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CHAPTER 20

URBAN SURFACE ENERGY BALANCE OVER WATER AND CONCRETE

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INTRODUCTION

The size of the storage heat flux in a city is an important energy source and sink which depends on the type of surface. The urban atmospheric environment depends on the local modification of three main climatic factors namely heat balance, composition of the air and surface colour and roughness conditions. These factors according to Smith (1975) influence more than one climatic elements. It is known that urban energy balance influences visibility, rainfall and thermal conditions. The energy balance at a surface represents the most basic accounting of heat and mass, necessary to establish a sound physical understanding of the resulting thermal climate. The reality is that such knowledge for cities has only just started to emerge, and few are available for tropical cities (Oke 1988, Oke et al 1992).

The objectives of the study are three fold: first to conduct direct observations of the surface energy balance in a humid tropical city. Second, to compare these results with those available from similar studies. Finally, to relate the results of these process studies to some of the more descriptive features of the climate.

Study Area

The study was conducted in Aba, Abia state. It is the largest humid tropical city that is truly continental without the moderating effects of large bodies of water. Aba (5°.06'N and 7°21'E) is located at about 100m amsl (above mean sea level), has a flat terrain and is in the rain forest zone of Nigeria. By 1991 the population of the town was about 0.5 million (1991 Population Census). The mean annual temperature is above 27°C but does not exceed 30°C. The diurnal and seasonal march of temperatures seem to be more significant than the annual temperatures mean. Heavy rain falls are experimenced here with total annual ranging from 2250 to 2500mm. The total dry months is about four while there are eight months of rain. Humidity is high throughout the year especially during the rains. always exceeding 70%.

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Materials And Method

Measurement of net radiation were taken over the surfaces, with the use of Thornthwaite Model 603 Net Radiometer and Type S-1 radiometers. Weekly measurements were taken. On the specific day of measurements, five measurement were taken at (7.00 a.m., 10.00 a.m., 1.00 p.m., 4.00 p.m., 6.00 p.m.), and for twelve calendar months (June to May). These were to enable the diurnal and seasonal patterns of the net radiation to be observed. However, the mean monthly values were used for the analysis of the diurnal and seasonal pattern of the net radiation over the surface. Two surfaces were measured: water and concrete surfaces. One is a natural surface while the other is man-made.

Results And Discusion

Over the water surface the net radiation reached its peak during the dry season, decreasing gradually with the onset of the rains. On a diurnal basis the afternoon exhibits a higher net radiation than the early morning and evening. However, it is interesting to note that the mornings have the lowest values of net radiation whereas the evenings still exhibit higher values than the early morning. This is a factor that indicates that within the urban area of Aba there is an urban heat island as the structures and the surfaces give out the stored up energy gradually. Also as water gives out heat slowly, the energy taken in by the water in the day is not lost quickly but rather slowly. This also accounts for the higher values of the net radiation in the evening than in the morning. Table 1 shows the average values of net radiation over water.

TABLE 1: NET RADIATION OVER WATER SURFACE IN ABA

Time	Monthly Average	Dry Season Average	Wet season Average	Maximum	Minimum
7.00 a.m.	0.327	0.369	0.306	0.403	0.278
10.00 a.m.	0.418	0.447	0.403	0.466	0.377
1.00 a.m.	0.551	0.588	0.532	0.600	0.495
4.00 p.m.	0.545	0.600	0.552	0.612	0.523
6.00 p.m.	0.347	0.405	0.317	0.441	0.300

Source: Computed From Field Data

It is observed that the afternoon has the highest value of net radiation, as a result of increased insolation and adverted energy from the complete hemisphere.

The net radiation over concrete surface showed a significant change from water surfaces. (Table 2). The annual overall average net radiation was about 0.476 gcal/cm^2/min as against 0.422 gcal/cm^2/min of water. The early morning pattern of net radiation rose from the minimum of 0.306 gcal/cm^2/min recorded in June, the peak of the rains to a maximum of 0.428 gcal/cm^2/min recorded in the month of February. The early morning monthly average stood at about 0.369 gcal/cm^2/min. By late morning an increase was recorded. This is because of the general increase in the global radiation due to increased insolation. The lowest value of the net radiation over concrete was recorded also between June and August, with a value of 0.419 gcal/cm²/min while the highest was observed in February with about 0.494 gcal/cm²/min. Thereafter there was a steady decrease in the value as the rains set in.

By early afternoon there was also a marked increased in the net radiation. The minimum being recorded in June was 0.542 gcal/cm²/min. The highest was about 0.622 gcal/cm²/min recorded in February the peak of the dry season. By late afternoon the net radiation was not too different from the early afternoon, for instance the minimum value was recorded in the month of June (0.557 gcal/cm²/min) while the maximum was recorded in February (0.618 gcal/cm²/min). 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 0.591 gcal/cm²/min.

In the evening the minimum value of net radiation was observed in July with a value of about 0.363 gcal/cm²/min, while a peak indicating a maximum for this period was 0.423 gcal/cm²/min recorded in February. The average for this period was about 0.389 gcal/cm²/min. The pattern therefore was a steady increase from the peak of the rainy season until the peak of the dry season.

Thereafter the values began to decrease more sharply till the minimum. Table 2 shows the variation that exist within the season.

TABLE 2: AVERAGE NET RADIATION OVER CONCRETE

Time	Monthly Average	Dry Season Average	Wet Season Average	Minimum	Maximum
7.00 a.m.	0.369	0.400	0.353	0.336	0.428
10.00 a.m.	0.444	0.476	0.428	0.419	0.494
1.00 a.m.	0.588	0.616	0.574	0.542	0.622
4.00 p.m.	0.591	0.615	0.579	0.557	0.619
6.00 p.m.	0.389	0.412	0.377	0.363	0.423

Source: *Computed from field data*

From table 2 it is obvious that the difference between the morning values of net radiation and those of the afternoon was much especially during the dry season. A difference of well over 0.140 gcal/cm²/min was noticeable during the dry season. This difference in value of net radiation between the periods was lower during the wet season. Table 3 shows the variation that exist in the wet season.

TABLE 3: GENERAL NET RADIATION IN WET SEASON

TIME	WATER	CONCRETE	DIFFERENCE
7.00 a.m.	0.327	0.369	0.042
10.00 a.m.	0.418	0.441	0.023
1.00 p.m.	0.551	0.588	0.037
4.00 p.m.	0.545	0.591	0.046
6.00 p.m.	0.347	0.389	0.042

There is a general increase in the afternoon net radiation over the concrete. This significantly explains the importance of surface cover, material composition of the cover and colour in the radiation dynamics of the urban centre. The higher absorption rate of the concrete results in higher ground and air temperatures. Since the concrete surface holds no moisture, the evaporative cooling does not occur as it would from a moist soil. The consequence of this is that the city is turned into a hot envelope of environment. The increase in net radiation recorded over concrete surface as compared with that of water surfaces arises as a result of the increased energy.

Implication

Urbanization, with increased concrete surfaces within the towns has serious implication for the energetics of the urban environment. The capacity of the urban fabrics like concrete to store energy without ways of disposition will result in higher air and ground temperatures. Hence the urban air is hotter in the day and in the night than the rural surburbs. The situation calls for ways of energy disposition to reduced the conversion of surplus energy into sensible heat. This is where water surface provides a reserviour of heat sinking and evapotranspiration. The increased evapotranspiration reduces the magnitude of surplus sensible heat that could have been used in heating the air and the ground.

In the urban centres pedestrian sidewalks and all concrete surfaces should be protected from the direct effect of the sun especially during the dry season by lining the side walks with shed trees. Not only will this help reduce the high air temperature values especially during the day, it will also increase the rate of evapotranspiration.

Within the urban environment there should be provision for pools of water. This will provide evaporation points and also increase the relative humidity.

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