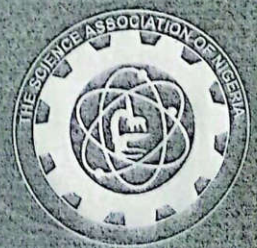


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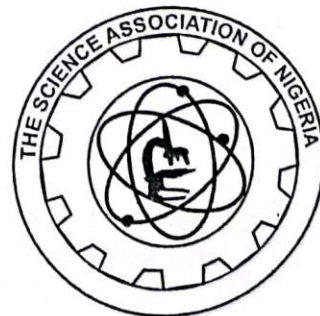
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Correlation of the Variation of Solar Radiation with the Frequency of Reported Cases of the Diseases of the Skin and Subcutaneous Tissue in Yola

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Abstract

Solar radiation data for 40 years collected from the meteorological center have been used to study the variation of solar radiation. Also data from the health management board for disease of the skin and subcutaneous tissue was used to correlate the solar insolation variation with the frequency of cases reported. The result shows that; solar radiation intensity is increasing over the years. An individual remaining in the sun in Yola receives an average solar insolation of $232.45 \text{ Js}^{-1}\text{m}^{-2}$ i.e. 1m^2 of the body exposed to the sun in Yola receives solar energy of about 232.45 J every second and 20.084 MJ every day. An adult of average body surface area of about 1.8 m^2 , receives an average energy of about 418.4 J every second he spends labouring outside. Also if likened to ionizing radiation and considering that the size of a typical mammalian cell $\approx 10 \mu\text{m}$, the energy mention above has the potential of cursing about 4.2663×10^7 ion pair per cell, with ion pairs giving rise to break in the chemical bond. There is a strong positive correlation ($R = 0.8138$) between the solar insolation and number of reported cases of the disease of the skin and subcutaneous tissue. A population growth weighed ratio of the disease cases with years could be very useful for a comprehensive result.

Introduction

Human exposure to solar radiation has important public health implications. Evidence of harm associated with overexposure to Ultraviolet Radiation (UV), a component of solar radiation has been demonstrated in many studies. Sunlight that reaches earth's surface contains three kinds of UV-radiation. UV-A, UV-B and UV-C, all contribute to sun burn and skin cancer as well as to conditions such as premature wrinkling of the skin (Yasuhiro *et al.*, 2004; Ichihashi *et al.*, 2003; Bruce *et al.*, 2001). Skin cancer and malignant melanoma are

among the most severe health effects, but a series of other health effects have been identified (WHO, 2006). The current report provides a quantification of the global disease burden associated with solar UV radiation. The information presented forms a knowledge base for the prevention of adverse effects of UV exposure that is achievable with known and accessible interventions. UV prevention focuses on protecting the skin and other organs from UV radiation. On the other hand, a moderate degree of UV exposure is necessary for the production of Vitamin D which is essential for bone health (Defey, 1982). Additionally, evidence emerges that low Vitamin D levels are likely to be associated with other chronic diseases (Reichrath, 2006). Thus, public health policy on ultraviolet radiation needs

Keywords: Solar Radiation, Ultra-violet Radiation, Exposure, Subcutaneous Tissue, Skin Cancer.

to aim at preventing the disease burden associated both with excessive and with insufficient UV exposure. It is a popular misconception that only fair-skinned people need to be concerned about overexposure to the sun. Darker skin has more protective melanin pigment, and the incidence of skin cancer is lower in dark-skinned people. Nevertheless, skin cancers do occur with this group and unfortunately they are often detected at a later, more dangerous stage (WHO, 2006).

Excessive UV exposure results in a number of chronic changes. These include various skin cancers of which melanoma is the most life-threatening and increased number of moles (benign abnormalities of melanocytes) and a range of other alterations arising from UV damage to keratinocytes and blood vessels. UV damage to fibrous tissues is often described as “photo-ageing”. Photo-ageing makes people look older because their skin loses its tightness and so sags or wrinkles. Caucasians have a higher risk of skin cancers because of the relative lack of skin pigmentation (Darell, 2008; Caroline, 2005; Jean-Luc *et al.*, 2001; Henry *et al.*, 1999; Frederick, 1997). The worldwide incidence of malignant melanoma continues to increase, and is strongly related to frequency of recreational exposure to the skin and to history of sunburn. There is evidence that risk of melanoma is also related to intermittent exposure to UV, especially in childhood, and to exposure to sunlamps. However the latter results are still preliminary (Gary, 2008; Richard *et al.*, 2006; Rona, 2006; Karen *et al.*, 2005). The risk of UV radiation-related health effects on the eye and immune system is independent of skin type (Vladislava, 2005).

Over 99% of the energy in the Earth's atmosphere has its origin from the radiation from the sun (Sulman, 1981; Navarra, 1979). The intensity of the solar radiation on a surface normal to the Sun's direction, outside the Earth's atmosphere and at the Earth's mean distance from the Sun is called the solar constant. Recent determinations of the solar constant have yielded a value of $1.351 \pm 0.028 \text{ kWm}^{-2}$ (Sara *et al.*, 2011; Sulman, 1981). About

two-thirds of this Energy actually reaches the surface of the Earth, the remainder being reflected, scattered or absorbed in the atmosphere. Of this Energy about 50% lies in the visible spectrum and about 5% is in the ultraviolet. The Solar radiation which reaches the surface of the Earth consists of a direct component (Sunlight) and a diffuse or scattered component (skylight). The total radiation, sunlight plus skylight, is designated global radiation (Sara *et al.*, 2011; Gary *et al.*, 2008; Sara, 2006; Jean, 2000; Defey, 1982). The global UV radiation is attenuated in the atmosphere principally by the following effects:

- a. Absorption by atmospheric ozone which is concentrated in a layer between 10 and 50km above sea level with a concentration maximum of about 10 ppm at an altitude of about 25 km. The total amount of 0.3 cm thick at standard temperature and pressure (STP). The absorption of UVR by ozone is important for wavelength less than 330 nm (the UVC and UVB regions which are the most the most dangerous regions of UV radiation (Odoh and Yunusa, 2013). In these regions, the values of the ozone absorption coefficient increases rapidly with decreasing wavelength so that there is practically no radiation with wavelengths less than 295 nm which reaches the Earth's surface (Defey, 1982).
- b. Rayleigh scattering caused by oxygen, nitrogen and other molecular components of the atmosphere, where the scattering particle is small compared with the wavelength of the radiation.
- c. Mie scattering caused by dust, aerosols, water droplets and other particles of diameter comparable to the wavelength of the radiation.
- d. In addition to the above effects, the degree of cloud cover and ground reflection will also affect the diffused component of the global radiation (Defey, 1982).

It is believed that the solar intensity is increasing over years because of a consistence damage been made in the ozone layer - a region of the earth's

atmosphere from 10-50 km above Earth surface, which screen the UV radiation coming from the sun (Suzanne, 2003; Harry, 1998; Frederick, 1997; Frederick, 1980; Angstrong, 1956). This damage has been known to be due to some human activities such as the long used of chlorofluorocarbons (CFC's) as refrigerants and as aerosol spray propellants, which pose a possible threat to the ozone layer e.g. up to 100,000 ozone molecules are destroyed per CFC molecules. Other factors such as deforestation, industrial pollution etc. are also highlighted as major threats to the ozone layer (Encarta, 2008). The result is that much of the ozone layer is continuously depleted leading all Earth's inhabitants being exposed to high level UV-radiation. Also the fact that, the depletion of the ozone layer which absorbs much of the UV-radiation will continue to increase skin damages and skin cancer later in the future will be prevalent (Encarta, 2008).

Theory

Estimate of the Human Average Body Surface Area (BSA): Solar radiation data are of immense importance in characterizing an area with respect to its agricultural potential, engineering design and

analysis of solar processes, obtaining an idea of the local climate and in medical science (health). For human, the exposure to solar radiation takes place on the entire body surface. The estimate of the average body surface was done using mathematical relations (or formula) by Mosteller (Mosteller, 1987). In this estimation,

Body surface area (BSA) in (m²) =

$$\left\{ \frac{H(cm) \times W(kg)}{3600} \right\}^{\frac{1}{2}} \quad (1)$$

where H = Height (cm) and W = Weight (kg) of the Human body and 3600 is a dimensionless proportional constant. This formula can be used to estimate the intensity of the UV radiation as a component of solar radiation and project possibly dose impacted to man.

Materials and Methods

The Gunn-Bellani, has been an instrument used many meteorological stations which measures the integrated solar radiation reaching the earth surface and has features as given in figure 1.

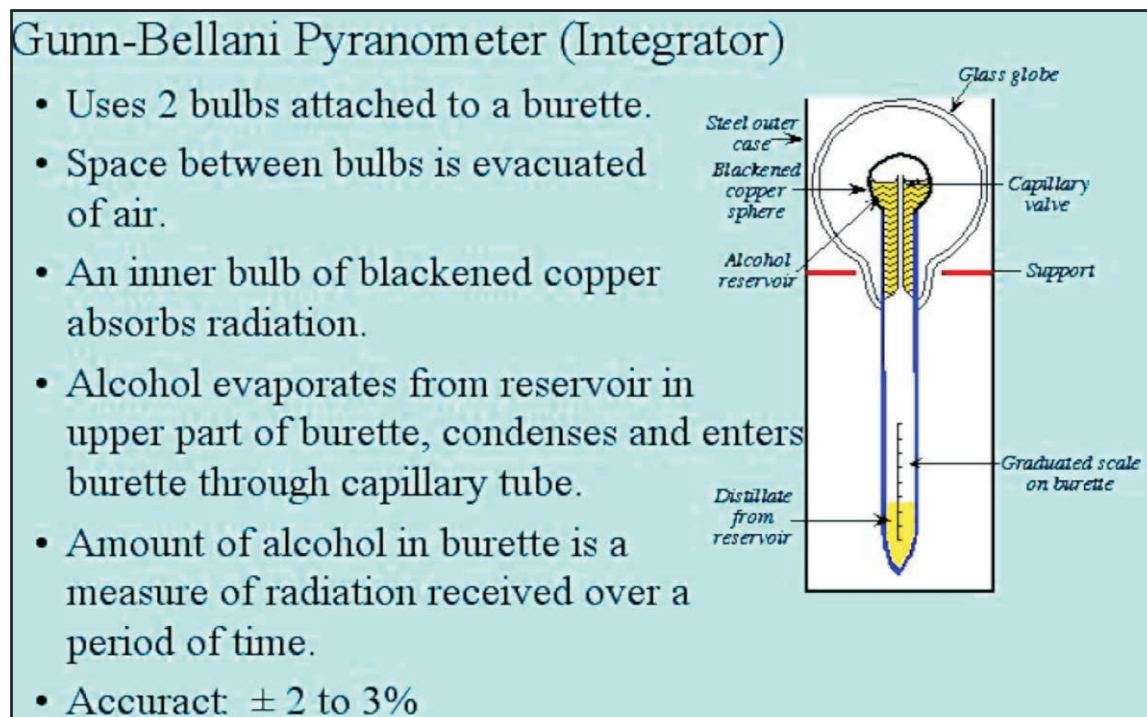


Figure 1: The Gunn-Bellani Pyranometer (source:<http://www.meteo.go.ke>)

The climatological data (solar radiation) was collected from the meteorological center located in Yola in the northeastern part of Nigeria at latitude $9^{\circ}14'$ and longitude $12^{\circ}28'$ at an altitude 190 m above sea level. The insolation values for 40 years (1969 to 2009) have been measured and recorded in ml using the Gunn-Bellani, an instrument which measures the integrated radiation reaching the blackened copper sphere which usually contains n-propyl alcohol or water, and connected to a calibrated condenser receiving tubes as indicated (in figure 1). The liquid vaporizes when heated by the solar radiation and condenses in the graduated receiver. The quantity of the condensate is a measure of the integrated solar energy during that interval. The quantity of liquid is measured in milliliter (ml) and can easily be converted to solar energy units, and the readings so obtained is to a high degree same as that by Eppley Pyranometer.

The solar radiation data collected was converted into absolute values ($\text{MJm}^{-2} \text{ day}^{-1}$) by a conversion factor of:

$$1 \text{ ml} = 1.216 \text{ MJm}^{-2} \text{ day}^{-1} \quad (2)$$

$$1 \text{ MJm}^{-2} \text{ day}^{-1} = 11.5741 \text{ W/m}^2 (\text{or } \text{Js}^{-1} \text{m}^{-2}) \quad (3)$$

This factor had been obtained in an earlier study (Eze, 1983) in which Gunn-Bellani readings were compared with corresponding values of an Eppley precision pyrometer.

To correlate the variation of the solar radiation with the prevalence of diseases of the skin and subcutaneous tissue, clinical data for the monthly total number of reported cases of the skin and subcutaneous tissue for nine years (2000 - 2008) were obtained from the Adamawa State Health Management Board. The record includes the number of people infected and those that died as a result of the infections. We used equation (1) to estimate the human average body surface area as a model of the body exposed to solar radiation.

Results and Discussion

The Solar radiation data of the location for the 40 years collected and the number of reported cases of

the disease of the skin and subcutaneous tissue were analyzed using Microsoft Excel to closely monitor their variation (increment) with years. The Total and Mean Insolation for each year was calculated in ml from the original data collected and were converted to the equivalent values in $\text{MJm}^{-2} \text{ day}^{-1}$ and W/m^2 (or $\text{Js}^{-1} \text{m}^{-2}$) using equations (2) and (3). The result is given in the table 1. The total and mean insolation for each month (JAN-DEC) (mean of the monthly mean insolation for the month), have been computed in ml and was converted also to $\text{MJm}^{-2} \text{ day}^{-1}$ W/m^2 respectively as presented in table 2.

From the graph of mean solar insolation against year (Fig. 1) it can be seen that solar radiation intensity is increasing over the years. The rate of increase was more noticeable when the data was grouped in an interval of 10 years, as indicated in Fig. 2. Generally it is a known fact that the change in solar insolation is not a phenomenon that is very noticeable over a short period of time. But from our projection over 40 years, we have been able to see how significantly this variation has taken place.

From table 2, it was estimated that an individual remaining in the sun in Yola receives an average solar insolation of $232.45 \text{ Js}^{-1} \text{m}^{-2}$ (W/m^2) i.e. 1 m^2 of the body exposed to the sun in Yola receives solar energy of about 232.45 J every second and 20.084 MJ every day. It follows also that an adult of average body surface area of about 1.8 m^2 (Encarta, 2008), receives average energy of about 418.41 J every second he/she spends laboring outside and about 36.1506 MJ if he/she spends the whole day exposed to sunlight. Suppose an individual was to spend 8 hours working in the sun on the average in a day from 8.00 am to 4.00 pm, he would have been exposed to energy of about 12.00 MJ as total body exposure.

It is known that a size of a typical mammalian cell = $10 \mu\text{m}$ ($\approx 10^{-12} \text{ m}^2$) (Simon, 1991). This implies that there are about 10^{12} cells per unit surface area of the skin. So insolation per unit cell = $2.3245 \times 10^{-10} \text{ J}$ per second. If this effect is likened to an ionization radiation, then to form 1 ion pair, one requires

Table 1: Total and mean insolation for each year in-ml, MJm⁻² day⁻¹ and w/m².

Year	Total insolation in (ml)	Mean insolation in ml	Equivalent mean insolation in MJm ⁻² day ⁻¹	Mean insolation in Jm ⁻² S ⁻¹ or (W/m ²)
1969	187.70	15.642	19.0207	220.15
1970	170.70	15.520	18.8723	218.43
1971	184.90	15.410	18.7386	216.88
1972	180.90	15.075	18.3312	212.17
1973	200.30	16.692	20.2975	234.93
1974	197.30	16.442	19.9935	231.41
1975	197.30	16.442	19.9935	231.41
1976	214.20	17.850	21.7056	251.22
1977	215.60	17.967	21.8479	252.87
1978	180.80	15.067	18.3215	212.05
1979	184.30	15.358	18.6753	216.15
1980	184.50	15.042	18.2911	211.70
1981	184.50	15.375	18.6960	216.39
1982	195.40	16.283	19.8001	229.17
1983	166.80	13.360	16.2458	188.03
1984	108.60	15.514	18.8650	218.35
1985	195.70	16.310	19.8323	229.55
1986	206.90	17.242	20.9663	242.67
1987	209.00	17.420	21.1827	245.17
1988	210.80	17.567	21.3615	247.24
1989	149.90	16.656	20.2537	234.42
1990	206.90	17.242	20.9663	242.67
1991	205.40	17.117	20.8143	240.91
1992	215.80	17.938	21.8673	253.10
1993	219.50	18.292	22.2431	257.44
1994	212.00	17.667	21.4831	248.65
1995	218.80	18.233	22.1713	256.61
1996	194.60	17.691	21.5123	248.99
1997	206.00	17.167	20.8751	241.61
1998	208.70	17.392	21.1487	244.78
1999	213.90	17.825	21.6752	250.87
2000	224.90	18.742	22.7903	263.78
2001	228.30	19.025	23.1344	267.76
2002	230.00	19.167	23.3071	269.76
2003	243.50	20.292	24.6751	285.59
2004	239.80	19.983	24.2993	281.24
2005	211.10	19.191	23.3363	270.10
2006	223.40	18.617	22.6383	262.02
2007	214.10	17.842	21.6959	251.11
2008	230.00	19.167	23.3071	269.76

approximately 34 eV (about 5.4474×10^{-18} J), which follows that we have about 4.2663×10^7 ion pairs per cell every second exposure to solar

radiation in Yola. Also, for someone exposed for 5 hours, about 7.67934×10^{11} ion pairs would be produced. This is obviously enough to bring

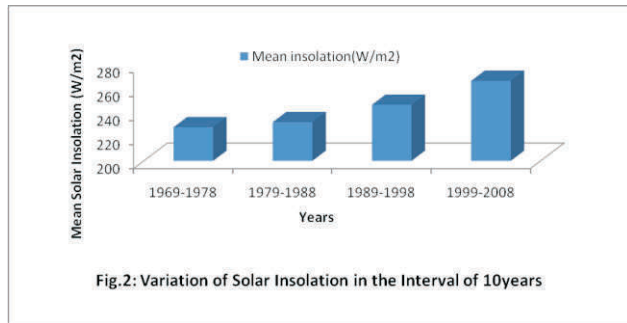
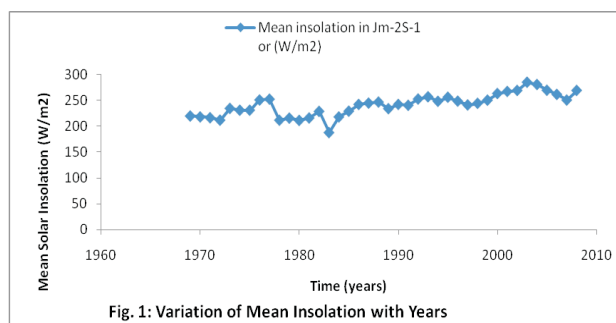


Table 2: Total and mean insolation for each month (JAN-DEC)

Month	Total insolation (ml)	Mean insolation (ml)	Mean (MJm ⁻² day ⁻¹)	Mean(w/m ²)
January	629.78	17.02	20.70	239.54
February	731.50	19.25	23.41	270.93
March	749.80	19.73	23.99	277.68
April	730.39	19.22	23.37	270.50
May	652.30	17.63	21.44	248.13
June	611.78	16.10	19.58	226.59
July	542.50	14.28	17.36	200.98
August	522.02	14.11	17.16	198.59
September	583.79	15.78	19.19	222.10
October	670.90	17.66	21.48	248.55
November	669.83	18.61	22.63	261.92
December	666.50	17.54	21.33	246.86

Table 3: Summary of mean insolation in the interval of 10 years

Year	Sum of mean insolation (W/m ²)	Mean insolation per decade (W/m ²)
1969-1978	2281.52	228.152
1979-1988	2324.42	232.442
1989-1998	2469.18	246.918
1999-2008	2669.14	266.914

serious medical consequence on the individual even though the radiation is not ionizing considering that production of ion pairs give rise to breaks in chemical bonds.

The prevalence of the disease of the skin and subcutaneous tissue has been presented in graphs by Fig. 4 and Fig.5. The result considered for some

Table 4: Summary of the disease of the skin and subcutaneous tissue (Source: Adamawa State Health Management Board).

Year	Total cases	Total death
2000	3104	4
2001	3220	6
2002	3310	6
2003	3369	6
2004	3507	7
2005	3808	7
2006	4306	8
2007	4067	8
2008	4413	9

years shows clearly that the number of reported cases was increasing over the years. The correlation between the variable parameters R was found to be 0.8138 (from $R^2 = 0.6622$) which means there is a

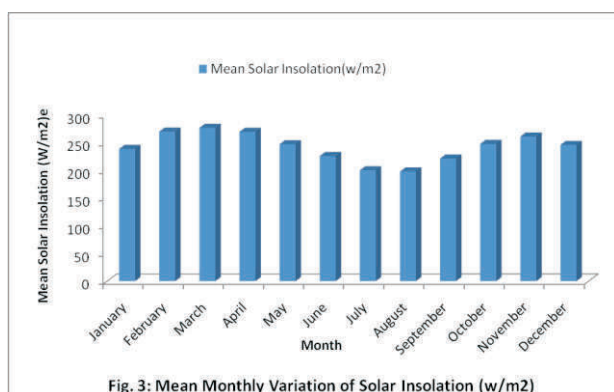


Fig. 3: Mean Monthly Variation of Solar Insolation (W/m²)

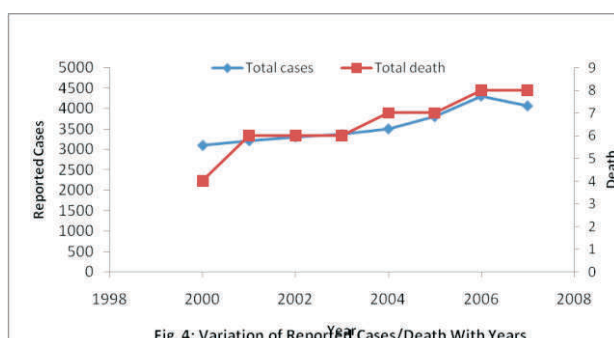


Fig. 4: Variation of Reported Cases/Death With Years

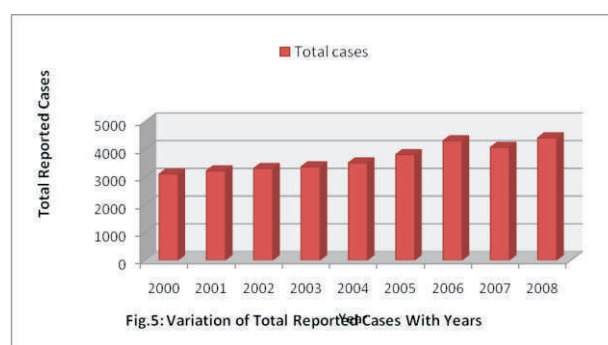


Fig. 5: Variation of Total Reported Cases With Years

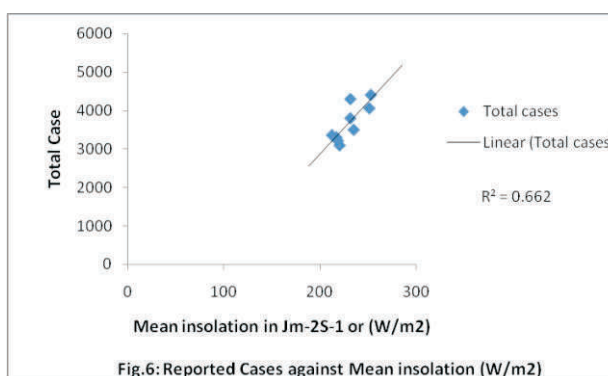


Fig. 6: Reported Cases against Mean insolation (W/m²)

strong positive correlation of the increasing cases of skin diseases with the increasing insolation over the years (Fig. 6). It was also noted that more cases are reported especially in August and September. The reason for this however, has not been known from this investigation.

Conclusion

The investigation has considered the variation of solar radiation reaching the earth surface with particular reference to Yola, Nigeria using meteorological data collected over 40 years and relating the observed changes to clinical record of skin and subcutaneous tissue diseases for certain years. The result shows that the solar intensity received in Yola has actually been increasing with the period under investigation. Since solar radiation contains various components of UV radiation, the later could also been increasing with years. This is in line with global reports given by World Health Organization (WHO, 2006). The factors responsible for this increasing insolation could no doubt not different from the world wide known fact of the destruction of the ozone layers (Harry *et al.*, 1998) arising from varied human activities all over the world.

Our survey has also shown that there is increasing cases of skin and subcutaneous tissue diseases with increasing solar intensity as the years go by. This means that if adequate measure is not taken for individual personal protection, and no pragmatic world legislation against activities favourable to the ozone depletion, people in Yola and of course the word at large will continue to suffer both short and long term effects including induction of cataract, skin erythema and skin cancer. Health organizations and government agencies should therefore, as a matter of necessity, put some measures in place by way of awareness campaign for people to avoid over exposure to the sun. Abstinence from the sun (mostly when the intensity is high around 11 am to 2 pm), adequate clothing, hats, the proper use of sun screen to prevent sun UV rays from reaching the skin and the use of sun glasses should be embraced by individual as means of personal safety from excessive exposure to UV radiation.

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