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Assessment of Solar Ultraviolet Radiation Level in Makurdi, Benue State

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Abstract: ***Ultraviolet Radiation (UVR) has been classified as a carcinogen. The sun is the primary source of exposure to UV. This research work was carried out to assess the safety level of solar Ultraviolet Radiation (UV) in Makurdi, Benue state. The Solar UV power densities measured between the hours of 10.00am and 4.00pm over a three week period were found to range from 22.8mWm-2 (UV index of 1) to 170.0 mWm-2 (UV index of 7). A survey questionnaire was also designed to assess the level of knowledge the effects of exposure to Solar UV. Results showed high level of awareness to the effects of exposure.***

Keywords: Ultraviolet radiation, Power density, UV index, Makurdi, Nigeria

1. Introduction

UV is one of the non-ionizing radiations in the electromagnetic spectrum and lies within the range of wavelengths 100 nm to 400 nm. The short wavelength limit of the UV region is often taken as the boundary between the ionizing radiation spectrum (wavelengths < 100 nm) and the non-ionizing radiation spectrum. UV can be classified into UVA (315 - 400 nm), UVB (280 - 315 nm) and UVC (100 - 280 nm) regions, although other conventions for UVA, UVB and UVC wavelength bands are in use.

A study [1], reviewed epidemiologic studies on occupational solar exposure and skin cancer. It was concluded at the end of the review that there was clear association between solar irradiation and skin cancer. The mechanisms for induction were however said to vary between the types of skin cancer and that they could not be solely attributed to occupational exposure with recreational exposure adding to the risks. The study suggested occupational exposure as being important since cancer incidences have been on the increase. In addition to cancer, exposure to UV rays can cause other health problems. UV rays, either from the sun or from artificial sources like tanning beds, can cause sunburn. UVB is mainly responsible for sunburn and DNA dimer formation that can lead to mutation. UVA generates oxidative reactions affecting DNA, proteins and lipids, and is also immunosuppressive [2]. In some people, exposure to UV rays can cause a rash or a type of allergic reaction. Exposure to UV rays can also cause premature aging of the skin and signs of sun damage such as liver spots, actinic keratosis, and solar elastosis. [3]

Another study [4] has stated that the eye is exposed to both UV A and UV B which have adverse effects and can result in deformation of various tissues within the eye. Strong evidence was said to support the association between chronic UV exposure and formation of Pterygium and is said particularly seen in people who live in sunny climates and those who work outdoors.

Studies have suggested the need for close monitoring of Ultraviolet radiation [5]. Several measures have been adopted by countries and other bodies in line with this. South Africa for instance is reported to have had six solar UVR monitoring stations managed by South African Weather Service to monitor Solar UV irradiance and to disseminate information in order to improve public awareness on the need to curtail UV exposure [5].

An assessment of solar UV radiation at a typical market setting in Gboko, Nigeria which has similar climatic conditions showed high UV exposures of about 432 Jm-2 in open space and 45.4 Jm-2 in the shade [6]. These values are seen to exceed exposure levels especially to the eye with a maximum permissible exposure of 30 Jm-2. While another study [7] investigated the level of UVR in BSU Makurdi. The study found high UV indices (7-12) which were indicative of very high UV doses. Further, studies were recommended for other locations and also in different seasons and then the results compared.

2. Ultraviolet (UV) Index

The ultraviolet index or UV Index is an international standard measurement of the strength of sunburn-producing ultraviolet (UV) radiation at a particular place and time. The scale was developed by Canadian scientists in 1992, then adopted and standardized by the UN's World Health Organization and World Meteorological Organization in 1994. The UV Index is a number linearly related to the intensity of sunburn-producing UV radiation at a given point on the earth's surface.

Spectrophotometers are designed to the horizontal irradiance at 154 wavelengths (Δλ= 0.5nm) 0ver the 285.5 nm to 363.0 nm spectral range. The UV index (UVI) is defined as follows:

$$UVI = \frac{1}{25}\left(\frac{mW}{m^2}\right)\int_{286.5nm}^{400nm} I(\lambda).\ w\ (\lambda)\ d\lambda \qquad (1)$$

Where W (λ) is the erythema weighting factor which varies over the spectral range, I is the radiation intensity and λ is the wavelength.

3. Materials and Methods

3.1 Measurement of UV Index and Power Density

For this study, a survey questionnaire and practical measurement with a solar UV meter were adopted. To take the measurements, the device was exposed to solar radiation with its sensor pointing directly to the sun. This enables the device to accurately measure amount of radiation it has been exposed to. The button below the display is pressed after which the readout gives the UV index and solar irradiance. Advisory measures are given based on the UV index observed.

The UV index and power density readings were at four locations (North bank, Wadata, Brewery, and Wurukum) between 10am and 4pm over a three week period. Five readings were taken for each time and an average value calculated over the period. In addition, a high level sensitivity digital thermometer for measuring ambient temperature was used to measure the environmental temperature for the times when the UV index and UV irradiance were measured. The power densities were later correlated.

3.2 Questionnaire Administration

The questionnaire was designed to assess the Knowledge of the effects (harmful and beneficial) exposure, average duration of daily exposure to solar UV and the means by which these knowledge was acquired to aid information dissemination in case of need for awareness campaign. A random sample of two hundred (200) respondents was adopted for the study

4. Results and Discussion

The study results are presented below:

Table 1: Solar UV Irradiance and Index for the First Week at Four Locations in Makurdi Metropolis

TIME	LOCATION											
	WURUKUM			WADATA			BREWERRY			NORTH BANK		
	I.D	P.D	TMP	I.D	P.D	TMP	I.D	P.D	TMP	I.D	P.D	TMP
10 AM	2	52.2	29.4	7	170.0	30.4	4	109.6	29.4	5	117.6	30.2
11 AM	3	67.4	31.1	6	149.0	31.2	6	152.2	33.8	4	91.6	34.6
12 PM	3	76.4	30.3	6	150.0	31.8	2	43.2	33.2	4	101.2	33.1
1 PM	6	146.2	36.0	4	114.2	33.3	2	55.6	36.5	6	148.6	33.4
2 PM	5	118.0	33.0	3	81.0	33.3	4	96.4	34.3	7	168.6	33.8
3 PM	4	91.6	30.3	2	50.4	32.3	6	139.8	33.4	5	125.0	32.5
4 PM	3	61.8	30.2	2	48.8	29.4	5	116.8	32.3	3	65.0	31.0
NOTE: P.D stands for UV power density in mW/m^2, TMP is the temperature in ^0C as at when the readings were taken and I.D is the observed solar UV index.												

Table 2: Solar UV Irradiance and Index for the Second Week at Four Locations in Makurdi Metropolis

TIME	LOCATION											
	WURUKUM			WADATA			BREWERRY			NORTH BANK		
	I.D	P.D	TMP	I.D	P.D	TMP	I.D	P.D	TMP	I.D	P.D	TMP
10 AM	5	111.4	31.4	4	91.4	29.1	5	117.0	24.0	4	93.2	31.4
11 AM	2	57.6	31.8	2	39.4	30.3	5	133.2	33.3	4	100.6	31.8
12 PM	6	149.2	33.8	7	167.0	29.9	6	161.2	34.6	4	91.6	33.8
1 PM	6	142.4	33.1	4	110.6	34.6	6	154.6	35.1	1	22.8	33.1
2 PM	6	154.4	33.4	4	91.0	32.4	6	142.0	32.8	2	55.4	32.7
3 PM	4	115.2	29.7	3	76.2	28.2	4	98.8	29.7	2	53.4	32.5
4 PM	4	97.3	28.6	1	29.6	27.0	5	73.0	29.4	2	43.6	28.1
NOTE:P.D stands for UV power density in mW/m^2, TMP is the temperature in ^0C as at when the readings were taken and I.D is the observed solar UV index.												

Table 3: Solar UV Irradiance and index for the third week at four locations in Makurdi Metropolis

TIME	LOCATION											
	WURUKUM			WADATA			BREWERRY			NORTH BANK		
	I.D	P.D	TMP	I.D	P.D	TMP	I.D	P.D	TMP	I.D	P.D	TMP
10 AM	4	109.0	27.3	5	116.4	26.7	5	117.2	31.8	4	110.6	29.4
11 AM	4	94.2	28.6	4	109.6	28.8	3	80.2	32.7	5	135.6	29.7
12 PM	3	83.2	29.3	6	153.4	29.2	5	118.6	32.2	5	129.2	32.3
1 PM	4	103.4	29.4	6	160.4	30.8	5	118.0	32.7	5	143.0	31.8
2 PM	3	82.2	30.0	5	123.4	28.9	4	109.0	32.7	4	104.8	31.9
3 PM	2	43.2	27.7	3	79.0	28.3	4	105.2	32.5	3	79.6	32.0
4 PM	1	19.0	26.8	2	43.4	28.6	2	48.2	29.4	2	60.0	32.5
NOTE: P.D stands for UV power density in mW/m^2, TMP is the temperature in ^0C as at when the readings were taken and I.D is the observed solar UV index.												

The results are shown graphically in figures 1 to 4

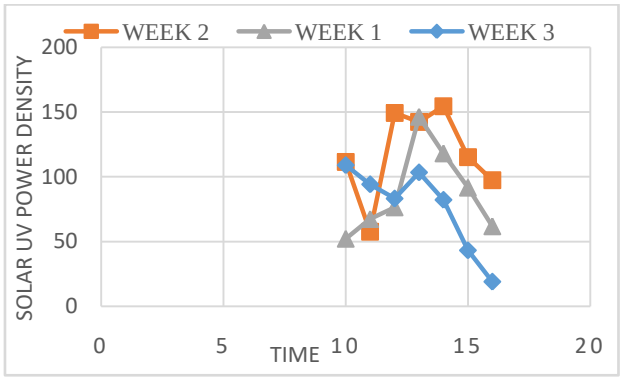

Figure 1: Variation of Solar UV Power Density with time at Wurukum

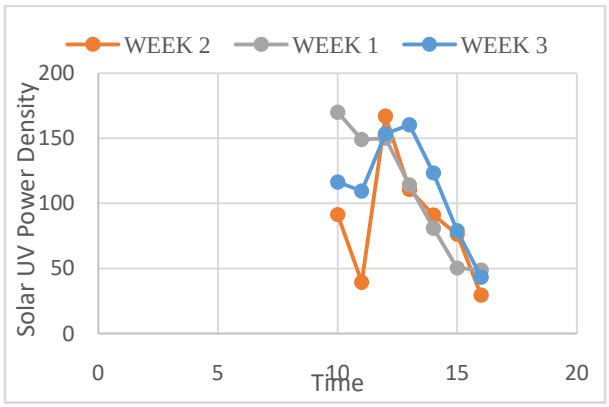

Figure 2: Variation of Solar UV Power Density with time at Wadata

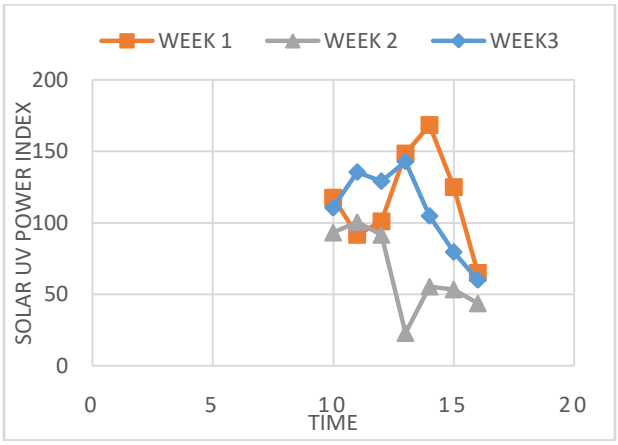

Figure 3: Variation of Solar UV Power Density with time at North Bank

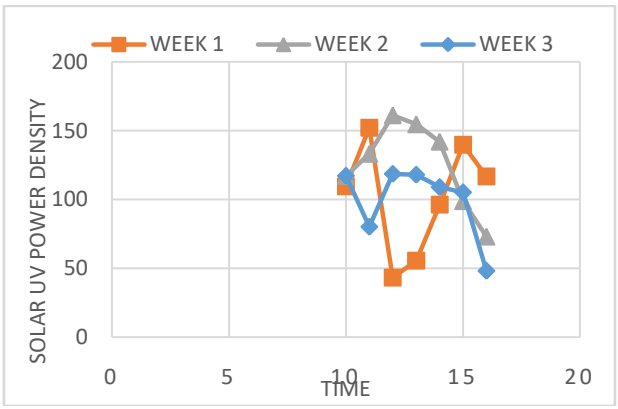

Figure 4: Variation of Solar UV Power Density with time at Brewery

5. Discussion of Results

TheUV indices were observed to vary with time on different days at the different locations (Wadata, Brewery, North Bank and Wurukum). During the first week, Wadata had a maximum UV index of 7 (Power density = 170.0 mW/m^2, Temperature = 30.4 ^{0}C, Time = 10.00am) and minimum UV index value of 2 (Power Density = 52.2 mW/m^2, Temperature = 29.4^{0}C, Time = 4.00pm), North Bank had a maximum UV index of 7 (Power Density = 168.6 mW/m^2, Temperature = 33.8^{0}C Time = 2.00 pm) and a minimum UV index of 3 (Power Density = 65.0 mW/m^2, Temperature = 31.0^{0}C, Time = 4.00 pm), Brewery had a maximum UV index of 6 (Power Density = 152.2 mW/m^2, Temperature = 33.8, Time = 12.00 pm) and a minimum UV index of 2 (Power Index = 43.2, Temperature 33.2, Time = 1.00 pm) while Wurukum had a maximum UV index of 6(Power Density 146.2 mW/m^2, Temperature = 36.0 and Time = 1.00 pm)and a minimum UV index of 2 (Power Density = 52.2 mW/m^2, Temperature = 29.4,Time = 10.00 am).
During the second week, Wadata had a maximum UV index of 7 (Power density = 167.0 mW/m^2, Temperature = 29.9 ^{0}C, Time = 12.00 pm) and minimum UV index value of 2 (Power Density = 39.4 mW/m^2, Temperature = 30.3^{0}C, Time = 11.00am), North Bank had a maximum UV index of 4 (Power Density = 100.6 mW/m^2, Temperature = 31.8^{0}C Time = 10.00 am) and a minimum UV index of 1 (Power Density = 22.8, Temperature =33.1^{0}C, Time = 1.00 pm), Brewery had a maximum UV index of 6 (Power Density = 161.2, Temperature = 34.6, Time = 12.00 pm) and a minimum UV index of 5 (Power Density = 73.0, Temperature = 29.4) while Wurukum had a maximum UV index of 6 (Power Density 154.4, Temperature = 33.4 and Time = 2.00 pm) and a minimum UV index of 2 (Power Density = 57.6, Temperature = 33.4,Time = 11.00 am).

For the third week, Wadata had a maximum UV index of 7 (Power density = 160.4 mW/m^2, Temperature = 29.7 ^{0}C, Time = 2.00 pm) and minimum UV index value of 2 (Power Density = 43.4 mW/m^2, Temperature = 28.^{0}C, Time = 4.00 pm), North Bank had a maximum UV index of 5 (Power Density = 143.0 mW/m^2, Temperature = 31.8^{0}C Time = 1.00 pm) and a minimum UV index of 1 (Power Density = 60.0 mW/m^2, Temperature =31.8^{0}C, Time = 4.00 pm), Brewery had a maximum UV index of 4 (Power Density = 109.0 mW/m^2, Temperature = 32.7, Time = 2.00 pm) and a minimum UV index of 2 (Power Density = 48.2, Temperature = 29.4) while Wurukum had a maximum UV index of 4 (Power Density = 103.4 mW/m^2, Temperature = 29.4, Time = 1.00 pm) and a minimum UV index of 1 (Power Density = 19.0 mW/m^2,Temperature = 26.8,Time = 4.00 pm).

The UV index was observed to drop abruptly on days when there was cloud cover. Generally, the UV index was observed to be low from 10.00 am and attained the peaks between 12.00 pm to 2.00 pm. There however was an exception with the readings taken at Wadata during the first week. For this day, there was a high UV index of 7 at 10.00 am with the temperature being 30.3^{0}C. The indices remained high at 6 until there was relative cloud cover at 1.00 pm and the index dropped to 4. The readings where similar for the

second week with maximum UV index of 7, power density 167.0 mW/m^2 and temperature of 33.8^{0}C at 12.00 pm.

The observations from these results are in conformity with generally observed trends in UV intensity as the peak values of measured UV index and intensity were about the mid hours of the day. Precautionary measures will be necessary for people who have to be outside when the intensities are high which is typically between 12.00pm and 2.00pm. The use of sunscreens as means of protecting the eyes from UV irradiation and also the use of protective clothing or shades will be important as recommended by US Environmental Protection Agency (EPA). [8]

The questionnaire results showed that one hundred and twenty two (63.5%) of the respondents have zero to four hours solar UV exposure, fifty three (26.5%) where exposed between four to six hours while seventeen (8.5%), were exposed for six hours and above. The average duration of exposure was found to range between four to eight hours in a day. Seventy four point one (74.1%) of the respondents were aware of the production of vitamin D when the skin is exposed to solar UV and seventy six point eight percent (78.6%) indicated that they were aware of the harmful effects of over exposure to the sun's rays. These shows high level of awareness of the effects of solar exposure. The results obtained from the survey questionnaire point to the need to educate the public on the need to check the specifications of these devices and also to engage practices that will reduce the level of radiation absorbed. This can be achieved through organizing seminars in schools and creating adverts and jingles through mass media. This is owing to the fact that fifty nine (30.7%) of the respondents that indicated having known the effects of RFR exposure said they learnt from seminars and also in school; fifty one (26.6%) learnt from friends and forty six (24%) learnt through media sources.

6. Conclusion

Measurements of solar UV between the hours of 10.00am and 4.00pm over a three week period showed that the intensities of UVR reaching the earth ranged from 22.8 mW/m^2 to 170.0 mW/m^2 with UV indices of 1 and 7 respectively. The amount of solar UV required to cause sunburn for black skinned people as shown in table 2.2 is around 7. The typical time required to exceed the set occupational exposure limit for exposure to other sources of UV is seen to be about 20 to 30 minutes when compared with the average solar UV indices observed. The effects to the eyes is seen to be more significant than that to the skin. As such it will be advisable to spend as minimal time as possible under the sun or to use protective clothing and sunscreens in order to reduce exposure.

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Author Profile

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