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Variability in Near-Surface Ultraviolet Radiation and Its Dependence on Atmospheric Parameters

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Abstract**—**Natural radiations such as ultraviolet (UV) radiation sourced from sun are known to be the main causes of skin cancer, sunburn, eye damage, premature aging of skin and other skin related diseases. Its percentage of radiation reaching the earth populace and its impacts are not well known. Its variability in near-surface relating to its impacts on populace depends on some atmospheric parameters. Hence, this work was embarked on to determine the variability in near-surface UV radiation and its dependency on some atmospheric parameters at different time of the day in Offa, Nigeria. The variability was determined using the data obtained from meteorological garden, Science Laboratory Technology Department, Federal Polytechnic Offa, Nigeria. The data obtained were solar UV radiation, solar radiation, temperature, humidity and pressure at 30 minutes interval. Relationships were determined and correlations were derived using SPSS Pearson Correlation tool. The results showed a significant level of correlation with p-value of 0.01 and 0.05 levels. Thus, the results revealed some good relationships between the solar UV radiation and other atmospheric parameters with significance level less than p-value obtained. Inferentially, interdependent relationships were found to exist. Therefore, the nature of relationship obtained could be a yardstick for decision making in short term environmental planning on solar UV radiation depending of some atmospheric parameters within Offa locality.

Keyword**—**Correlation, inferential, radiation, yardstick.

I. Introduction

UV radiation is a known radiation that causes human health problems such as skin cancer, eye damage, premature aging of skin etc. and also damage to animal, planet, microorganism, as well as non-living things [5]. Most of these effects are due to the errors caused mainly by ignorance of ozone concentration and other factors such as aerosols, humidity, temperature, pressure and solar radiation, which directly or indirectly cause variability of UV radiation on the surface of the earth at different time of the day.

UV radiation is an electromagnetic radiation with a wavelength from 100 nm to 380 nm, shorter than that of visible light but longer than X-rays. Sunlight is the major source of UV radiation. It is also produced by some electric arcs and mercury vapour lamps, black lights and tanning lamps [1]. As revealed by Dunbar, some researchers also showed that UV radiation is like energy that ionizes atoms and its long wavelength can result in chemical reactions and allow many substances to fluoresce (glow) [1]. The biological damage of UV radiation is mostly higher than ordinary heating effects and many practical applications are derived from its organic molecular actions.

Some familiar effects of over-exposure to UV radiation such as suntan, freckling and sunburn are along with higher risk of skin cancer [2]. Living things on dry land would be severely damaged by UV radiations from sun that are not filtered out by the atmosphere of Earth. High energetic UV radiation with extremely shorter wavelength (below 121 nm) can strongly ionize air and be absorbed before reaching the ground [2]. Also, in most of land vertebrates such as human, it is a factor responsible for the formation of bone strengthening vitamin D. In relation to human health, UV spectrums are both beneficial and harmful.

There are three different types of UV radiation emmited from sun and they all have potential to damage human skin in different ways [4]. Ultraviolet radiations for ageing (UVA) are the highest with 95% among the radiations reaching the earth surface and has ability to cause wrinkles, sunspot and other premature aging of skin. Action spectrum shows that UVA does not cause immediate reaction, but rather because skin redness and photokeratitis at the earlier stage with wavelengths begins near UVB band (315 nm) and increase rapidly to 300 nm [4]. These can also lead to cancer of the skin.

Research activities show that UVB radiations affect the top layer of the skin, damages DNA in the skin and cause skin cancer and sunburn mostly. It also stimulates the production of vitamin D at rates of up to 1000 IUs per minute in the skin. This vitamin helps to control calcium metabolism for the nervous system and bone health, cell proliferation, immunity, blood pressure and insulin secretion. However, human's excessive exposure to such UV radiation can result in acute and chronic harmful effects on the skin, eye, and immune system [3]. UVC does not reach the earth surface (absorbed mostly by atmosphere) hence; it is not normally considered a risk factor for skin cancer. It is mostly found in man-made sources of UVC radiation (welding torches or mercury lamps) [4].

To ascertain the variability of solar UV radiation and its dependency on some atmospheric parameters, a survey test was carried out on UV radiation and some atmospheric parameters at meteorological garden, Science Laboratory Technology Department, Federal Polytechnic Offa in Nigeria. With the experiment, five atmospheric data were obtained for the analysis and some relationship were determined at some level of correlation to establish some facts and test of

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significant on the variability of near-surface UV radiation and atmospheric temperature, humidity, pressure and solar radiation at different time intervals of the day.

II. Methodology

A. Acquisition of Data

For this study, the data were acquired from meteorological garden, Science Laboratory Technology Department, Federal Polytechnic Offa, Nigeria. The data acquired were solar UV radiation, solar radiation, atmospheric temperature, humidity and pressure for July, 2016 at every 30 minutes internal. The data were extracted from the stored data using Ambient Weather EZ – 125 – 35M 35" Mast Extension for Weather Station. The data obtained were summed together to obtain the average mean value at every 30 minutes and for the entire month of July, 2016.

B. Statistical Analysis

With the average mean of the data obtained for July, 2016, the data were subjected to a statistical test using Pearson correlation. This was done to determine the nature and the degree of significant of correlation that exists between near-surface UV radiation, solar radiation, temperature, relative humidity and pressure at 30 minutes intervals of the day. The test values are between 7:00 and 19:00 GMT (day length period).

III. Results and Discussion

Table I shows the variations of results obtained for this work. Also, Figs. 1-5 depict the results obtained between 0.00 GMT and 23.30 GMT daily and for the entire month of July, 2016.

Notation: For Tables I and II, the following parameters and units are valid:
T = Time in GMT
UVR= Ultraviolet Radiation in $Js^{-1}m^{-2}$
SR= Solar Radiation in $Js^{-1}m^{-2}$
Te = Temperature in ^0C
H = Humidity in %
P = Pressure in $Kgms^{-2}$
PC = Pearson Correlation
N = Number of the test value

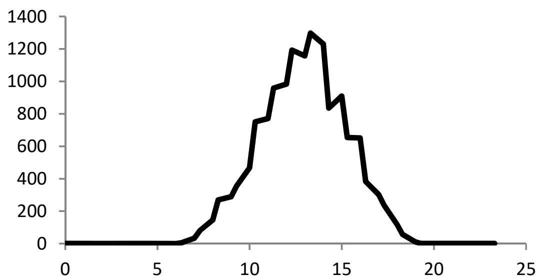

Fig. 1 UV Radiation ($Js^{-1}m^{-2}$) against Time Intervals (GMT)

TABLE I
UV Radiation, Solar Radiation, Temperature, Humidity and Pressure at Different Time Intervals

T (GMT)	*UVR* ($Js^{-1}m^{-2}$)	*SR* ($Js^{-1}m^{-2}$)	*Te* (^0C)	*H* (%)	*P* ($Kgm^{-1}s^{-2}$)
0.00	0.72	0	23.84	94.86	968.40
0.30	0.85	0	23.72	95.14	968.10
1.00	0.57	0	23.67	95.29	967.90
1.30	0.71	0	23.57	95.29	967.70
2.00	0.71	0	23.54	95.71	967.40
2.30	0.57	0	23.47	95.71	967.20
3.00	0.85	0	23.40	95.86	967.10
3.30	1.00	0	23.42	95.57	967.00
4.00	0.57	0	23.31	96.00	966.80
4.30	0.85	0	23.18	95.86	966.80
5.00	1.00	0	23.15	96.29	967.00
5.30	0.57	0	23.08	95.57	967.10
6.00	0.42	0	23.08	95.71	967.40
6.30	5.00	0	23.10	95.00	967.60
7.00	33.57	17.49	23.05	94.86	967.90
7.30	80.29	51.5	23.08	95.14	968.20
8.00	145.72	109.67	23.22	94.00	968.60
8.30	269.71	220.16	23.55	91.00	968.70
9.00	289.43	194.67	23.91	86.57	969.00
9.30	355.86	237.19	24.31	85.71	969.30
10.00	466.86	285.9	24.62	83.86	969.50
10.30	750.29	457.43	25.12	82.29	969.40
11.00	771.29	463.34	25.34	79.71	969.30
11.30	959.29	545	25.87	76.29	969.10
12.00	983.43	595.87	26.34	74.29	968.80
12.30	1193.00	664.24	27.01	70.71	968.50
13.00	1157.14	657.4	28.10	68.57	968.10
13.30	1297.71	748.02	28.11	68.57	967.60
14.00	1230.86	746.37	28.45	66.14	967.30
14.30	835.19	548.49	28.74	66.00	967.00
15.00	910.00	693.37	29.07	64.43	966.60
15.30	654.86	408.3	29.24	65.00	966.20
16.00	652.00	645.06	29.30	63.71	965.90
16.30	382.19	354.56	29.30	65.43	965.70
17.00	303.00	359.33	28.18	71.41	965.70
17.30	236.14	276.95	27.95	73.86	965.70
18.00	118.71	150.99	27.31	77.14	965.60
18.30	57.14	69.07	26.62	79.17	965.70
19.00	10.71	3.63	26.02	84.29	965.90
19.30	1.00	0	25.44	87.00	966.00
20.00	1.00	0	24.98	88.43	966.40
20.30	0.86	0	24.82	89.50	966.60
21.00	1.00	0	24.71	90.43	967.10
21.30	1.00	0	24.55	91.71	967.40
22.00	0.86	0	24.34	93.43	967.90
22.30	0.86	0	24.24	93.86	968.10
23.00	0.86	0	24.14	94.14	968.20
23.30	0.86	0	24.08	94.29	968.30

IV. Descriptions of Figures

Fig. 1 presents the variation of UV radiation at different time intervals. In the graph, it was depicted that UV radiation values recorded tended to be zero (0 W/m^2) between 0:00 and 6:00 GMT and 19:30 and 23:30 GMT daily. The values increased positively as time increases between 6:30 and 12:30

GMT and gradually decrease till around 19:00 GMT daily within the period of the experiment.

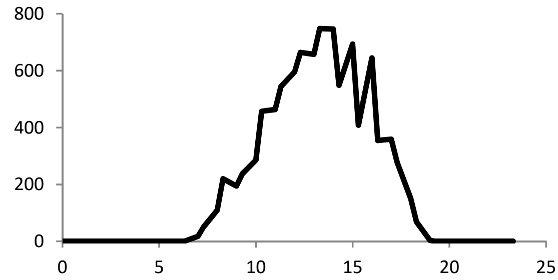

Fig. 2 Solar Radiation ($Js^{-1}m^{-2}$) against Time Intervals (GMT)

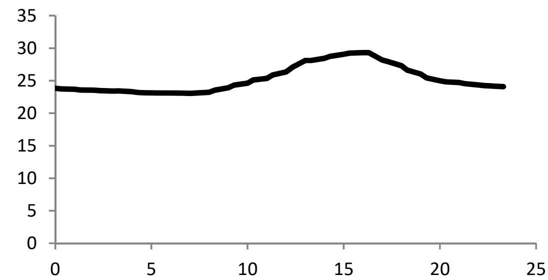

Fig. 3 Temperature (^{0}C) against Time Intervals (GMT)

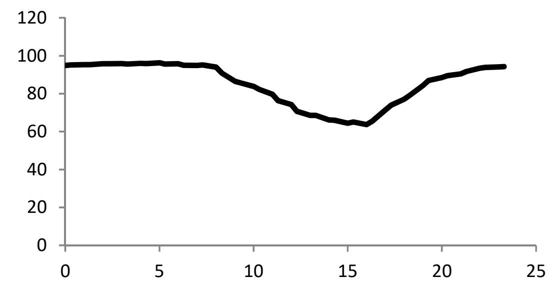

Fig. 4 Humidity (%) against Time Intervals (GMT)

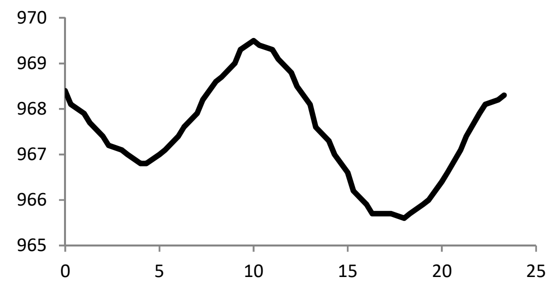

Fig. 5 Pressure ($Kgms^{-2}$) against Time Intervals (GMT)

Fig. 2 presents the variation of solar radiation at different time intervals. In the graph, it was also depicted that solar radiation values recorded were zero (0 W/m^2) between 0:00 and 6:30 GMT and 19:30 and 23:30 GMT daily. As shown on the graph, the values obtained increased positively between 7:00 and 14:00 GMT and gradually decreased till 19:00 GMT daily within the period of the experiment. Thus, the variation on the graph with that of UV radiation (Fig. 1) showed that both parameters follow the same trend with slight fluctuations as time increases. The fluctuations were traced to be the influence of other atmospheric parameters such as temperature, humidity and pressure.

Fig. 3 illustrates the variation of atmospheric temperature at different time intervals of the day. With the variations on the graph, the minimum temperature experience was 23.00 ^{0}C mainly at around 4:30 to 7:30 GMT and maximum temperature experience was 29.60 ^{0}C mainly at around 15:00 to 16:30 GMT mostly every day. It was a raining season period which seems to be cloudier.

Fig. 4 illustrates the variation of atmospheric humidity at different time intervals of the day. With the variations in the graph, the minimum humidity observed was 63.71% mainly at around 15:00 to 16:00 GMT and maximum humidity observed was 96.29% mainly at around 4:30 to 5:30 GMT mostly every day. This shows that both temperature and humidity opposed each other in variations every day.

Fig. 5 illustrates the variation of atmospheric pressure at different time intervals of the day. As shown on the graph, atmospheric pressure appears to be more complicated in the atmosphere. Its variations do not follow any of the aforementioned parameters. It fluctuates almost every day. The minimum pressure observed was 962.10 N/m^2 mainly at around 4:00 to 4:30 GMT and maximum pressure observed was 970.40 N/m^2 at 16:00 to 19:00 GMT.

Table II presents the results of statistical test obtained using Pearson correlations. This determines the nature of the relationship that exists between the atmospheric parameters.

TABLE II
PEARSON CORRELATION FOR UV RADIATION, SOLAR RADIATION, TEMPERATURE, HUMIDITY AND PRESSURE AT DIFFERENT TIME INTERVALS

	T (*GMT*)	*Te* (^{0}C)	*H* (*%*)	*P* ($Kgms^{-2}$)	*SR* ($Js^{-1}m^{-2}$)	*UVR* ($Js^{-1}m^{-2}$)
T (PC)	1	0.790**	0.665**	0.861**	0.147	0.007
Sig. (2-tailed)		0.000	0.000	0.000	0.483	0.975
N	25	25	25	25	25	25
Te (PC)	0.790**	1	0.970**	0.676**	0.633**	0.480*
Sig. (2-tailed)	0.000		0.000	0.000	0.001	0.015
N	25	25	25	25	25	25
H (PC)	0.665**	0.970**	1	0.490*	0.779**	0.649**
Sig. (2-tailed)	0.000	0.000		0.013	0.000	0.000
N	25	25	25	25	25	25
P (PC)	0.861**	0.676**	0.490*	1	0.084	0.263
Sig. (2-tailed)	0.000	0.000	0.013		0.689	0.204
N	25	25	25	25	25	25
SR (PC)	0.147	0.633**	0.779**	0.084	1	0.956**
Sig. (2-tailed)	0.483	0.001	0.000	0.689		0.000
N	25	25	25	25	25	25
UVR (PC)	0.007	0.480*	0.649**	0.263	0.956**	1
Sig. (2-tailed)	0.975	0.015	0.000	0.204	0.000	
N	25	25	25	25	25	25

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

The notations in Table II are valid for each parameter and their units remain the same as Table I. As shown, the probability value (P-value) for the level of significance is 0.01 and 0.05. Therefore, any correlation value less than or equal to p-value (i.e. $0.01 \geq P \leq 0.05$) is highly correlated and significant, and any value higher than p – value is not correlated and not significant. The degree of correlation ranges between 0 and 1 meaning that, it is highly correlated as values decreases from 1 to 0 ($1 \rightarrow 0$) and less correlated as values increases from 0 to 1 ($0 \rightarrow 1$).

In reckoning with the results obtained, correlation of solar UV and time with a significant value of 0.975 shows that, solar UV does not depend on time but highly depends on solar radiation, humidity, temperature and partially depends on pressure with significant value of 0.000, 0.000, 0.015 and 0.204 respectively. Thus, the relationship determined validates the dependency of UV radiations on other atmospheric parameters. Inferentially, the nature of relationship obtained could be a yardstick for short term environmental planning within Offa locality.

V. Conclusion

Variability in near-surface UV radiation and its dependence on some atmospheric parameters have been determined using meteorological data obtained from Science Laboratory Technology Department, Federal Polytechnic Offa, Nigeria. Results showed that UV radiation only exists for the period of solar radiation (day-length period). Statistically, when we compared the data obtained for UV radiation with other atmospheric parameters (solar radiation, temperature, humidity and pressure), results show that some relationship exist. Hence, the nature of relationship established with the significance level less than probability level (p - value) confirm that the correlation is significant at a particular level and can be useful for further prediction on the variability of solar UV radiations at different time intervals with respects to some atmospheric parameters.

VI. Recommendation

Known that solar UV radiations are naturally occurring radiations that contribute to the highest exposure of ionizing radiation to the public, it existence and variations with day-length on earth surface are affected by many atmospheric parameters. However, its relationship with atmospheric temperature, humidity pressure and solar radiation determined could be used to predict its availability on the earth surface. Hence, these results could be a yardstick for decision making in short term environmental planning on solar UV radiation dependence on some atmospheric parameters within Offa locality.

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