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# Rainfall Characteristics at Makurdi, North–Central Nigeria II

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**Abstract**

Rainfall characteristics were evaluated in Makurdi in the Guinea Savanna agroclimatic belt of Nigeria. Pluviograhic rainfall data were collected for the period 1985 to 1987. The mean Annual rainfall was 1140mm.The highest rainfall amount per storm event was 71.7mm while the highest six- minute rainfall intensity was 240mmh-$^{1}$. The mean monthly Kinetic energy (E) using the Wischmeier and Smith (1978) equation ranged from 2.0 to 84.1MJha$^{-1}$ whereas the value ranged from 2.5 to 128.0MJha$^{-1}$ using Kowal and Kassam (1976) equation (designated $E_k$).Conventional rainfall erosivity used for evaluation were the $EI_{30}$, K.E > 25 and $AI_m$. The ranges of monthly erosivity based on these indices were 24 to 406 MJ.mmha$^{-1}$h$^{-1}$, 0.7 to 9.0MJha$^{-1}$ and 270 to 4280 mm$^{2}$h$^{-1}$ respectively. Following Obi and Salako (1995) additional indices, namely, E(A), $E_kI_{30}$, $E_kI_m$ ,$E(A)I_{30}$ and $E_kAI_m$ were evaluated. Mean monthly erosivity values ranges based on these indices were 18 to 471 MJ.mmha$^{-1}$h$^{-1}$, 31 to 595 MJ.mmha$^{-1}$h$^{-1}$, 76 to 1594 MJ.mmha$^{-1}$h$^{-1}$, 218 to 26992 MJ.mmha$^{-1}$h$^{-1}$ and 527 to 67293 MJ.mmha$^{-1}$h$^{-1}$ respectively. The findings enable better understanding of the rainfall effects on soil erosion in the region. The generally high erosivity values are pointers to the compelling need for soil protective covers in particular and the integration of other serious conservation measures as key strategies for sustainable production in the agro-ecological zone.

**Key words**: Rainfall, Eosivity, USLE.

## 1.0 Introduction

Rainfall erosivity (R) is one of the six factors in the Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978) and the Revised Universal Soil Loss Equation (RUSLE) (Renard et al., 1997) for erosion prediction. It is the potential ability of rain to cause erosion and is a function of the physical characteristics of the rains. These characteristics include intensity, amount, duration, drop-size distribution, terminal velocity, wind velocity and slope angle, and thus, determine the erosiviness of rainfall (Lal, 1977). Wischmeier and Smith, 1978 and Hudson, 1981 pointed out Kinetic energy as a characteristic that affects rainfall erosivity. Among this characteristics only rainfall amount – daily and annual are usually measured especially in developed countries due to non- availability or lack of proper management of equipments such as auto recording raingauges (Jackson, 1989). Rainfall Kinetic energy (E) and intensity (I) have been widely used as indices of rainfall erosivity (Salles *et al.*, 2002; van Dijk *et al.*,2002),particularly by combining both as a product of E and $I_{30}$ (maximum30-minute intensity),Although this compound index is widely used, other indices such as the kinetic energy of rainfall intensities greater than 25mmh$^{-1}$(K.E>25)(Hudson, 1995), product of daily rainfall amount(A) and maximum intensity($I_m$)( Lal,1976) have been proposed to estimate the erosivity of tropical rains. With no detailed study on rainfall physical characteristics in Benue hitherto, the objectives of the study were (i) to quantify the key physical characteristics of rainfall in Makurdi, and (ii) to provide information on the erosive nature of rains in the area.

## 2 .0 Materials and Methods

### *2.1. Location and Climate of the Study Area*

The study was conducted in Makurdi, Benue state in the Southern Guinea Savanna belt of Nigeria located at latitude 7.41'N and longitude 8.37'E.The annual rainfall ranges from 1000mm to 1250mm. There are two distinct seasons – wet and dry. The wet season is bimodal. The mean temperature is $28^0$C.The altitude is 103m above sea level. The soil is generally coarse textured (Fagbami, 2000).

### *2.2 Rainfall data analyses*

Autographic data for the period 1985 - 1987 from auto recording raingauges were obtained from the NIMET office at Oshodi, Lagos and analyzed. All legible data were used. About 143 charts were analyzed. The six – minute intensity data were used in characterizing storms in terms of intensity class distribution. Rainfall erosivity was evaluated with the conventional indices, namely, $EI_{30}$ (Wischmeier and Smith, 1978), K.E.>25 (Hudson, 1981), and $AI_m$ (Lal, 1976). Furthermore the $E_kI_{30}$ and the $E_kI_m$ proposed by Salako et al. (1991) and the $E_kAI_m$ (Nwaukwa et al., 2007) were evaluated. Finally a proposed index of E(A)$I_{30}$ was also evaluated. The units of the indices are MJ.mmha$^{-1}$h$^{-1}$, MJha$^{-1}$, mm$^2$h$^{-1}$, MJ.mmha$^{-1}$h$^{-1}$, MJ.mmha$^{-1}$h$^{-1}$, MJ.mmha$^{-1}$h$^{-1}$ respectively as outlined. The terms $I_{30}$, A, $I_m$ and K.E >25 are maximum 30–minute intensity, rainfall amount, maximum 6-minute intensity, kinetic energy of rainfall[computed using Wischmeier and Smith(1978) procedure]with intensities exceeding or equal to 25mmh$^{-1}$

## 3.0 Results and Discussion

### 3.1 Single erosivity indices; rainfall amount, kinetic energy and intensity

For the single erosivity indices the highest rainfall amount per storm event was 71.1mm.The highest monthly values of the kinetic energy obtained according to Wischmeier and Smith equation, designated E and that of Kowal and Kassam designated $E_k$ for the period of study were 84.1 MJha$^{-1}$ and 127.9 MJha$^{-1}$ respectively(table 1). It was observed that rain event $E_k$ was about 1.5 times more than the rain event E. Obi and Salako (1995), reported $E_k$ being 1.7 times higher than E. Many researchers (Hudson, 1981; Salako et al., 1991 and Obi and Salako, 1995) have reported that the E model underestimated the kinetic energy of tropical storms. The $E_k$ model was empirically derived from tropical rainfall data. Monthly values of $I_m$ ranged between 30 – 470 mmh$^{-1}$ while $I_{30}$ ranged from 12.4 – 296 mmh$^{-1}$. The magnitude of $I_{30}$ and $I_m$ were indications of the distribution of intense rainstorm in the different months of the year in Makurdi.

### *3.2 Kinetic energy and erosivity indices*

The highest six-minute intensity was 240 mm $h^{-1}$. Armon (1984) reported 325 mm $h^{-1}$ and 250 mm $h^{-1}$ as the highest 5-minute and 7.5 -minute intensities for South-eastern Nigeria. The highest six-minute intensity for Nsukka was 250 mm $h^{-1}$ (Obi and Salako, 1995).The study reveals that the threshold values of 25 mm $h^{-1}$ and 75 mm $h^{-1}$ will be exceeded in Makurdi.

**Table 1:** ***The mean monthly kinetic and erosivity of rainfall between 1985 and 1987 at Makurdi.***

| Month | Kinetic energy[a] | | Rainfall erosivity indices | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | E ($MJha^{-1}$) | $E_k$ ($MJha^{-1}$) | $EI_{30}$ ($MJ.mmha^{-1}h^{-1}$) | K.E>25 ($MJha^{-1}$) | $AI_m$ ($mmh^{-1}$) | $E_kI_{30}$ ($MJ.mmha^{-1}h^{-1}$) | $E_kI_m$ | $E_kAI_m$ ($MJ.mmha^{-1}h^{-1}$) | E (A) $I_{30}$ |
| Jan | - | - | - | - | - | - | - | - | - |
| Feb | - | - | - | - | - | - | - | - | - |
| Mar | - | - | - | - | - | - | - | - | - |
| Apr | 1.95 | 2.5 | 24 | 0.7 | 270 | 31 | 76 | 527 | 218 |
| May | 27.1 | 41.1 | 1197 | 24 | 10618 | 1775 | 2638 | 72231 | 31872 |
| Jun | 22.4 | 26.1 | 556 | 20 | 6074 | 644 | 2145 | 46636 | 12496 |
| Jul | 36.6 | 54.7 | 1081 | 34 | 12365 | 1487 | 3964 | 96484 | 39422 |
| Aug | 84.1 | 127.9 | 3246 | 69 | 34242 | 4969 | 13670 | 449433 | 173781 |
| Sep | - | - | - | - | - | - | - | - | - |

[a] *E was computed using Wischmeier and Smith(1978) equation and its data set was used for the evaluation of $EI_{30}$, K.E>25 and E (A) $I_{30}$ erosivity indices. $E_k$ was computed using Kowal and Kassam (1976) equation and its data set was used to evaluate $E_kI_{30}$, $E_kI_m$, $E_kAI_m$.*

**Table 2:** ***Monthly means of computed compound rainfall erosivity indices for Makurdi (1985 -1987).***

| | MONTHS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **indices** | April | May | | June | | July | | August |
| | 1987 | 1987 | 1986 | 1985 | 1987 | 1986 | 1987 | 1987 |
| **$EI_{30}$ ($MJ.mmha^{-1}h^{-1}$)** | 396 | 396 | 201 | 178 | 106 | 138 | 245 | 406 |
| **K.E > 1 ($MJha^{-1}$)** | 0.7 | 7 | 5 | 7 | 3 | 6 | 7 | 9 |
| **$E(A)I_{30}$ ($MJ.mmha^{-1}h^{-1}$)** | 218 | 26992 | 6125 | 4412 | 1836 | 4288 | 11,480 | 19309 |
| **$E_kAI_m$ ($MJ.mmha^{-1}h^{-1}$)** | 527 | 67293 | 12862 | 19429 | 3,888 | 15372 | 23221 | 49937 |
| **$E_KI_m$ ($MJ.mmha^{-1}h^{-1}$)** | 76 | 1594 | 614 | 756 | 316 | 723 | 862 | 1519 |
| **$AI_m$ ($mmh^{-1}$)** | 270 | 3727 | 1676 | 2,099 | 938 | 1958 | 2490 | 4280 |
| **$E_kI_{30}$ ($MJ.mmha^{-1}h^{-1}$)** | 31 | 595 | 284 | 169 | 153 | 162 | 361 | 552 |

The mean monthly rainfall erosivity, as computed for the various indices studied, are shown in (Table 2). The monthly erosivity values calculated for the conventional indices and the various proposed indices, namely, $EI_{30}$, K.E>25 $mmh^{-1}$ and $AI_m$, $E_kI_{30}$, $E_kI_m$ , $E_kAI_m$ and E $(A)I_{30}$, are shown in Table 2. From the study rainfall erosivity at Makurdi is considered very high.

## 4.0 General Discussion

The present study utilized auto recording data for 3-years to characterize rainfall erosivity. Long term data of more than 30-years (Wischmeier and Smith, 1978) are desirable, however, in Nigeria this desire cannot be met due to lack of data from auto recording raingauges and poor maintenance of same. It is in this context that short –term data are used to provide site –specific information on rainfall erosivity to avoid extrapolation of data from different agro climatic zones.

The erosivity values here presented will be useful for soil loss estimation. The $EI_{30}$ which was recommended for the universal soil loss equation (Wischmeier and Smith, 1978) was evaluated in this study for the different months of the year. The $E_kI_{30}$, $E_kI_m$ ,$E_kAI_m$ and $E(A)I_{30}$ also fit dimensionally into universal soil loss equation.

## 5.0 Conclusion

The present study leads to the following conclusions:

- Storm intensities were high and frequent. Storms less than 20mm per rain event were very frequent and were complimented with exceptional storms as high as 71mm per rain event.
- $EI_{30}$ can be improved for rainfall erosivity evaluation in Makurdi by multiplying it with a coefficient of 1.5 or more as shown when compared with erosivity values of $E_kI_{30}$ and $E_kI_m$. It was also improved by incorporating rainfall amount (A) into the index.
- Rainfall erosivity is high in Makurdi with multiple rainfall erosivity peaks during the rainy season.

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