



Adverse Impact of Harmful Thermal Energy Radiations on the Temperate Ecosystem in Bauchi Metropolis, Bauchi State

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ABSTRACT

The study assessed the adverse impact of harmful thermal energy radiations on the temperate ecosystem in Bauchi metropolis, Bauchi State, Nigeria. To carry out this research properly, instruments that include microwave imaging radiometer (MIR), scanning multichannel microwave radiometer (SMMR) and conical scan configuration (CSC) were utilized for the impacts assessment. Four specific objectives were formulated to guide the conduct of this research. Field experiments were carried out for the study. Clustered random sampling was employed to draw the sample of 13 points out of the total population of the research site. Results obtained indicated that thermal energy radiation is relatively high in Bauchi metropolis, which resulted in adverse ecological, physical, economic and health consequences upon the inhabitants. The expected research outcomes would be harnessed to mitigate the detrimental thermally radiated wave emissions that hamper the balanced ecological setups, with humans, animals and plants most negatively affected. That would provide veritable opportunities for addressing atmospheric radiations damage in a number of ways using affordable means and resources at disposal. Based on the findings of this study, it was concluded that the adverse impacts of harmful thermal energy radiations on the temperate ecosystem in Bauchi metropolis are pegged high. The findings further reveal that there is a long way to go to be able to address the mess on the ecosystem, which hinder the ecological, physical, climatic, economic and health wellbeing of the affected inhabitants. Hence mitigating measures should be put in place. The study recommended among others that, enough ecology friendly, green-leaved trees should be planted, nurtured, grown, protected and maintained on the outskirts, neighbourhoods and along the streets in order to preserve the environment with its quality ecosystem. Indiscriminate deforestation and bush burning should be avoided far, near or around human habitats. Adequate legislation and enforcement of environmental preservation laws should be ensured.

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INTRODUCTION

Thermal radiation connotes the mode of heat transfer from one point or location to another in the form of

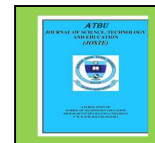
electromagnetic waves. It is a process by which electromagnetic energy is emitted by heated surfaces in all directions and travels directly to its point of absorption

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at the speed of light without the need of intervening medium to carry it (BYJU, 2020; Kerone, 2021). Thermal radiations are advantageous to the survival of living organisms on earth, as they are, to some degrees, disadvantageous to the ecosystem and its constituents (NOAA, 2013).

It is an electromagnetic radiation generated by the thermal motion of molecules or particles in matter. All matter with a temperature exceeding absolute zero emits thermal radiation (Hermann, 2013). It is interesting to appreciate that thermal emission through evacuated space can only occur by means of radiation. Likewise, it can happen between two bodies separated by a medium colder than both bodies (Kerone, 2021).

Thermal radiations vary in wavelengths ranging from longest infrared rays through the visible light spectrum to the shortest ultraviolet rays (NOAA, 2013). The distribution and intensity of radiant energy within the range rely significantly on temperature of the emitting surface. The total radiant heat energy emitted by a surface, according to Stefan-Boltzmann law, is proportional to the fourth power of its absolute temperature (Britanica Encyclopedia, 2020).

In the earth's atmosphere, the impacts of harmful thermal radiations in different forms tend to pose negative consequences on the ecosystems in which humans, animals and plants co-habit or live separately (Liu, 2013). It is in this light that this research intends to identify various factors that aid to the increase in harmful thermal radiations in our environment for expediting prompt positive response to neutralize

the resultant effects in Bauchi metropolis, Bauchi state.

Statement of the Problem

The alarming rate of increase in harmful thermal radiations from natural surfaces mostly due to human activities, apart from the few likely natural factors, has become a serious concern to affected societies. These put together pose threats to life and wellbeing of people, plants and animals in the ecosystem. Life on earth would be nearly impossible without the supply of thermal energy radiations, but if it exceeds the normal consumable level it would result in an imbalanced ecosystem most especially in temperate and semi-temperate zones.

It is becoming so disturbing how the trend of ecological abuses occasioned by indiscriminate felling down of trees, industrial productions, heat emissions from burning fuels, coals, bunsen burners, stoves, etc. over grazing, bush burning, and unplanned infrastructural expansions in towns and cities, has been impacting negatively on lives and livelihoods of people most especially in developing countries where adequate attention is not given to the preservation of the ecosystem as it is obtained in industrialized, developed world. With this study, the impact of thermal radiations vis-à-vis their harmfulness on the ecosystem will be identified, assessed and discussed in order to provide mitigating measures that will reasonably reduce them for attaining and conserving the thermal balance.

Objectives of the Study

The main purpose of the research was to study the adverse

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impacts and neutralization of harmful thermal radiations on the temperate ecosystem of Bauchi metropolis, Bauchi state, Nigeria.

Specifically, the objectives include:

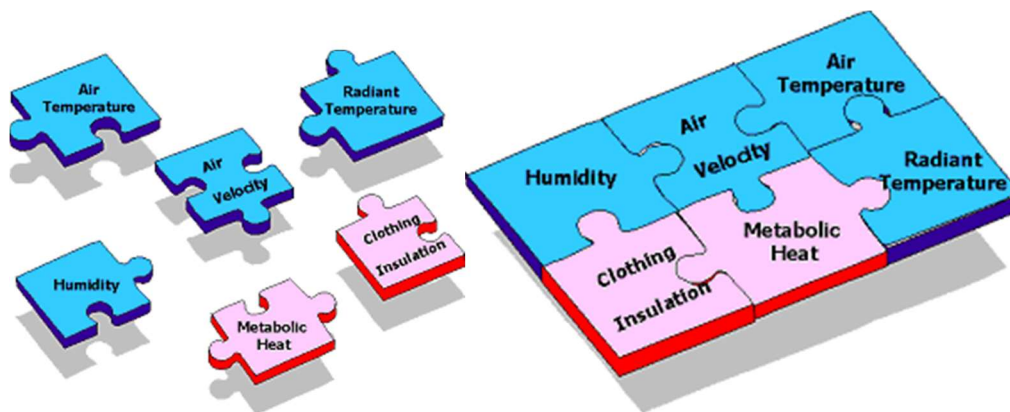
1. To identify and assess factors (both human and natural) that give rise to harmful thermal radiations in the temperate ecosystem.
2. To identify and assess the adverse impacts (effects) of harmful thermal radiations on the temperate ecosystem,
3. To identify measures that will help in the substantial reduction in harmful thermal emissions in the ecosystem.
4. To create awareness to the public on how well to preserve the ecology devoid of its degradation that would result in excessive thermal radiations that hamper the ecosystem.

Factors of Thermal Comfort

The most commonly used indicator of thermal comfort is air temperature because it is easy to use and most people can relate to it. However, air temperature alone is not a valid or accurate indicator of thermal comfort or thermal stress. It should always be considered in relation to other environmental and personal factors (HSE-UK, 2018).

The six factors affecting thermal comfort are both environmental and personal. These factors may be independent of each other, but they together contribute to a body's thermal comfort.

Four environmental factors are air temperature, radiant temperature, air velocity and humidity while the two personal factors are clothing insulation and metabolic heat.



ENVIRONMENTAL FACTORS

Air Temperature

This is the temperature of the air surrounding the body. It is usually given in degree Celsius ($^{\circ}\text{C}$).

Radiant Temperature

Thermal radiation is the heat that radiates from a warm object. Radiant heat may be present if there are heat sources in an environment. Radiant temperature has a greater

influence than air temperature on how we lose or gain heat to the environment. Examples of radiant heat sources include: the sun, fire, electric fires, ovens, kiln walls, cookers, dryers, hot surfaces and machinery, melted metals, etc. (HSE-UK, 2018; Dembsey, 2016).

Air Velocity

This describes the speed of air moving across a body and may help cool it if the air is cooler than the environment. Air velocity is an important factor in thermal comfort for example:

1. Still or stagnant air in indoor environments that are artificially heated may cause people to feel stuffy. It may also lead to a build-up in odour
2. Moving air in warm or humid conditions can increase heat loss through convection without any change in air temperature
3. Physical activity also increases air movement, so air velocity may be corrected to account for a person's level of physical activity
4. Small air movements in cool or cold environments may be perceived as a draught as people are particularly sensitive to these movements (HSE-UK, 2018).

Humidity

If water is heated and it evaporates to the surrounding environment, the resultant amount of water in the air will provide humidity. Relative humidity is the ratio between the actual amount of water vapour in the air and the maximum amount of water vapour that the air can hold at

that air temperature (BYJU, 2018; HSE-UK, 2018). Relative humidity between 40% and 70% does not have a major impact on thermal comfort. In workplaces which are not air conditioned, or where the weather conditions outdoors may influence the indoor thermal environment, relative humidity may be higher than 70%. Humidity in indoor environments can vary greatly, and may be dependent on whether there are drying processes (paper mills, laundry etc) where steam is given off (HSE-UK, 2018).

High humidity environments have a lot of vapour in the air, which prevents the evaporation of sweat from the skin. In hot environments, humidity is important because less sweat evaporates when humidity is high (80%+). The evaporation of sweat is the main method of heat reduction (HSE-UK, 2018).

When non-breathable vapour-impermeable personal protective equipment (PPE) is worn, the humidity inside the garment increases as the wearer sweats because the sweat cannot evaporate. If an employee is wearing this type of PPE (eg asbestos or chemical protection suits etc) the humidity within the PPE will be high (HSE-UK, 2018; Wieczorek, 2016).

PERSONAL FACTORS

Clothing Insulation

Thermal comfort is, to a greater extent, dependent on the insulating effect of clothing on the wearer. Wearing too much clothing or PPE may be a primary cause of heat stress even if the environment is not considered warm or hot. If clothing does not provide enough insulation, the wearer may be at risk from cold injuries such as



frostbite or hypothermia in cold conditions (HSE-UK, 2018; Wieczorek, 2016).

Clothing is both a potential cause of thermal discomfort as well as a control for it as we adapt to the climate in which we work. You may add layers of clothing if you feel cold, or remove layers of clothing if you feel warm. Many companies inhibit this ability for employees to make reasonable adaptations to their clothing as they require them to wear a specific uniform or PPE (HSE-UK, 2018; Wieczorek & Dembsey, 2016).

It is important to identify how the clothing contributes to thermal comfort or discomfort. By periodically evaluating the level of protection provided by existing PPE and evaluating newer types of PPE you may be able to improve the level of thermal comfort.

Work Rate/Metabolic Heat

The more physical work we do, the more heat we produce. The more heat we produce, the more heat needs to be lost so we don't overheat. The impact of metabolic rate on thermal comfort is critical. A person's physical characteristics should always be borne in mind when considering their thermal comfort, as factors such as their size and weight, age, fitness level and sex can all have an impact on how they feel, even if other factors such as air temperature, humidity and air velocity are all constant (HSE-UK, 2018).

Background Radiation

Background radiation, coming primarily from natural minerals, is around us all the time. Fortunately, there are very few situations where an

average person is exposed to uncontrolled sources of radiation above background. Nevertheless, it is wise to be prepared and know what to do if such a situation arises.

One of the best ways to be prepared is to understand the radiation protection principles of time, distance and shielding. During a radiological emergency (a large release of radioactive material into the environment), we can use these principles to help protect ourselves and our families (US-FEMA, 2021).

Time, Distance and Shielding

Time, distance, and shielding actions minimize your exposure to radiation in much the same way as they would to protect you against overexposure to the sun:

1. Time: For people who are exposed to radiation in addition to natural background radiation, limiting or minimizing the exposure time reduces the dose from the radiation source.
2. Distance: Just as the heat from a fire reduces as you move further away, the dose of radiation decreases dramatically as you increase your distance from the source.
3. Shielding: Barriers of lead, concrete, or water provide protection from penetrating gamma rays and x-rays. This is why certain radioactive materials are stored under water or in concrete or lead-lined rooms, and why dentists place a lead blanket on patients receiving x-rays of their teeth. Therefore, inserting the proper

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shield between you and a radiation source will greatly reduce or eliminate the dose you receive (US-CDCP, 2021).

Radiation Emergencies

In a large scale radiological release, such as a nuclear power plant accident or terrorist incident, the following advice has been tested and proven to provide maximum protection. If a radiation emergency occurs, you can take actions to protect yourself, your loved ones and your pets: Get inside, stay inside and stay tuned. Follow the advice of emergency responders and officials (US-CDCP, 2021; US-FEMA, 2021).

RESEARCH METHODOLOGY

Field experiments were carried out for the study. Clustered random sampling was employed to draw the sample of 13 points out of the total population of the research site. The instruments used were microwave imaging radiometer (MIR), scanning multichannel microwave radiometer (SMMR) and conical scan configuration (CSC), which were pre-tested by the experts in the field of ecology and environmental management science. The reliability of the instruments was certainly consistent. The method of data collection used was via microwave imaging radiometer, scanning multichannel microwave radiometer, and conical scan configuration and the data was analysed by statistical tools.

RESULTS

Results of adverse harmful impact of thermal radiation energy on the temperate ecosystem in Bauchi metropolis are presented in the table as follows.

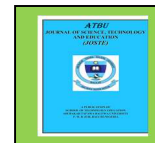
S/N	SITE	T _M (°C)	T _A (°C)	T _E (°C)	T _{AVG} (°C)	RI	E	TVR (KW/M ²)	HT _R (J ⁻² °C)	THERMAL BALANCE
1.	TWN	18	29	24	23.7	0.10	0.92	243	0.017	High
		±1.2	±0.9	±0.8	±1.0					
2.	ARR	16	30	23	23.0	0.20	0.84	256	0.013	High Relatively high
		±0.6	±0.4	±1.5	±0.8					
3.	BCM	17	28	24	23.0	0.10	0.89	244	0.014	High
		±0.7	±0.8	±0.6	±0.7					
4.	MDL	18	30	25	24.3	0.40	0.97	192	0.019	Moderate Relatively high
		±0.8	±0.3	±0.2	±0.4					
5.	BKR	15	29	26	23.3	0.20	0.98	243	0.016	High Relatively high
		±0.6	±0.7	±1.6	±1.0					
6.	ODP	19	30	23	24.0	0.30	0.96	241	0.018	High
		±0.4	±0.3	±0.6	±1.3					
7.	YLW	18	28	25	23.7	0.15	0.98	263	0.018	High
		±0.7	±1.4	±0.8	±1.0					
8.	IKL	16	32	25	23.3	0.20	0.99	271	0.017	High Mid level high
		±0.3	±0.8	±0.4	±0.5					
9.	WTD	15	31	26	24.0	0.40	0.91	214	0.017	High
		±0.6	±0.5	±0.4	±0.5					
10.	MKR	17	30	22	23.0	0.30	0.97	261	0.015	High
		±0.3	±1.2	±1.4	±1.0					
11.		18	29	23	23.0	0.20	0.98	268	0.016	High

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	ZNG	±1.3	±0.9	±0.6	±0.9					
		19	30	25	24.7					Relatively
12.	RLW	±0.8	±0.6	±0.7	±0.7	0.30	0.92	236	0.019	high
		17	28	24	23.0					Mid level
13.	YDS	±0.4	±0.6	±0.7	±0.6	0.05	0.96	214	0.015	high

Framework for impact of thermal radiation energy on the temperate ecosystem in Bauchi metropolis (Source: Field experiment, 2022)

Key of Acronyms: Turwin (TWN), Awala-Ran Road (ARR), Bauchi Central Market (BCM), Muda Lawal Market/Motor Park/Garrages (MDL), Bakaro (BKR), Old Dass Park (ODP), Yelwa (YLW), Inkil (IKL), Wuntin Dada (WTD), Makera (MKR), Zango (ZNG), Railway (RLW) and Yan Doka Street (TDS) respectively.

FINDINGS OF THE STUDY

Specifically, the findings of the study are as follows:

- i. Harmful thermal energy radiations are considerably caused and aggravated by indiscriminate felling down of trees, over-dependence on the use of fossil fuels and other non-renewable energy sources by households, vehicles and industries; over-use of coals and firewood sources of heat energy in houses, unregulated burning of garbage within and around neighbourhoods; over-crowded buildings with no room for thermal neutralization, and other natural climatic causes.
- ii. Adverse impacts of harmful thermal energy include extreme weather patterns, draught and early cessation of rainfall, desert encroachment, increase in the level of sea water which results in serious flooding, degeneration of biodiversity and ecosystem (plants and animals are already affected), tendency for the outbreak of tropic-related diseases, decline in the quality of living and livelihoods, accruable economic losses due to climatic changes (decline in agricultural productivity), and

increase in governance costs for the reclamation/restoration of the ecosystem.

- iii. Thermal energy radiations in Bauchi metropolis stood at high by average, implying that workable measures need to be taken in earnest in order to restore its gradually, but steadily changing ecological patterns and composition.

DISCUSSION OF FINDINGS

The overall average temperature of the 13 sites used for the assessment of thermal energy radiations stands at 34°C with approximately 0.36 radiation index. The heat generation (as it affects people) is intensive, frequent, extreme and less predictable, as it was compounded by emission or release of gases such as nitrous oxide, carbon (iv) oxide, methane, and ozone (O₃) into the atmosphere (Hermann, 2013).

The study indicates that the total amount of radiation for each of the wide ranges of frequency increases steeply as the temperature rises (Kerone, 2021). It reflects on thermal radiation level of concern, that is the threshold level of thermal energy radiation associated with excessive burnt fuels, indiscriminate deforestation, pool fire,

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jet fire, boiling liquid expanding vapour explosion (BLEVE), which hazards may exist (NOAA, 2013; Christopher, 2016).

Finding reveals that the nature and consequences of human activities coupled with naturally uncontrolled climatic deviations and occurrences have continued to expose people to harmful effects of higher thermal energy radiations, and without even a commensurable commitment to mitigate the situation on the parts of the affected dwellers and governments (Zigya, 2021).

Deduced from the findings, the rates of temperature and thermal energy radiations vary slightly across 13 different radiation points/sites of the study. The rates are low in the morning, increased to reach its maximum in the afternoon, and thereby lowered down in the evening. In often times, the rates did not even get much lower in the early evening period, indicating that a significant radiation impacts still exist which are monitored in terms of joule per second degree Celsius (Mendham, 2007; Hermann, 2013). Consequential effects being observed leave much to be desired in the course of ecological restoration to its stable thermal level conducive to human, animals and plants lives.

CONCLUSION

Based on the findings of this study, it was concluded that there exist, to some extent, the adverse impacts of harmful thermal energy radiations on the temperate ecosystem in Bauchi metropolis. Their rates are pegged higher. The findings further reveal that there is a long way to go to be able to address the mess on the ecosystem,

which hinder the ecological, physical, climatic, economic and health wellbeing of the affected inhabitants. Hence mitigating measures should be put in place.

RECOMMENDATIONS

The following recommendations were made in the study:

1. Enough ecology friendly, green-leaved trees should be planted, nurtured, grown, protected and maintained on the outskirts, neighbourhoods and along the streets in order to preserve the environment with its quality ecosystem.
2. Indiscriminate deforestation and bush burning should be avoided far, near or around human habitats. Adequate legislation and enforcement of environmental preservation laws should be ensured.
3. Sufficient measures should be taken to ensure the massive release of burnt fuels and other non-renewable energy sources are greatly reduced using locally available, accessible and affordable alternatives in order to preserve the ozone layer.
4. Street green flowering gardens and open field court yards in designated metropolitan locations should be provided to drastically neutralize the harsh effects of high thermal radiation.
5. Over-dependence on burning of coals and firewood as major sources of energy in households should be greatly reduced to preserve the ecosystem. To achieve this, steady supply of electricity and other sources of renewable energy become inevitable.

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6. Frequent supply of water should be ensured, which should be utilized to moisten the compounds of houses with a view to lessening the thermal generation effects on the environment.
7. Heavy and medium-size industries should be resettled to a specially clustered industrial zone(s) so that the impact of thermal energy radiation will be driven away from the direct reach of people.
8. Modern township transportation system that utilizes solar-powered technologies should be introduced as an alternative to fuel-powered conventional public transport system especially commercial motorcycle operators thereby provide them with effective and sustainable means of livelihoods so that they cannot be put out of jobs. This will go a long way to lower the level of thermally generated emission of harmful gases in the atmosphere
9. Adequate actions should be taken to ensure appropriate town planning is followed accordingly. Overcrowded buildings should not be allowed as a way of checkmating excessive thermal energy radiation and absorptions.
10. Adequate monitoring of activities and circumstances that give rise to higher thermal energy radiations should be ascertained in order to take appropriate actions to preserve the environment.

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