OPEN ACCESS Freely available online

Journal of Oceanography and Marine Research

Research Article

Analysis of Temporal Variation and Heat Influx of Rocks in Lokoja Metropolis, Kogi State, Nigeria

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ABSTRACT

This research aims at analyzing the heat influx and the temporal variation of rocks in Lokoja, Kogi State, Nigeria. With the objectives of estimating the land surface temperature of lokoja, investigating the relative humidity and ambient air temperature variations and distributions impact on rock dwellers in the study area, examining the relationship between LST and Vegetation Density in lokoja metropolis and creating awareness of the effects of the rise in temperature in the study area. Satellite imageries and climate data were obtained and analyzed for LST, NDVI and Thermal comfort index. The results shows that vegetation tends to reduce and with an increase in surface temperature, which in turn mage the comfort index in the study area higher.

Keywords: Land surface temperature; Relative humidity; Thermal index; NDVI

INTRODUCTION

Rocks are present in many areas of the Earth. They occupy very different positions on the globe and they differ in shape, extension, altitude, vegetation cover, and climate regime. Therefore, there is every tendency they can be affected differently by climate change because they share some common features relating to climate change coupled with human anthropogenic activities been carried out on them, for example, "quarrying" in other to generate raw materials like granite, gavels, laterite, and hardcore for construction purposes. Mountain or rocky areas globally have a marked and complex topography and so their climates vary considerably over short distances, which in turn make climate change projection very difficult to make rock themselves play a major role in influencing regional and global climates, most especially when human-induced activities such as "quarrying" is been carried out on them. They can act as barriers for wind flow, which induces enhanced precipitation on the windward side, and reduced precipitation and warmer temperatures on the leeward side. Changes in atmospheric wind flow patterns may induce large and locally varying precipitation responses in mountain areas, which could be much stronger than average regional climate change. For example, model simulations show that in Scandinavian mountains in Norway, enhanced westerly wind flow might induce up to a 70% increase in precipitation, while average warming without changes in the wind flows would lead to an increase in precipitation of up to only 20%.

The impacts of a warmer climate are different for different elevations. Areas at the snow line or freezing line will be affected particularly heavily, as they might undergo a shift from mainly snow-covered to mainly snow-free. For example, every degree Celsius increase in temperature will cause the snow line to rise on average by about 150 m, and even more at lower elevations. In such regions, precipitation will change from snow to rain. The decrease in snow cover will lead to above-average warming of mountains because snow-free surfaces absorb much more radiation than snow-covered surfaces [1]. In the harsh environment of high mountain regions, climate change can profoundly affect the food chain, as multiple studies show. Diminished snow cover and changing precipitation patterns affect subsistence agriculture in high-elevation villages in a country like India and Nepal [2].

In Nigeria and some parts of Africa, mountains are specific ecosystems, characterized by their diversity and complexity [3]. Steep topographic, climatic and biological gradients combined with sharp seasonal contrasts favor the triggering of extreme climatic and geomorphic events, which may in turn strongly affect the ecological and human environment [4].

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Received: November 22, 2021; **Accepted**: December 06, 2021; **Published**: December 13, 2021

Citation: Agu CC (2021) Analysis of Temporal Variation and Heat Influx of Rocks in Lokoja Metropolis, Kogi State, Nigeria. J Oceanogr Mar Res. S4: 005.

In lokoja, apart from a heat-absorbing agent such as road, water, and other dark matters, there had been about 15-20 quarrying sites whose mining depth exceeded 1000 meters by 2014. Most of the old sites would turn into deep quarrying sites in years to come. With the increase of quarrying depth, the high geothermal problem is becoming more and more prominent. And so far, there has been about 30 quarrying site within and around lokoja. Examples of areas where you can find quarrying sites include; Jimgbe, Mount Parti, Felele, and Kwata, etc. Large quarrying depth and high geothermal strata were deemed to be the main reasons for the mine heat hazard in Lokoja, especially in the central and northern parts of the state [5].

This research aims to study the temporal variation and heat influx of rocks in Lokoja. And the above aim is to be achieved through the following objectives

- To estimate the land surface temperature of lokoja.
- To investigate relative humidity and ambient air temperature variations and distributions impact on rock dwellers in the study area.
- To examine the relationship between LST and Vegetation Density in lokoja metropolis.
- To create awareness of the effects of the rise in temperature in the study area.

The purpose of this research is to examine the socio-temporal heat eminence of rocks in the study area. Heats from rocks have always been a silent disaster that has been affecting the environment and the inhabitants around it. Thus, its impact is majorly on health and agriculture Beniston [1]. Thermal heats emitted from rocks have strong implications for the socio-ecological, biophysical, and human systems [6].

The higher temperatures in mountainous regions like Lokoja may allow mosquitoes, ticks, and mites to inhabit higher elevations, placing the inhabitants at risk of diseases carried by these vectors. On the other hand, the generally lower environmental temperatures in rocky areas, especially at night, might also enhance well-being, sleep quality; recreation, and other aspects of daily living.

MATERIALS AND METHODS

This study, therefore, is out to show that heat from rocks causes a serious threat to the people of lokoja metropolis especially in the areas of health, food security, and social infrastructural security. The insecurity posed by climate change means that Nigeria at large and Kogi state, in particular, must wake up and build a climate-resilient country in ways of adopting efficient mitigation and adaptation measures.

A good number of people are living in rocky areas (i.e., elevations above 1000 m) and a lot more visit those regions for leisure activities or recreation such as hiking. However, only limited information is available on the effects of climate change on the health of rocky/mountain dwellers and visitors. As we know, the effect of rocks on human life cannot be overemphasized and as such inhabitants of this regions requires to be of the know the effects of these rocks and the activities carried out around them as it affects weather, agriculture, health and how the negative effect can be curbed minimally. Chronic heat exposure could be particularly detrimental to inhabitants of rocky regions lacking the infrastructure to manage intense heat.

Lokoja is highly favored by nature as the location of the meeting point of Rivers Niger and Benue, a factor which has attracted peoples to the area, most especially those who engage in fish farming activities. The town which shares common boundaries with Kogi, Ajaokuta, Adavi, Kabba/Bunu, and Bassa Local Government Areas of the state has been witnessing rapid urbanization and socio-economic growth owing to the continued influx of people since it attained the status of state capital in 1991 and its proximity to the Ajaokuta steel complex and Obajana cement company.

High intense temperature from rocks as a result of human activities, rocks natural ability to absorb and release heat energy, obstruction of airflow due to their unique level of elevation and other dark matter such as roads and rivers has made lokoja to be experiencing unprecedented heat. Agricultural and health sectors have suffered more from the severe impact of this heat which has led to the loss of vegetation, flood, and destruction of farmlands. Other chronic diseases that have been affecting the dweller around rocky or mountain areas include heat rashes, meningitis, heat cramp, heatstroke, and body dehydration.

Lokoja is the capital of Kogi State in Nigeria, located between latitude 7° 45' N and-7° 50' N of the equator and longitude 6° 41' E-6° 45' E of the Greenwich Meridian. It lies at an altitude of 45 m-125 m above mean sea level. The city is surrounded by Patti ridge hills and ridges. Lokoja has situated 76 km from Okene, along the Okene-Abuja highway and it is a gateway of sort between the Eastern, Western and Northern parts of the country (Figure 1).

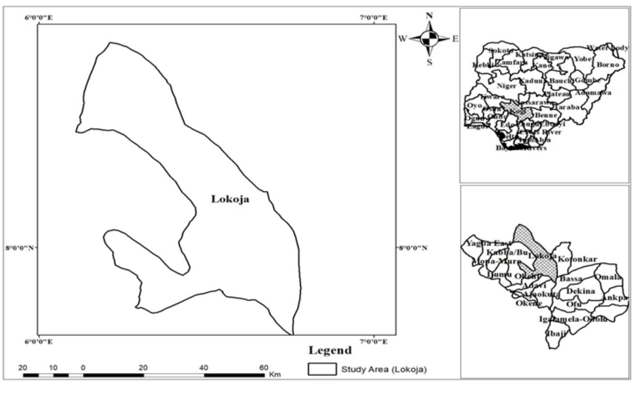

Figure 1: Study area map (Lokoja, Kogi State).

Data used

The dataset used for this study were secondary data which contains non-spatial and spatial attributes. These are Landsat 7 Enhanced Thematic Mapper (ETM+) and Landsat 8 Operational Land Imager (OLI) images, topographic maps, Temperature, Rainfall, and Relative Humidity data. Software packages include; ArcGIS version 10.5(Table 1).

Table 1: Data types and sources.

Data list	Data type	Data	Data source	Resolution
Landsat 8	Secondary	Satellite imagery	Earth explorer	30 m
Temperature, and Relative Humidity data	Secondary	Climate data	Prediction of worldwide energy resources, NASA	

The Landsat imageries were acquired from (URL; http://earthexplorer.usgs.gov). Landsat 8 OLI for the year 07 February 2020, a path of 189 and row of 054 as revealed. They have a spatial resolution of 30 m, with bands that extend to 12.

Climate data (Temperature and Relative Humidity) were acquired from Prediction of Worldwide Energy Resources (POWER) (https://power.larc.nasa.gov/data-access-viewer/) for 1985, 1990, 1995, 2000, 2005, 2010, and 2019 daily data.

Software used

The software used is as listed:

ArcGIS 10.5: The spatial plus statistical analyst extensions of the ArcGIS 10.5 version will be applied to take out both the spatial analyses and the spatial statistical analyses.

Microsoft excel: is a spreadsheet program use to estimate and analyze numerical data. The software was being applied to transmit out the statistical investigation.

The methodology adopted for this work was categorized into four stages (a) Normalized difference vegetation index (NDVI) generated. (b) Land Surface Temperature (LST) generated (c) Thermal comfort index was also generated.

Normalized difference vegetation index

NDVI is used to compute vegetation greenness and beneficial to comprehend vegetation density and evaluating fluctuations in vegetal fitness.

NDVI=NIR-R

NIR+R

It is delivered a single-band product specified. The spatial disparity of NDVI is not focused on the effect of vegetation quantity, likewise landscape, incline, lunar energy disposal, and further reasons. NDVI is normally used as a degree of terrestrial greenness built on the supposition that the NDVI significance is relative to the sum of green vegetation in an image pixel region. Theoretically, NDVI ethics are signified as a proportional tenanting in value from -1 to 1 likewise in repetition, great damaging values signify water, ethics nearby zero signify bare soil, and ethics adjacent to one signify thick green vegetation.

Land surface temperature

Land surface temperature is the temperature of the land from solar radiation [7]. Apparent heat and emissivity at scales: Remote Sensing Reviews, Journal. https://doi.org/10. ArcGIS 10.5 was used to retrieve the land apparent Temperature.

Thermal comfort/discomfort index

Air temperature and relative humidity data were used to analyze the thermal comfort/Discomfort of the study area. Despite the achievement of a scientist through modern technology, the comfort of humans is still influenced to an excessive level by these two thermal indices: temperature and humidity. Thermal comfort indices are diverse and generally relevant only in assured settings, as distinct by ecological arrays. This array of pertinent is though only stated for particular directories. Besides, studies of these directories conclude that they are valid in a much thinner series of conservational circumstances than appealing. Many thermal guides have been broadly used to prompt the anthropological relief level in extents or phases by the amalgamation of climatological and biological statistics based on conservational environments. Since accounts of earlier training and guides reflected for Nigeria, it was recommended that Temperature-Humidity Index (THI) is significant as an index of thermal comfort in the tropics since it has the benefit of providing the mutual result of temperature and humidity on comfort within a thin array of conservational situations. THI is similarly used to analyze human thermal environments to evaluate the affiliation amid climatological variables, like airborne heat and virtual moisture. Thom (1959) indicated that the actual temperature completed an extensive array of its standards underneath open-air circumstances, which can be estimated by a modest undeviating comparison joining the corporal constraints of airborne temperature (desiccated-bulb temperature) and (damp-bulb temperature). This suggested experimental index, which is, in detail, a modification of AT^*, remains what he termed the Temperature-Humidity Index (THI) otherwise the Discomfort Index (DI). Scientists have anticipated several balanced or experimental bioclimatic guides that designate the perception of temperateness that individual experiences based on acquaintance to diverse arrangements of factors that impact thermal comfort such as airborne heat, virtual humidity, airspeed, meteorological gravity, apparel, movement, etc. Excel was used for Statistical Analysis.

The thermal Discomfort Index (DI) was summarized from Thom's formula which is DI=T-(0.55-0.0055*RH) (T-14.5).
Where T: Temperature; RH: Relative Humidity.

Thom's table DI Series was used to regulate the proportion of the study area that suffer from discomfort (Table 2).

Table 2: Thom's' classification of DI ranges.

DI classification	DI range(0c)
No Discomfort	
Under 50% of Populations feel discomfort	21 ≤ DI<24
0ver 50% of Populations feels discomfort	24 ≤ DI<27
Most of the population suffers discomfort	27 ≤ DI<29
Everyone feels severe stress	29 ≤ DI<32
State of a medical emergency	DI ≥ 32

RESULTS AND DISCUSSION

This section reveals the result of the analysis performed at the study area and as well discussed as follows;

Normalized difference vegetation index

NDVI is normally used as a degree of terrestrial greenness built on the supposition that the NDVI significance is relative to the sum of green vegetation in an image pixel region. So by looking at the analysis of the study area, it is noted that the vegetative cover is less sufficient to absorb the heat content of the area. NDVI values range from -1 to +1 and the lowest value from our study area is -0.19 while the highest value is 0.39 from this, it can be said that most of the areas of Lokoja are rocks and bare ground with little or no vegetative cover (Figure 2).

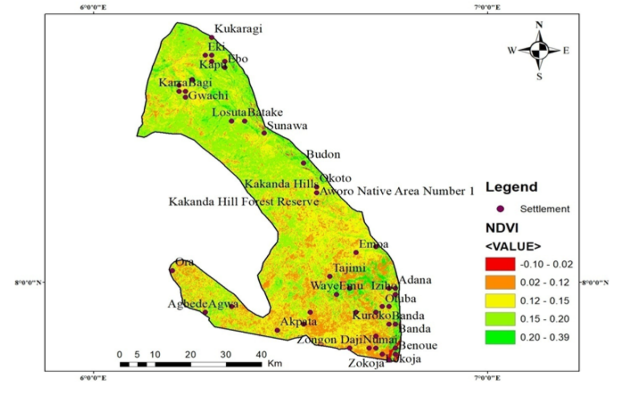

Figure 2: NDVI of Lokoja.

Land surface temperature

Land surface temperature is how hot the surface of the earth would feel to the touch in a particular location. From a satellite's point of view, the surface is whatever it sees when it looks through the atmosphere to the ground. Thus, the land surface temperature is not the same as the air temperature that is included in the daily weather report. From the analysis, it is observed that temperature was cool at the towns that lay at the bank of River Niger, the water close to them helps in absorbing the heat in that areas, while areas that are far from the River experience increase in temperature. The highest value of the land surface temperature recorded was 42.27℃, while the lowest land surface temperature recorded was 21.61°C, and the diagram can be shown (Figure 3).

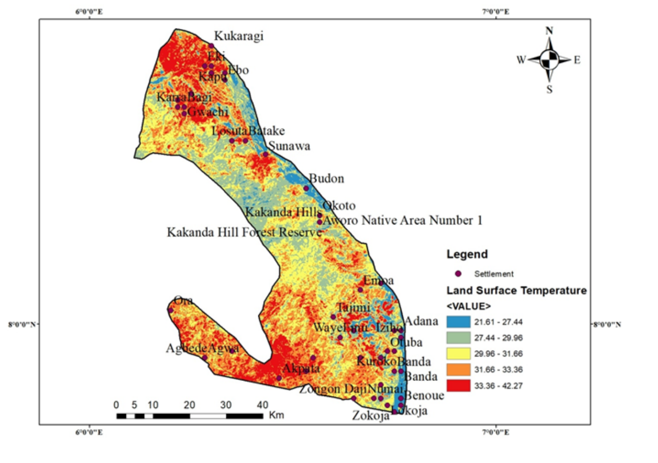

Figure 3: Land surface temperature of the study area.

Temperature changes can also contribute to mechanical weathering in a process called thermal stress. Changes in temperature cause rock to expand (with heat) and contract (with cold). As this happens over and over again, the structure of the rock weakens. Over time, it crumbles. As rocks expand and contract, the heat creates a physical weathering process where the rock splits apart into fragments. It also contributes to chemical weathering when moisture or oxygen in the atmosphere alters the chemical composition of rock minerals. The cycle of heating and cooling creates an accumulation of stresses called thermal fatigue that fragment the rock surface. This affects the study area and increases the temperature.

Thermal comfort/discomfort index

This section deals with the Comfort or Discomfort of the study area throughout 35 yrs, and it shows that the thermal comfort of the area gets a slight increase of the thermal index of the period of the years. According to Thom's thermal discomfort index table of classification and looking at the result as of 2019, it shows that more than half of the population of Lokoja feels discomfort, as regards to 1985 which shows that not more than half of the population of Lokoja feel discomforted and from the analysis, shows that the discomfort index keeps increasing over the year (Table 3).

Table 3: Thom's discomfort index of the study area.

Year	Relative humidity(%)	Temperature (°C)	Thermal index (°C)	Implication
1985	74.86	25.21	23.72	Under 50% feels discomfort
1990	74.62	25.95	24.35	Over 50% feels discomfort
1995	78.37	25.3	24.01	Over 50% feels discomfort
2000	68.17	26.38	24.3	Over 50% feels discomfort
2005	67.59	27.42	25.11	Over 50% feels discomfort
2010	74.54	26.5	24.82	Over 50% feels discomfort
2019	73.03	26.65	24.85	Over 50% feels discomfort

Adaptation and mitigation

Heat can be dangerous, causing illnesses such as heat cramps and heat stroke, or even death. Warmer temperatures can also lead to a chain reaction of other changes around the world. That's because increasing air temperature also affects the oceans, weather patterns, and plants and animals. Based on the Normalized Differential Vegetation Index (NDVI) result of the study area, it can be said that the vegetation in the study area is not much encouraging needed to combat the increase in heat in the environment. This is because this increase enumerates from Urbanization, Green House Gas emissions (GHG), Deforestation, and other anthropogenic activities. All these activities go to the ecosystem and heat it. But in the case where the vegetation is encouraged and we have more of it in the study area, it will absorb more of the carbon dioxide in the environment and also form as a shad from the solar radiation to the rocks and surface in the study area. Shading can decrease radiant temperature and greatly improve outdoor thermal comfort. Providing shading on streets, building entries and public venues using greenery, artificial structures, or a combination of both can block solar radiation and increase outdoor thermal comfort.

The use of water as a way to cool cities has been known for thousands of years. Water-based landscapes such as rivers, lakes, wetlands, and bioswales can reduce urban ambient temperatures by 1℃-2℃. This is a result of water heat retention and evaporative cooling. In addition to natural water bodies, various other water-based technologies are now available for both decorative and climatic reasons. Examples include passive water systems, like ponds, pools, and fountains, and active or hybrid systems, such as evaporative wind towers and sprinklers. Active and passive systems can decrease ambient temperatures by 3℃-8℃, looking at the Land Surface Temperature analysis, towns that are closer to the bank of the river Niger experienced a decrease in temperature, water, in essence, absorbs heat radiation and will be encouraged to increase the water fountains in most of the towns and increase more of artificial lakes which can also serve for irrigation purpose in Agricultural practice of the state. Water-based systems are usually combined with green infrastructure to enhance urban cooling, improve air quality, aid in flood management, and provide attractive public spaces.

Other areas that can help to reduce the increase in temperature of the study area can be also to encourage the use of green roofs and walls in building structures. They provide cooling benefits by shading buildings and through evaporation from leaves. They generally show less cooling benefit than white roofs, cost more to install and maintain, and use additional water and energy.

CONCLUSION

This work looked at the temporal variation and heat influx of rocks in Lokoja, with the objectives being implored to solve our problems, using Landsat 8 satellite imagery and climate data of the study area. NDVI analysis gave an insight into the vegetative cover of the area which has not been enough to help reduce the increase in temperature. And from the result of our LST and the thermal index analysis, it can be said that the surface temperature and thermal discomfort of the area are high and tend to increase every year. This causes serious damage to the health of the populace.

ACKNOWLEDGEMENTS

The authors wish to acknowledge, United State Geological Survey and Prediction of Worldwide Energy Resource (POWER) for providing data used for this study.

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