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*RESEARCH ARTICLE*

# Estimation of rainstorm kinetic energy for Ambikapur Chhattisgarh

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## ABSTRACT

The kinetic energy of rainstorm plays an important role in runoff and erosion process. Knowledge of relationship between rainfall intensity and kinetic energy and its variations in time and space is important for erosion prediction. Rainstorm kinetic energy, as a function of the mass and terminal velocity of raindrops has often been suggested as an ability of rainfall to detach soil particles. Therefore, this study was carried out to evaluate the variability of rainfall and its kinetic energy for Ambikapur. Time of occurrence of rainfall, rainfall amount, intensity and kinetic energy were evaluated. Kinetic energy was estimated with Zanchi and Torri's equation and by Marshal and Palmer's equation of kinetic energy. Among four rainy months, maximum rainfall amount of 222.94 mm was observed for the month of August and lowest rainfall amount of 92.64 mm was observed for June. Kinetic energy by both the models was found to be maximum for July with K.E-1 as 38.71 MJ/ha, K.E-2 as 43.20 MJ/ha and for August K.E-1 as 39.33 MJ/ha and K.E-2 as 42.88 MJ/ha, respectively. For rest of the months *i.e.* for September and June kinetic energy was in decreasing trend. Co-efficient of determination for monthly variation of kinetic energy was found to be $R^2 = 0.965$.

**KEY WORDS :** Kinetic energy of rainfall, Rainfall intensity

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## INTRODUCTION

Rainfall events is a function of the kinetic energy of the rain that impacts the soil. As rain consists of a spectrum of drop sizes, the kinetic energy is dependent upon the nature of the distribution of those sizes. In particular, larger drops have both greater mass and vertical terminal velocity such that a disproportionate amount of energy and potential erosion results from the action of a small number of large drops.Soil loss is a major issue among the agriculture industry and water management fields across the entire globe (Eswaran *et al.*, 2001). Rainfall represents a distribution of differently sized drops that attain corresponding different terminal velocities in stable air. Rainfall kinetic energy and rainstorm intensity are predominant factors contributing to runoff and soil erosion process (Renard *et al.*,1997). The determination of both the parameters is, therefore, of paramount important for runoff and erosion prediction purposes. Bonell (1998) observed that any change in rainfall characteristics which favours higher intensities would encourage the occurrence of overland flow and cause erosion. The study of mechanisms of water erosion brings out two characteristics of precipitation, which makes it the dominating causative factor of the phenomenon: intensity and depth of amount (which depends on the intensity-duration combination) (WMO, 1983). Hudson (1995) defined three attributes of rain pertaining to erosion. Intensity of a rain, generally expressed as mm/hr, is usually highly variable during the course of a rainstorm. The time pattern of rain intensity also differs from storm to storm, from place to place and from season to season. The second attribute is the duration of a rain, the length of time from the start of a rainstorm to its ending. As the third parameter Hudson states the energy of a rainstorm, being the summation of the kinetic energies of all raindrops falling on a unit area. Thus, kinetic energy represents the total energy available for detachment and transportation of soil particles. The most widely used kinetic energy-intensity relationship is that proposed by Zanchi and Torri (1980) and that of Marshall and Palmer (1948) was used to estimate the kinetic energy in this study. Kinetic energy was used in detachment formulas proposed by Ekern (1950); Rose (1960); Bubenzer and Jones (1971) and Quansah (1981). Kinetic energy, kinetic energy per unit of drop area, momentum and momentum per unit of drop area where factor suggested by Meyer (1965) potential importance of soil erosion. In addition to the above parameters, kinetic energy and momentum per unit of drop circumference were identified by A1-Durrah and Bradford (1982) as rainfall factors of possible significance. The objectives of this study were to estimate rainstorm kinetic energy for Ambikapur district.

## EXPERIMENTAL PROCEDURE

Location and extent Ambikapur is a city and Surguja district headquarters. The district is one of the oldest districts of the Indian state of Chhattisgarh, in east-central India. Ambikapur is also the divisional headquarters of Surguja Division which consists of the five districts of Surguja, Korea, Balrampur, Surajpur and Jashpur. Ambikapur is located at 23°12'N 83°2'E [4]. It has an average elevation of 623 metres (2078 feet). The district is spread over a forest-rich area of 22,237 km². Most of the district's terrain is forested and hilly. Natural resources include bauxite, forest products and paddy crops. Ambikapur has a tropical climate. It is hot and humid because of its proximity to the Tropic of Cancer and its dependence on the monsoons for rain. Summer temperature in Chhattisgarh can reach 45°C. The monsoon season is from late june to October and is a welcome respite from the heat. Ambikapur receives an average rainfall of 1292 millimeters (50.9 in). July and August being the months of maximum rainfall (Table A).

### Data analysis :

Precipitation data required for study which covered rainfall amount of 21 years from 1993 to 2013 were obtained from agro-meteorological research station of Chhattisgarh and meteorological station Ambikapur, Chhattisgarh. Statistical analysis and normalization of rainfall data was done and statistical parameters *i.e.* mean, median, standard deviation and skewness was calculated.

### Kinetic energy of rainfall :

The result of various studies had suggested that soil splash rate is a combined function of rainfall intensity and some measure of raindrop fall velocity (Ellison,1944 and Bisal,1960). In particular, rainfall kinetic energy Ek (product of mass and fall velocity squared) has often been suggested as an indicator of rainfall erosivity, *i.e.* the ability of rain to detached soil particles (Mihara, 1951 and Free, 1960). Rose (1960) concluded that rainfall momentum is a slightly better predictor of soil detachment than kinetic energy, but Hudson (1971) demonstrated that for natural rainfall, momentum and kinetic energy exhibit similar relationships with intensity.

Kinetic energy of rainstorm is given by the formula given by Zanchi and Torri (1980)

$$E = 0.0981 + 0.1125 \log I \qquad \ldots(1)$$

Marshall and Palmer (1948) also gave Eq. for calculating kinetic energy of rainstorm :

**Table A: Statistical parameter for normalized and observed rainfall data of Ambikapur**

| Statistical | July | | August | | September | | October | | November | | December | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| parameter | Ob. | Norm | Ob. | Norm | Ob. | Norm | Ob. | Norm | Ob. | Norm | Ob. | Norm |
| Std.dev | 38.42 | 42.63 | 40.27 | 43.71 | 40.27 | 31.45 | 11.43 | 16.32 | 11.85 | 13.76 | 7.19 | 8.99 |
| Skew. | 4.62 | 1.52 | 4.44 | 1.78 | 4.53 | 0.89 | 5.56 | 0.93 | 5.47 | 1.40 | 5.56 | 1.81 |
| Mean | 27.99 | 79.4 | 16.15 | 62.12 | 16.15 | 51.19 | 4.00 | 19.72 | 3.94 | 10.86 | 2.92 | 5.65 |

**E = 0.0895 + 0.0844log I** ….(2)

where,

E is kinetic energy of storm in MJ/h.mm.

I is rainfall intensity in mm/h.

## EXPERIMENTAL FINDINGS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads, Table 1 and Fig. 1 to 4.

### Estimation of storm kinetic energy :

The mean monthly variation of kinetic energy by different models in month July with normalized data. Kinetic energy was estimated with Zanchi and Torri's equation (M-I) and Marshall and Palmer's (M-II). Zanchi and Torri's(M-I) always found to be little higher values of kinetic energy in comparison of Marshall and Palmer's (M-II). It is revealed that the kinetic energy for different month July, August, September, October with different time duration for rainfall at 2,5,10,20,50 years having high and low values. These values also show that kinetic energy decreasing with increasing duration.

**Table 1: High and low values of kinetic energy for different months**

| Years | 2 | | 5 | | 10 | | 20 | | 50 | |
|---|---|---|---|---|---|---|---|---|---|---|
| sample → | High | Low | High | Low | High | Low | High | Low | High | Low |
| Model- II | 0.377 | 0.214 | 0.446 | 0.286 | 0.465 | 0.306 | 0.480 | 0.319 | 0.494 | 0.333 |
| Model-II | 0.297 | 0.177 | 0.351 | 0.231 | 0.367 | 0.245 | 0.376 | 0.255 | 0.386 | 0.266 |
| August | | | | | | | | | | |
| Model-I | 0.375 | 0.214 | 0.446 | 0.285 | 0.466 | 0.305 | 0.480 | 0.319 | 0.493 | 0.332 |
| Model-II | 0.297 | 0.176 | 0.351 | 0.230 | 0.366 | 0.245 | 0.376 | 0.255 | 0.386 | 0.266 |
| September | | | | | | | | | | |
| Model- II | 0.375 | 0.214 | 0.252 | 0.090 | 0.263 | 0.102 | 0.272 | 0.110 | 0.281 | 0.120 |
| Model-II | 0.297 | 0.176 | 0.475 | 0.084 | 0.213 | 0.092 | 0.219 | 0.098 | 0.227 | 0.106 |
| October | | | | | | | | | | |
| Model-I | 0.185 | 0.024 | 0.215 | 0.054 | 0.227 | 0.067 | 0.237 | 0.076 | 0.248 | 0.087 |
| Model-II | 0.154 | 0.034 | 0.177 | 0.056 | 0.166 | 0.066 | 0.143 | 0.073 | 0.202 | 0.081 |

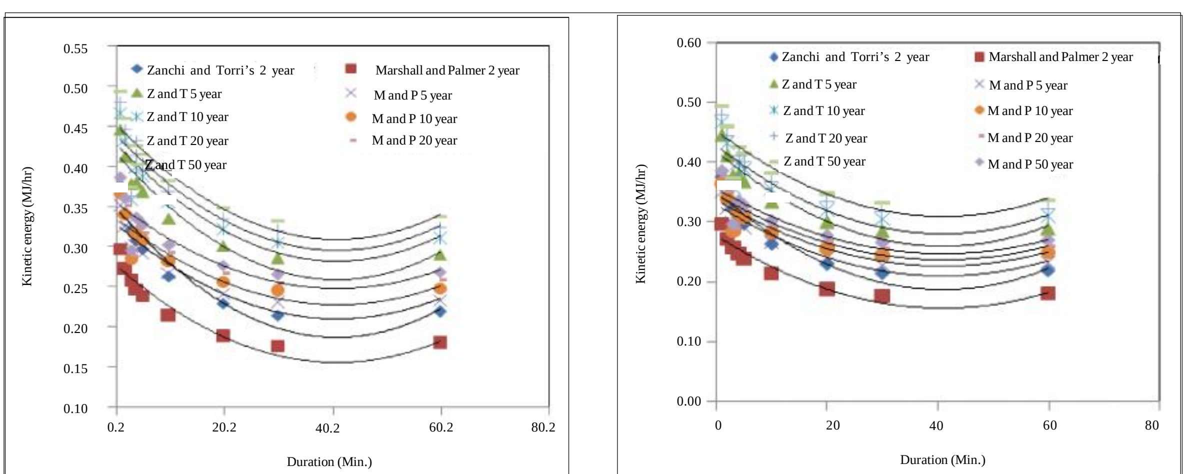


**Fig. 1 : Variation of kinetic energy by both models in different duration for month July and August**

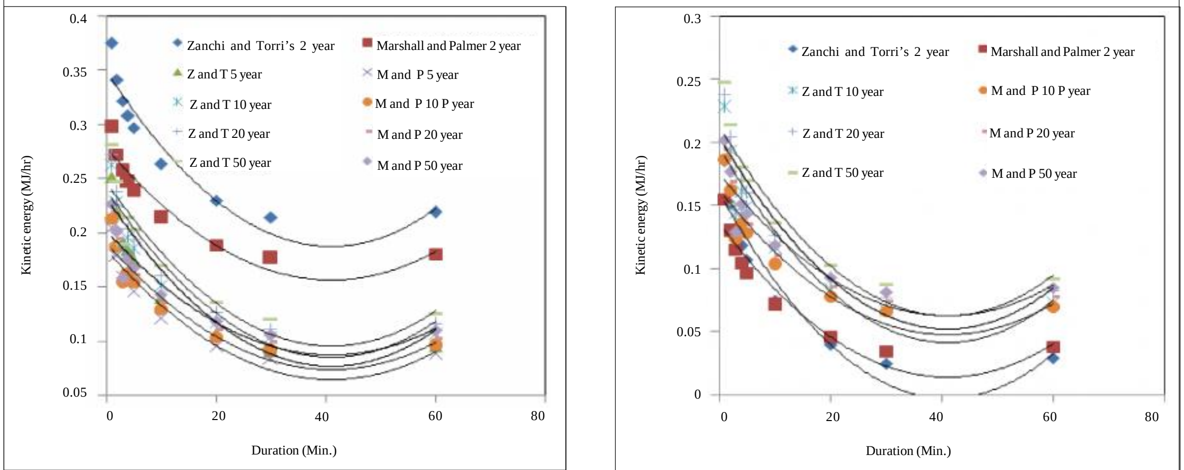


**Fig. 2 : Variation of kinetic energy by both models in different duration for month September and October**

**Relationship between the rainstorm kinetic energy for model-I and model-II :**

The curve generated are shows the relationship between kinetic energy by Zanchi and Torri's (model-I) and kinetic energy by Marshall and Palmer (model-II) for month July, August, September, October respectively. A generated curve between two models shows the linear relationship between two models. Linear relationship shown by two different models for the duration of 2 year, 5 year, 10 year, 20 year, 50 year. The value of kinetic energy by two different models was not found more differ. The value of kinetic energy by Zanchi and Torri found more as compare the value of rainfall kinetic energy by Marshall and Palmer.

**Conclusion :**

For estimation of soil erosion, specifically on detachment of soil particles by raindrop impact, kinetic energy is a commonly suggested indicator of the raindrop's ability to detach soil particles from the soil mass. Estimation of rainfall kinetic energy requires daily rainfall data. It varies along with the duration of rainfall.It found variation in different monsoon months at different durations. The mean monthly variation of kinetic energy by different models in month July with normalized data. Kinetic energy was estimated with Zanchi and Torri's equation (M-I) and Marshall

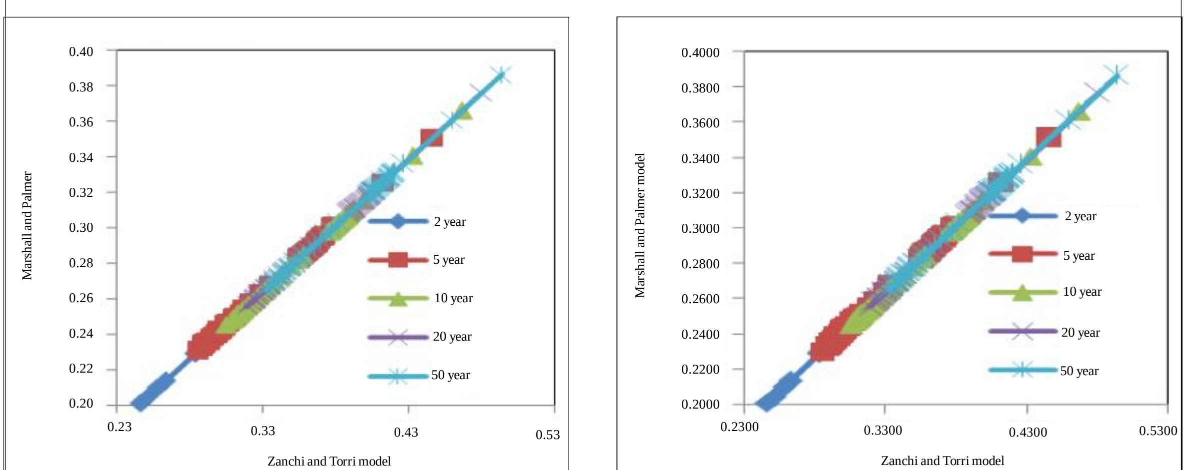


**Fig. 3 : Zanchi and Torri and Marshall and Palmer model relationship for Ambikapur for July and August**

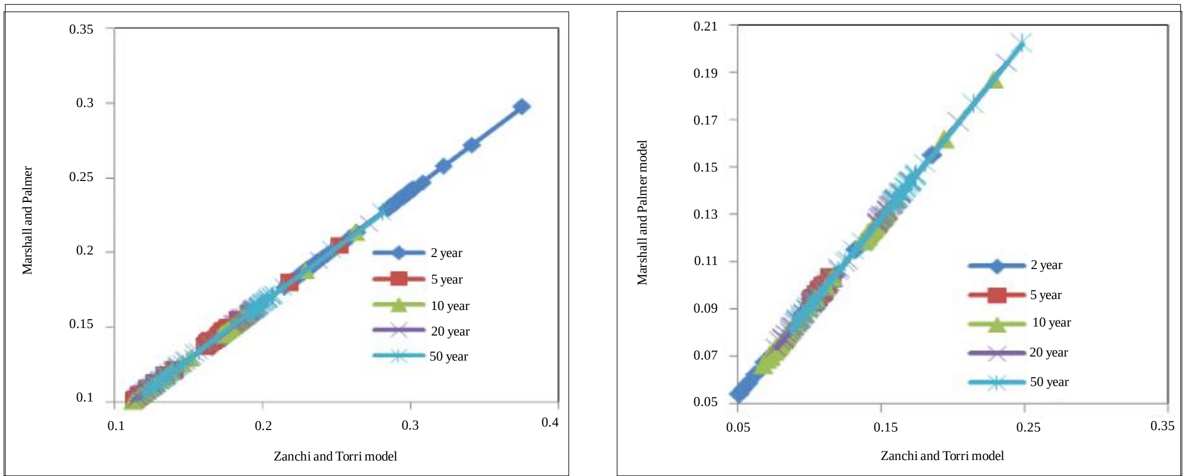


**Fig. 4 : Zanchi and Torri and Marshall and Palmer model relationship for Ambikapur for September and October month**

and Palmer's (M-II) for the time period of 2 year, 5 year, 10 year, 20 year, 50 year, respectivily. Zanchi and Torri's (M-I) always found to be little higher values of kinetic energy in comparison of Marshall and Palmer's (M-II). Kinetic energy found variation in different monsoon months at different durations.

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