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IMPACTS OF STRATOSPHERIC OZONE DEPLETION AND GLOBAL WARMINNG IN NORTHERN NIGERIA

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ABSTRACT

In order to reduce the prevailing health complications associated with over-exposure to ultraviolet-B radiation from the Sun in northern Nigeria, this study investigated the impacts of the depletion of stratospheric Ozone and global warming in northern Nigeria. Meteorological data such as maximum and minimum temperatures obtained from Nigerian Meteorological Agency Abuja and UVB radiation data from NASA were used to carry out the study. The results of the analyzed temperature data for 40 years (1981-2020) showed that the study area is warming. An analyses of the UVB radiation data showed increasing trends in the number of days with very high UVB radiation and extreme UVB radiation. The results of this study showed that the amount of UVB radiation reaching the earth surface is increasing and has manifested in the increasing health complications associated with prolonged exposure to UV radiation. Prolonged exposure to solar radiation is linked with diseases such as cancer, blindness, skin disorder, and immunosuppression which are on the increase in the study area. In view of the enormous health effects associated with prolonged exposure to UVB radiation, this study seeks to create a public awareness that will help people to limit their exposure to UV radiation from the Sun.

Keywords: Ultraviolet, radiation, warming, solar, health, awareness, exposure.

Introduction

The gradual increase in global temperatures has become an issue of great concern to every country in the world. The manifestation of climate change in the form of extreme weather events such as heat waves, drought and flood has in a great way affected both humans and economic activities negatively. The continuous combustion of fossil fuels and the emission of substances such as chlorofluorocarbons and hydrofluorocarbons has contributed immensely to global warming and Ozone depletion in the stratosphere respectively. The Chlorofluorocarbons (CFCs) are compounds which contains carbon, fluorine, and hydrogen sometimes. They are family of inert, nontoxic, nonflammable, liquefied chemicals that are used in refrigeration, air conditioning and aerosol propellants. Hydrofluorocarbons (HFCs) are organic compounds that contain fluorine and hydrogen atoms, which are

frequently used as refrigerants in air conditioning system (R-134).

Temperature variability has been identified as one of the major indices which influences the degree of climate change (Agada and Yakubu, 2022). The variability of temperature is associated with events such as global warming, heat waves, Ozone depletion in the stratosphere, drought, precipitation and atmospheric air circulation. A continuous increase in the global temperatures has induced a warming effect on the earth surface which has negatively affected the ecosystem (Agada and Yakubu, 2022). Global warming is the gradual increase in the earth's temperature due to elevated greenhouse effects caused by increased levels of anthropogenic emissions such as carbon dioxide, Chlorofluorocarbons (CFCs), nitrous oxide and other greenhouse gases. The increase in anthropogenic gaseous emissions since 1970's has been identified to have contributed to the warming of the troposphere which is the lower layer of the atmosphere and the gradual cooling of the stratosphere due to Ozone depletion. The accumulation of carbon dioxide in the atmosphere affects the stratospheric Ozone as well as the earth surface ultraviolet radiation through changes induced on the clouds and the Earth's surface reflectivity.

Ozone depletion can be defined as the gradual diminishing of earth's Ozone layer caused by the emissions of chemical substances which contain chlorine or bromine compounds. These chemicals react with ozone in the stratosphere to reduce the concentration of Ozone in the stratosphere. The stratospheric Ozone layer in the atmosphere helps to filter out the harmful ultraviolet radiation from the Sun. Ozone depletion is a great environmental problem because it is associated with the increase in the amount of ultraviolet radiation reaching the Earth's surface. The increase in the amount of ultraviolet radiation on the earth surface is responsible for the increase in the rate of skin cancer, eye cataracts, genetic and immune system suppression (WHO, 2020). In recent times, hospital records have shown that there is a gradual increase in the number of people suffering from health complication such as eye cataracts, skin cancer, and immune system disorder which are associated with overexposure to ultraviolet radiation from the Sun in the northern part of Nigeria (Ochicha*et al.*, 2004; Ahachi*et al.*, 2016). Some researchers observed that the increase in the concentration of carbondioxide, chlorofluorocarbon and other bye products of fossil fuel combustion has depleted the stratospheric Ozone layer, thereby causing more solar radiation to reach the earth surface (Seinfeld and Pandis. 1998).

The lives of living organisms depend on the radiant energy from the Sun. Solar radiation is composed of electromagnetic spectrum which includes the ultraviolet radiation (UV), visible rays and the infra-red radiation. Solar radiation is characterized by both long wavelength radiations (microwaves and radio-frequency and microwaves) and shorter wavelength (ionizing) radiations. Ultra-violet

radiation (UVR) wavelength ranges between 100-400nm (Figure 1) and it could be characterize into UVA (315 - 400nm), UVB (280 -315 nm), and UVC (100 – 280 nm).As the solar radiation passes through the atmosphere, all UVC is absorbed by Ozone, water vapour, oxygen and carbon dioxide. UVA is not significantly filtered by the atmosphere. As the Ozone layer depletes, the ecosystem gets exposed to higher concentration of UVB radiation (University of Leeds, 2005).

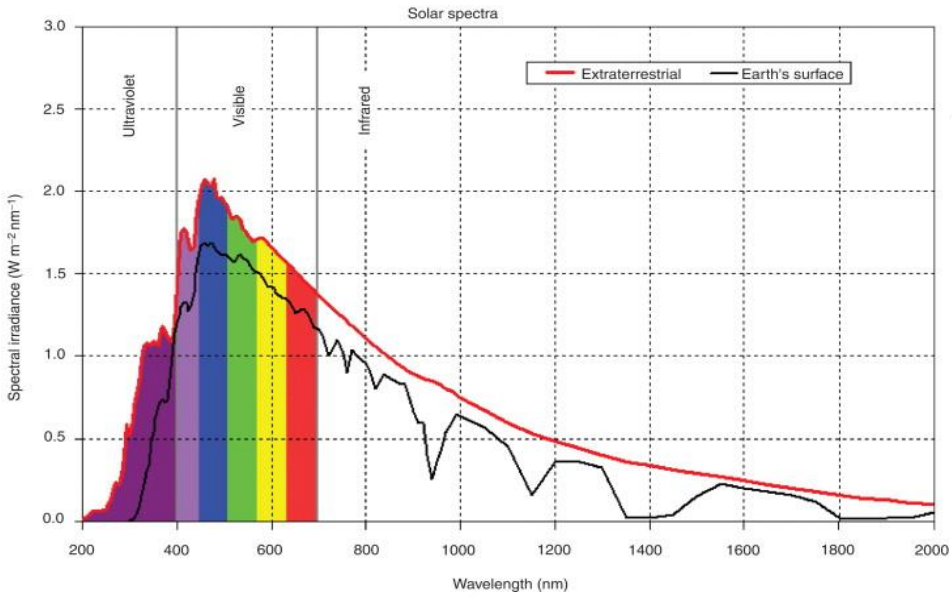


Figure 1: The solar spectrum showing wavelength distribution extra-terrestrially and on the Earth's surface. Adapted from Gies*etal*. 2004.

The daily temperature is a function of the amount of solar radiation reaching the earth surface. The ultraviolet radiation has been identified to be responsible for accelerating human ageing on the Earth surface (Malvy et al., 2000; Richard and Tim, 2006). Several research reports have shown that outdoor workers such as Farmers have high risk of cancer (Wiklund and Dick, 1995; Richard and Tim 2006). Pogoda and Preston-Martin, in 1996 reported that cancer risk is strongly related to lifetime solar radiation exposure and annual time spent outdoors. Ricard and Tim, in 2006 established that there is a great causal relationship between solar ultraviolet radiation and cancer of the lip. Cataract is a common disease in the extreme northern Nigeria where the daily temperatures are always high due to prolonged dry season and its semi-arid climatic features (Kyari et al., 2009).

A cataract is a dense, cloudy area that forms in the lens of the eye. A cataract is known to form when there is a protein clumps growth which prevents the lens of the eye from sending clear images to the retina. Some researchers have reported that cataract risk increases with high solar radiation exposure (West et al., 1998; Delcourt et al., 2000; McCarty et al. 2000). A study by Bachem 1956, showed that cataracts in small animals can be induced in the laboratory using artificial ultraviolet radiation source. Some studies have also shown that the increase in viral diseases infection is associated with increase in sunlight exposure (Hersey et al., 1983; Chadonnet et al., 1989). The Nigeria National Blindness and Visual Impairment Survey (NNBVIS) reported a higher prevalence of visual impairment and blindness in rural areas compared to the urban areas (NNBVIS, 2020). The NNBVIS report showed that the Northwest and the Northeast have the highest prevalence compared to other parts of Nigeria. They have blindness prevalence of 4.8% and 6.1% respectively. The data from the Nigerian blindness survey estimated an increase of about 43% in the number of people with severe visual impairment and blindness from cataract in the year 2020. The World Health Organization (WHO) estimated that globally there are 39 million blind people and another 285 million are visually impaired. Africa accounts for about 15% of blindness. WHO (2020) indicated that over-exposure to UV is the major cause of skin cancer. Globally over 1.5 million people were diagnosed with skin cancer (WHO, 2020).

In view of the relationship between the depletion of the stratospheric Ozone layer and the rising temperature on the Earth surface, the Earth surface temperature can also be used as a finger print to investigate the effects of stratospheric Ozone layer depletion and the global warming. The rising cases of blindness and other diseases related to the impacts of Ultraviolet radiations in the northern parts of Nigeria necessitated this study.

Materials

The datasets used for this study were obtained from the Nigerian Meteorological Agency (NiMet) Abuja and the National Aeronautical and Space Administration (NASA). The maximum and minimum temperature datasets were obtained from the NiMet Abuja and the daily ultraviolet index data were obtained from NASA (http://neo.gsfc.nasa.gov/view.php?datasetId=AURA_UVI_CLIM_M).

Research Method

Time series analysis was used to analyze the obtained datasets. The Standard Anomaly Index (SAI) was calculated using equation (1),

$$SAI = \frac{x_i - x_m}{\sigma} \qquad (1)$$

Where, x_i is the mean temperature for each year and x_m is the long-term mean temperature. σ is the standard deviation of the annual maximum temperature for the long-term. Periods below the long-term

average were considered cooling periods and periods above the long-term average were considered warming periods. The standard anomaly index of the temperature was compared to the threshold risk levels (Table 1).

Table 1: Standard Anomaly Index (Source: Marck, 2015)

S/N	Event	Interpretation
1	SAI ≥ 2.0	Extremely hot
2	SAI $\geq 1.5 < 2$	Very hot
3	SAI $\geq 1.0 < 1.5$	Moderately hot
4	SAI $< 1.0 > -1.0$	Near normal
5	SAI $\leq -1.0 > -1.5$	Moderately cold
6.	SAI $\leq -1.5 > -2.0$	Very cold
7.	SAI ≤ -2.0	Extremely cold

The daily exposure of the UV radiation were evaluated using the UVB index scale (Table 2).

Table 2: UVB Radiation Index Scale (WHO, 2022)

S/N	UVB Index	Exposure Level
1	<2	Low
2	3 to 5	Moderate
3	6 to 8	High
4	8 to 10	Very high
5	11+	Extreme

The UVB index gives an indication of the level of UVB radiation and the potential danger of sun exposure. The UVB index predicts UVB intensity levels on a scale of 1 to 11+, where 1 indicates a low risk of overexposure and 11+ signifies an extreme risk (WHO, 2022). The mean daily data was converted to obtain the mean monthly data per hour. This data was then computed by calculating the mean hourly UVB index for the total number of days in a month for a period of twenty-five (25) years. This process was used to compute the number of days with very high UVB radiation index and the days

with extreme UVB radiation index. A time series was used to determine the trend in the UVB radiation index between 1995 and 2017.

Results

The results of the analyses of the forty (40) years maximum temperature data from the northern part of Nigeria clearly indicates that the area is warming and it has been impacted by climate change (Figure 2). The results showed that the year 1987 and 2016 were extreme hot, and there were consistent increase in the maximum temperature trend from 2013 to 2020. The increase in the solar flux reaching the Earth surface is responsible for the increasing trend in the maximum temperature of the study area.

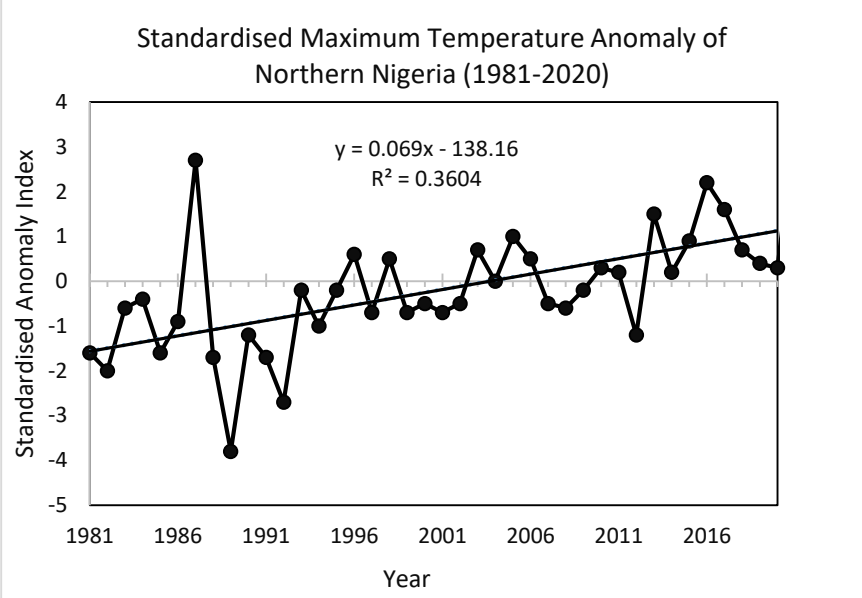


Figure 2: Standardized Maximum Temperature Anomaly Index for Northern Nigeria.

The results of the analyzed minimum temperature data from 1981 to 2020 also showed that there is an increasing trend in the minimum temperature of the study area (Figure 3).

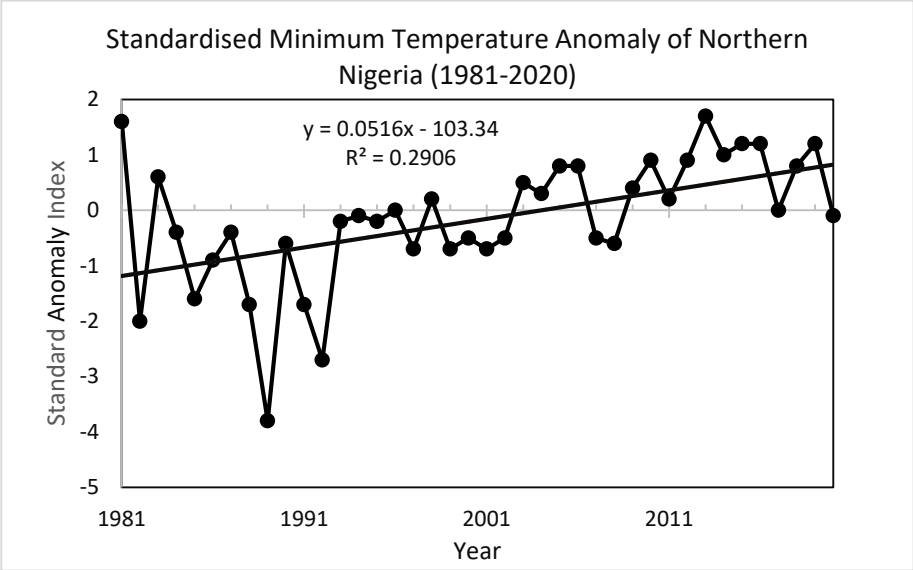


Figure 3: Standardized Minimum Temperature Anomaly Index for Northern Nigeria.

Both the maximum and the minimum temperature trends in the study area have shown that the amount of solar radiation reaching the earth surface is increasing due to the depletion of the stratosphericOzone layer. The continuous emission of greenhouse gases through the process of fossil fuel combustion also contributed to the warming effects of the Earth surface. The increasing temperatures have manifested as extreme events which includes heatwaves and drought. The changing climate has affected both agriculture and other economic activities in the region, and might lead to warmer and dryer weather conditions which may increase the concentration of aerosols in the atmosphere and lower the groundwater table in the area.

The analysis of the UVB radiation index showed an increasing trend in the number of days of extreme UVB radiation (Figure 4).

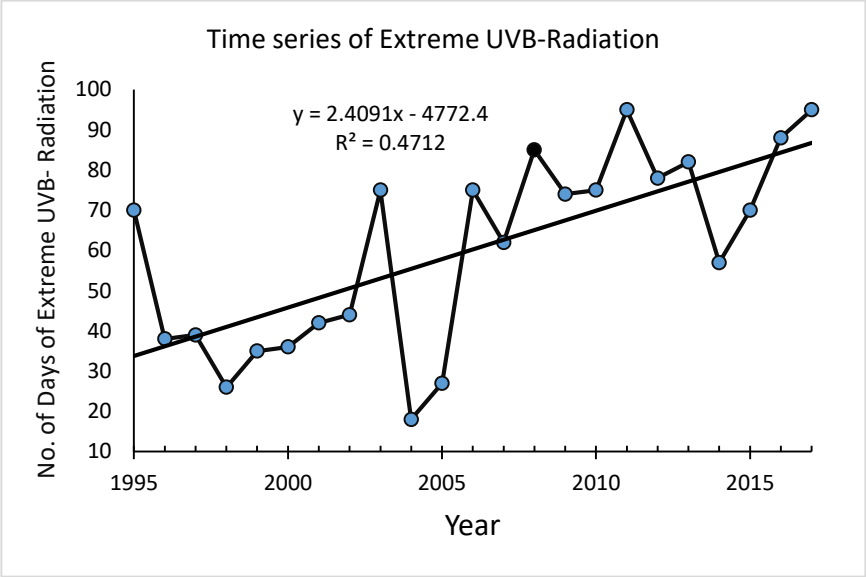


Figure 4: Time series showing days of extreme UVB-Radiation

The results showed that in 1995 there was 70 days of extreme UVB radiation and the days of extreme radiation increases from 1999 continuously to 2003. There were 75 days of extreme UVB radiation in both 2003 and 2006.Extreme UVB radiation days are characterized with UVB radiation index which ranges from 11 and above (Table 2). The days of the extreme UVB radiation reduces between 2004 and 2005. The year 2011 and 2017 had the highest number of days of extreme UVB radiation. The continuous increase in the number of days of extreme UVB radiation is a clear indication that the stratospheric Ozone layer is depleting. The increase in the solar flux reaching the earth surface is associated with the increase the amount of extreme UVB radiation reaching the earth surface. The results of the study also showed that there is an increasing trend in the number of days of very high UVB radiation (Figure 5). In 2015, there was about 180 days of very high UVB radiation (Figure 5). Very high UVB radiation days are characterized with UVB radiation index which ranges from 8 to 10 (Table 2). The results of the study revealed that the increasing trends in the number of days of both extreme and very high UVB radiation in the study area are responsible for the increase in the rate of health complications such as blindness, cataracts, and skin cancer that are common in the area. Solar radiation is known to be very important for health development of humans, animals, and plants, but excess of solar radiation is harmful to human health. The sunlight helps human and some animals to develop vitamin D which helps to prevent the formation of bone disorder such as rickets, osteomalacia and osteoporosis.

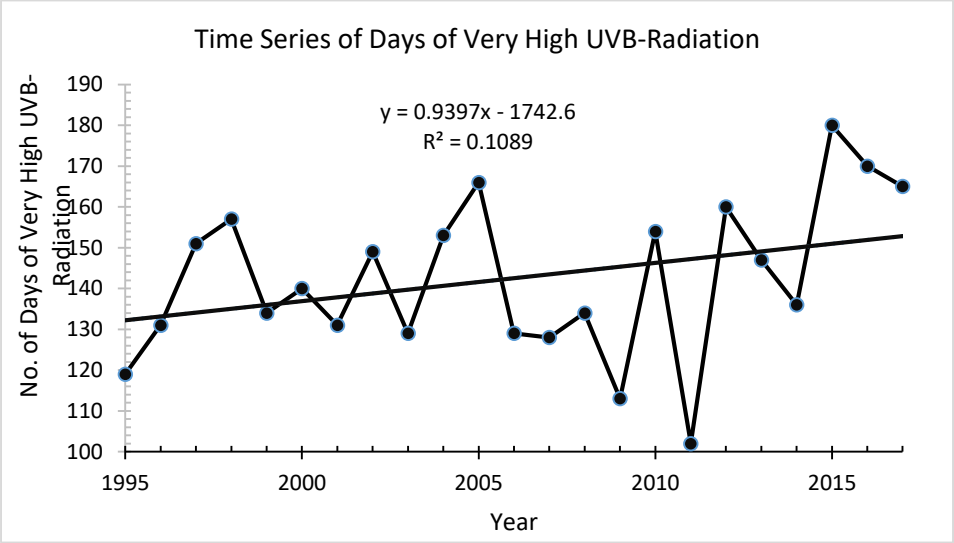


Figure 5: Time series showing days of very high UVB-Radiation

Considering the health complications associated with over-exposure to UVB radiation such as blindness, cancer, cataract, photo-aging, and immune-suppression, the need to understand the impacts of continuous Ozone depletion in the stratosphere is very important to reduce the morbidity and mortality rates associated with over-exposure to ultraviolet radiation. Over-exposure of children to UV radiation can cause the manifestation of UV related health complications in their later age. Therefore, children should be made to avoid overexposure to UV radiation.

The increase in both maximum and minimum temperatures observed in the results of this study are clear manifestation of global warming which are in most times accompanied with changes in the amount of rainfall and its patterns. The increase in industrial activities in recent time has contributed immensely to an increase in fossil fuel combustions and emissions which constitute environmental health hazards and increases the prevalence of cancer and respiratory infections. Some of the years with high number of days of extreme ultraviolet radiation correspond with the drought years. The occurrence of drought and heat waves in the northern part of Nigeria contribute to the worsen situation of global warming. The findings of this study shows that a continuous depletion of the stratospheric Ozone layer will cause an increase in the Earth surface temperature because the incoming solar radiation will be less absorbed by the diminishing stratospheric Ozone layer and most of them will be radiated into the Earth surface. Considering the fact that there is a

gradual increase in UV-related illness and death in the study area due to inadequate public awareness on the dangers of over-exposure to UVB radiation especially during the solar noon when the sun is highest in the sky, the results of this study will in a great way provide the needed information that will help the public to limit their exposure to UVB radiation. UVB radiation health complications could be cumulative for a prolonged period of exposure. Therefore, the need for public awareness on the health effects of prolonged exposure to UVB radiation is very important, especially in Nigeria and Africa at large, where a greater percentage of the population are farmers who spent much time in the sun to carry out their farming activities. Prolonged exposure to UVB radiation is associated with acute and late health complications such cancer, cataracts, skin disorder and immunosuppression. In view of the enormous health effects caused by prolonged exposure to UVB radiation from the Sun, there is a need for continuous public awareness to sensitize the public on the dangers of over-exposure to sunlight.

Conclusion

This study investigated the impact of the depletion of stratospheric Ozone and global warming in Northern Nigeria. Meteorological data such as maximum and minimum temperatures obtained from Nigerian Meteorological Agency Abuja and UVB radiation data from NASA were used to carry out the study. The results of the analyzed temperature data for 40 years (1981-2020) showed that the study area is warming. The warming effects have affected both agricultural and economic activities negatively in the area. An analyses of the UVB radiation data showed increasing trends in the number of days with very high UVB radiation and extreme UVB radiation. Majority of the people in the study area are farmers who are always exposed to UVB radiation due to their occupation. Their prolonged exposure to UVB radiation on daily basis makes them potentially susceptible to disease such as blindness, skin cancer, cataracts, erythema, and photo-aging. Intense public awareness will help the people in the study area and other places alike to limit their exposure to ultraviolet radiation from the Sun. The findings of this study is in agreement with the reports of Kyari*et al*. 2009 and NNBVIS, 2020.

Recommendation

Based on the findings of this study, the following are recommended.

I. Public health campaign should be encourage at all levels in the society to sensitize the public on the danger of over-exposure to ultraviolet radiation from the Sun.

ii. Tree planting projects should be encouraged to protect the environment from the warming effects caused by increasing temperature trend.

iii. Global solar UV radiation index alert systems should be made available to the public in order to sensitize them on the need to use sun protection when the need arises.

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