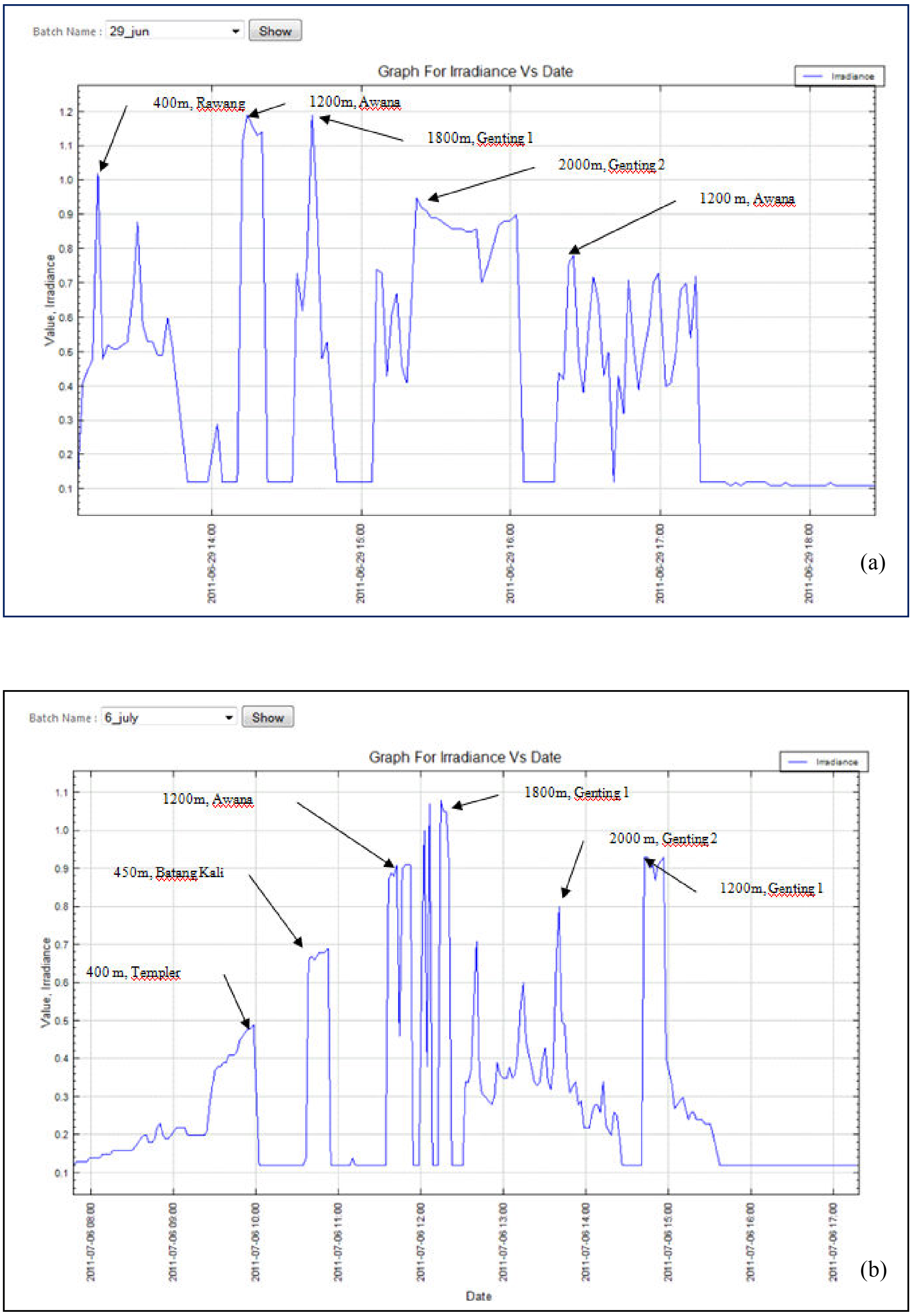

Fig. 6 UV Level at Genting Highlands (a) 29 June 2011 (b) 6 July 2011

Above sea level at 2000 m the reading is going down to 0.95 kw/m^2 and similar with the graph of Figure 6.B at 0.8 kw/m^2. Quick observation from the graph is the value of UV is slightly higher within 1200 m to 1800 m above sea level.

VII. DISCUSSION

The investigation contributes two significant impacts associated with UV exposure to human and environment. First, it has been recorded that there was a marginal difference of UV percentage against different level of altitude. Places at the altitude between 1200m to 1800m recorded UV rays slightly higher compared at lower altitude. Second, UV readings at lower altitude was scattered regardless of human activity factors such as human population area, seaside, industrial area, highway and etc.

The results are provisionally acceptable but further investigation is highly required. Further investigations that would help to strengthen the hypothesis are outlined as follow:

i. Type of UV rays that significantly contribute for the high UV. This is to correlate the type of UV with specific skin disease or other related disease to UV.
ii. Status of Health especially related disease to UV against different altitude. This is to investigate the population of related disease to UV or vice versa.
iii. Status of environment related to crops, plantation, air pollution and temperature.

In the investigation, the hypothesis defined that the higher the altitude, the higher the UV exposure to human. The simple factor is due to the distance between Sun and the Earth which is shorter, therefore the percentage of UV is not fully filtered out. The measurement of UV at altitudes between 1200m to 1800m had shown high UV compared to altitude at 420 m. However, the reading was significantly less when the measurement was carried out above than 1800 m. The average reading of UV at this level was approximately 0.7 kw/m^2, even though the sensor was directly exposed to the Sun. This phenomenon is completely interesting for the next stage of investigation.

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