ENVIRONMENTAL ANALAR

A Journal of Environmental Analysis

No.3, Sept., 1999

ISSN 1595 - 0174

ENVIRONMENTAL SYSTEMS CLUB INC.

Env. Anal. 3 (1999) pp 174-181

ENVIRONMENTAL ANALAR

ENVIRONMENTAL IMPLICATIONS OF RADIATION BALANCE OVER CONCRETE SURFACES IN NIGERIA'S URBAN CENTRES: AN EXAMPLE OF ABA IN ABIA STATE, NIGERIA.

E. M. Ekanem

Department of Geography

University of Uyo, Akwa Ibom State.

Accepted 23rd November, 1998

Abstract

A study on the radiation balance over concrete surfaces was conducted in Aba, a typical humid tropical city. The aim was to determine the magnitude of net radiation over this surface that occupies a significant part of our urban centers. The diurnal and seasonal patterns and its effects on the thermal regime of the environment were also examined. Using two net radiometers, measurements were taken weekly for one calendar year (12 months).

Results show that the dry months recorded higher values of radiation than the wet months. The diurnal pattern shows a steady increase from 0700hr till the peak at about 01500hr, thereafter values begin to decline. The implication of the study as it affects the thermal regime of the urban environment is also discussed.

Introduction

In Nigeria, urbanization is taking place at a rapid rate because of increasing population. This rapid urbanization leads to severe problems of environmental deterioration resulting in unhealthy living conditions, and shortage of water etc. If climatological informations, principles and experience were incorporated into the planning of the rapidly growing urban areas, much of the problems of urbanization could have been solved. Urbanization has impacts on urban climates (Oke 1979, Landsberg 1981). Emerging buildings which are mainly concrete, roads and concrete floors etc. in urban areas have effect on radiative cooling/heating and wind circulation. The type of materials and designs of buildings/houses should depend on the local climatic elements and their extreme values. Therefore, planners and designers must consider the climatic factors and variability of the climatic elements before engineering constructions of building, drains and concrete floors in urban areas are implemented.

Aim and Objectives

The focus of this study is on the character of the net radiation from the concrete cement surfaces in an urban environment. This is more so knowing that most structures within the city are built with concrete

The detail objectives of the study then are:

(a) To examine the magnitude of the net radiation over the concrete cement surface

(b) To determine the diurnal and seasonal variability of the net radiation on the concrete cement surface.

(c) To determine the effects of this on the thermal regime of the immediate urban environment.

(d) To examine the implication of the results (a-c) for urban planning.

Study Area

This study was conducted in the humid tropical city of Aba, Abia State in Nigeria, a settlement established in 1901 as a military camp. It is an important commercial centre east of the Niger. Located at 5°.06´N and 7°.21´E. (Fig.1). Aba is a moist tropical city, with well over 2,000mm of rainfall. Temperatures are always high throughout

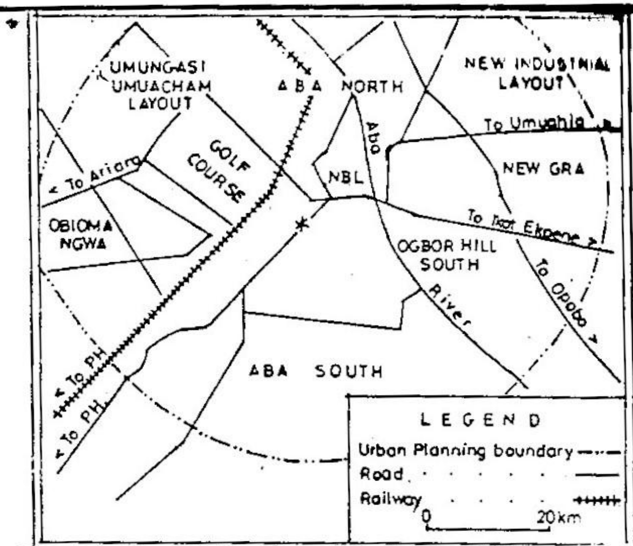

Fig. 1: Map of Aba Showing Points of Measurement.

the year with high relative humidity. The city was chosen because of its continentality - located some 150 kilometres from the ocean, and its medium size of about one 1 kilometres in diameter. The city is generally below 100 meters above sea level (Ofomata, 1975).

Material and Methods

Measurements of net radiation over the concrete surface were taken with the use of Thorthwait Model 603 net and Type S-1 radiometers and weekly measurements were obtained. On specific days of measurements, five consecutive readings were taken at 7.00 a.m (0700hr); 10.00 am (1000hr); 1.00 pm (1300hrs); 4.00 pm (1600hr); and 6.00 pm (1800hr). These readings were done for twelve calendar months (June to May), to obtain both the diurnal and seasonal variation of the net radiation over the surface. However, it is the mean monthly values that were used for the analyses. The output from the instruments were fed to a portable millivolt with a maximum output of twelve and a resistance of one hundred (100) ohms. The calibration used was that quoted by the manufacture with a 98%. accuracy level and 30 seconds response time to radiation changes.

Results and Discussion

The net radiation over the concrete surface showed higher value than that of ground, grass and water (Ekanem, 1997). results of measurements indicate that the monthly all time average net radiation over the concrete surface was 0.476 gcal/cm^2/mn (0.332 Jkg m^{-2} S^{-1}) as opposed to 0.442 gcal/cm^2/mn (0.308 Jkg m^{-2} S^{-1}), and 056 gcal cm^2/mn (0.322 Jkg m^{-2} S^{-1})of water, grass and bare ground surfaces respectively (Ekanem, 1997).

The early morning (0700hr) pattern rose from the minimum of 0.234 gcal/cm^2/mn (0.163 Jkg m^{-2} S^{-1}) recorded in June, the near peak of the rains, to a maximum of 0.428 gcal/cm^2/mn (0.299 Jkg m^{-2} S^{-1}) recorded in the month of February. The early morning average stood at 0.369 gcal/cm^2/min (0.257 Jkg m^{-2} S^{-1}). By late morning (10.00hr) an increase was recorded for the net radiation.

This is as expected, since there was a general increase in the global radiation by late morning as a result of the increased insolation. The least of the values of net radiation for the late morning period over the concrete was recorded between June and August with a value of 0.419 gcal/cm^2/mn (0.292 Jkg m^{-2} S^{-1}); while the highest was observed in February with a value of 0.494 gcal/cm^2/mn (0.345 Jkg m^{-2} S^{-1}). Thereafter, there was a steady decrease in the value as the rains set in.

By early afternoon (1300hr), there was a marked increase in the net radiation over the concrete surface. The minimum recorded value of this component of radiation was 0.542 gcal/cm^2/mn (0.378 Jkg m^{-2} S^{-1}) in June. Thereafter was a steady increase until the peak of 0.622 gcal/cm^2/mn (0.434 Jkg m^{-2} S^{-1}) observed in February which was the heat of the dry season. The monthly average value of this component of radiation at this time was noted to be 0.588 gcal cm^2/mn (0.410 Jkg m^{-2} S^{-1}). In the late afternoon (1600hr), the net radiation over the concrete surface was not too different from that of the early afternoon. For instance, the miniium value was recorded in June 0.557 gcal/cm^2/mn (0.398 Jkg m^{-2} S^{-1}); while the peak was also recorded in the month of February being 0.619 gcal/cm^2/mn (0.432 Jkg m^{-2} S^{-1}). However, the overall monthly average for this period

differs from that of the early afternoon. At this point in time the value of the monthly average was about 0.591 gcal/cm^2/mn (0.412 Jkg m^{-2} S^{-1}). In the evening (1800hr), the minimum value of net radiation was observed in July with a value of about 0.363 gcal/cm^2/mn (0.253 Jkg m^{-2} S^{-1}); while the peak indicating a maximum for this period was 0.423 gcal/cm^2/mn (0.295 Jkg m^{-2} S^{-1}) recorded in February. The average for this period was about 0.389 gcal/cm^2/mn (0.271 Jkg m^{-2} S^{-1}). The pattern, therefore was a steady increase from the heart or peak of the rainy season until the peak of the dry season. Thereafter the values began to decrease more sharply till it hit the minimum.

It is obvious that the difference between the morning values of net radiation and those of the afternoon is much, especially during the dry season. A difference of well over 0.140 gcal/cm^2/mn (0.098 Jkg m^{-2} S^{-1}) was noticeable between morning and the afternoon values of net radiation during the dry season. The difference in value of the net radiation between the periods was not that wide during the wet season. Figs. 2 and 3 show graphically the pattern of net radiation over the concrete surface.

It is pertinent to note here that in the dry season the peak of net radiation was reached in the early afternoon whereas in the rains the peak was reached in the late afternoon; a situation that has been associated with the fact that concrete surface receives and retains maximum energy early in the dry season whereas there is a lag in time during the rains. Generally, therefore the pattern of net radiation over the concrete surface has been that of increase toward the afternoon and dry months and a decrease towards the night and wet months. This is attributed to not only the reduced insolation, cloudiness but also to the character of the surface. The dry months exhibit higher insolation and the water contents of the surface is very low.

Implications

Most structures in the urban environment are made with concrete and of recent there is this increasing changes of the surface surrounding buildings, from the natural to concrete in the urban

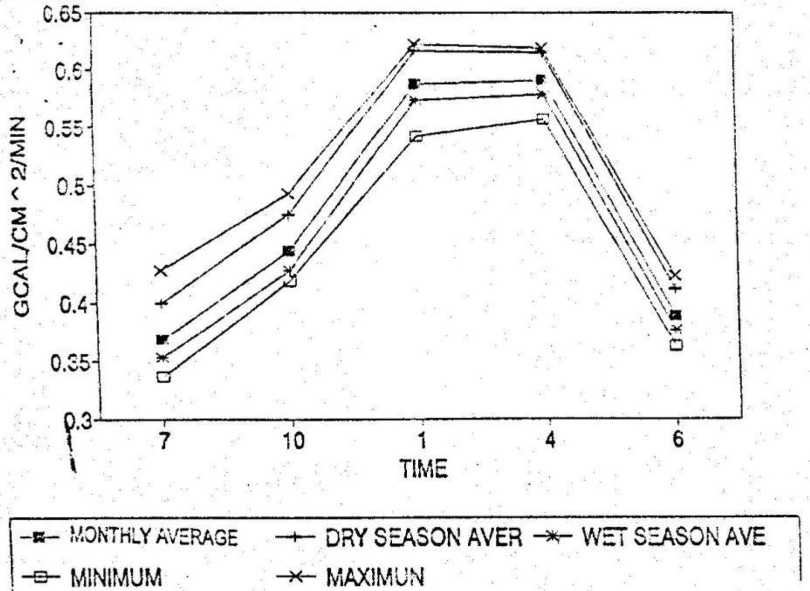

Fig. 2: Average Net Radiation Over Concrete Surface

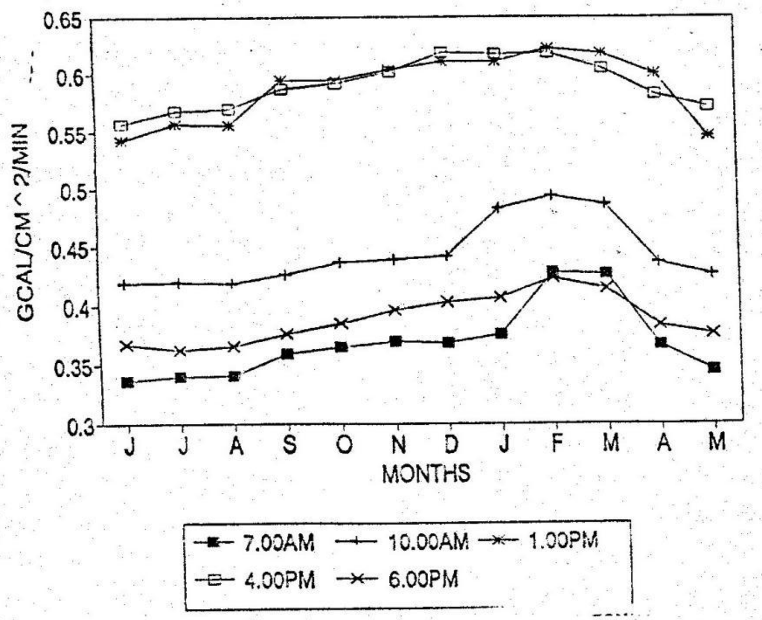

Fig. 3: Monthly Average Net Radiation Over Concrete Surface

environment. This has serious implications for the total energy balances of the urban environment and the subsequent thermal regimes. The high net radiation over the concrete surface which incidentally is higher that those of the natural surfaces like grass and bare grounds is an indication that there will be excess energy over the urban atmosphere. This surplus excess energy will be converted to sensible heat as there are less avenue of the expenditure and disposition of the energy in the urban environment. This will contribute to higher urban temperature even into the night. The consequence of this will be the highly uncomfortable situation in terms of the thermal regime of the environment, with great effects on human activities within the urban system.

Recommendations

Based on the results of this study, it is pertinent to make a few recommendations that could help to effectively reduce and regulate the micro climatic environment of the area where concrete surface are predominant.

It may be possible to counter the effects of the excess energy by providing a form of evaporative cooling. This could be in the form of pools of water. This could provide a source of expenditure of the surplus energy quite apart from the cooling that will result as a direct effect of the evaporation.

It is recommended that all structures erected or laid with concrete should be smoother and painted with white colour. This will reduce the rate of absorption of the energy by increasing the albedo of the surface. This will subsequently reduce the energy emission by this surface. Also planting of shed trees over all surfaces that were of concrete will be of immense help as it will cut off the direct absorption of insolation by this surfaces and structures quite apart from the fact that it will increase the rate of evapotranspiration. Grass lawn will be of greater benefit than surfaces laid to concrete. Grasses show lower radiation balance and also provide means of expenditure of energy. Therefore, where concrete can be avoided grassing should be put in their place. Where it cannot be avoided areas near to it should be planted to grass as this will encourage a more conducive advected energy system within the environment, reducing excess heat.

References

Ekanem, E. M. (1997); "Surface Energy Balance in a Humid Tropical City of Aba." *Unpublished Ph.D Thesis*. Department of Geography, University of Ibadan.

Landsberg, H. E. (1981) "Urban Climate" *International Geophysics series*, Vol. 23. Academic Press. New York, 275pp.

Ofomata. G.E.K., (1975). "Relief" in Ofomata, G. E. K. (ed) *Nigeria in Maps*: Eastern states. Ethiopia Publishing House, Benin City. pp. 8-9.

Oke, T. R. (1979). Review of Urban Climatology, 1973-1976. *Tech. Note No. 169*: UMO. No. 539.