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Assessment and mapping of rainfall erosivity and erodibility status of Tamil Nadu

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Abstract : Erosion Index is one of the important parameters in estimating soil loss from the Universal Soil Loss Equation of Wischmeier. For this, monthly, seasonal and annual Erosion Index (E1) values of 18 stations in Tamil Nadu were computed for assessing the rainfall erosivity for various stations and preparing the Iso-erodent map of Tamil Nadu. Annual erosion index values are shared by southwest (June - September) and northeast (October - December) monsoon rains in Tamil Nadu. Iso-erodent values for 65 stations were computed using relationship between mean annual/seasonal (June - September and October - December) rainfall and respective erosion index values. Iso-erodent maps for Tamil Nadu for annual and seasonal (June - September and October - December) periods are shown. Annual E1 values ranges from 299 at Tuticorin to 835 at Nagapatinam. The seasonal (June - September) E1 ranges from 16 at Pamban to 423 at Tirupattur while northeast monsoon E1's ranges from 58 at Karur to 555 at Nagapatinam. Variation in E1 reflects the diversity of rainfall erosion potential in the State. Distribution curves expressing average values are given for 18 stations. Values of Erosion Index for return periods of 2, 5 and 10 years are indicated to assist in assessing soil loss with 20, 20 and 50% probability. **(*Key words : Rainfall erosion, Iso-erodent value, Erodibility, Erosion Index (E1), E1 distribution curve*).**

The numerical assessment of Soil loss by water under a particular management practice can be achieved with the help of Universal Soil Loss Equation (USLE) as described by Wischmeir and Smith (1978) is

$$A = R\,K\,L\,S\,C\,P$$

Where, A is the average annual soil loss, R is the rainfall erosivity factor, K is the soil erodibility factor, L is the slope length factor, S is the slope steepness factor, C is the cover management factor and P is the erosion control practice factor.

The USLE is held to be good enough to predict soil erosion in a manner to the process based models like RUSSLE and WEPP (Laflen *et al.* 1997). The rainfall factor, R in the equation defines the erosivity of rain. Wischmeier (1958) found that one hundredth of the product of kinetic energy of rainstorm (KE) and the 30-minute intensity (I_{30}) is the most reliable estimate of rainfall erosion potential and termed as EI_{30}. Annual total of storm EI_{30} value is referred as the rainfall erosion index and R is the location value of this index. In Rhodesia (Africa), Hudson (1971) found that the kinetic energy of individual storms falling at intensities of 25 mm per hour or greater was closely related to soil loss. In India (at Dehradun and Coimbatore), EI_{30} value gave a better correlation ('r' ranged from 0.74 to 0.96) with soil loss and hence, it continues to be the most reliable estimate of rainfall erosion practice (Ram Babu *et al.* 1978a).

The annual E1 value is important to find out geographical difference in the ability of average annual rainfall to cause erosion. Monthly and seasonal E1 values are required to obtain the location differences in the distribution of erosive rainstorms within the year. The find out the difference in the erosion producing potentials of rainfall patterns in the particular State/region, a state-wise erosion index value map is desired.

The importance of the parameter (EI_{30}) in soil conservation programmes is well recognized. In India, however, such data are not available for many stations to prepare State maps. Ram Babu *et al.* (1978a and 1978b) determined E1 values for 4 stations of Tamil Nadu which were inadequate to prepare erosion index map of Tamil Nadu. An effort has been made to process and analyze the data of 18 stations of Tamil Nadu to obtain monthly, seasonal and annual EI_{30} values, Iso-erodent maps (annual and seasonal), E1 values at 2, 5 and 10 years return period and erosion distribution curves.

Materials and Methods

Data collection and processing

The recording raingauge data for storms greater than 12.5 mm were obtained from the Indian Meteorological Department, Pune for 18 stations located in the state of Tamil Nadu. Due to non-availability of long period record for all the stations under study, 15 and more years record for 13 stations and 8-12 years data for five stations (1974 to 1995) have been used for computation of EI values. The data for all the stations were checked for adequacy of length of record through 'R' test using the procedure of Ogrosky and Mockus (1957) and found to satisfy the relevant test. Average annual rainfall data for the stations under study were obtained from the publications of India Meteorological Department, (IMD 1962 and 1995).

Computation of Erosion Index (EI_{30})

The method suggested by Wischmeier and Smith (1978) was used for estimating the erosion index value of each storm. Storms greater than 12.5 mm of rain were considered for computation of EI value. The storms separated by more than 6 hours, they were considered as different storms. The EI_{30} can be expressed as :

$$EI_{30} = \frac{KE \times I_{30}}{100} \qquad \text{-----------------------} (1)$$

Where, EI_{30} = erosion index, KE = kinetic energy of the storm and I_{30} = maximum 30 minute rainfall intensity of the storm.

Kinetic energy for the rainstorm in metric unit was computed by the equation proposed by Wischmeier and Smith (1969), defined as :

$$KE = 210.3 + 89 \log I \qquad \text{-----------------} (2)$$

Where, KE = kinetic energy in metric-tonnes per hectare centimeter, and

I = rainfall intensity in centimetres per hour.

For obtaining monthly and annual EI values, the storm EI for that length of period were added. In case erosion index values are desired for any particular week, season, or crop growing period etc. the storm EI values for that length of time may be summed up.

Frequency analysis of Erosion Index (EI)

The purpose of frequency analysis is generally the prediction of what will happen in future. Frequency analysis of erosion-index data provides the value of erosion index which are expected to be exceeded, on the average, one in 2, 5, 10 years or any desired return period.

There are several theoretical interpretations or reasoning for the preference of one method over the other (Chow, 1964). Mathematical or graphical methods are generally used for frequency analysis. A rigid mathematical treatment is not justified when the data available are for less than 30 years (Dalrymple, 1960). As our EI data were of shorter duration of about 15 years or less, graphical method was preferred. Gumble's extreme value technique was applied for computation of the return period values (Ogrosky and Mockus, 1957) and the frequency line was drawn through the plotted points by 'computed method' {Annual EI on log scale (X-axis) and per cent chance of occurrence of EI value on probability scale (Y-axis)}. The 'computed method' eliminates subjectivity and is considered to be mathematically sound. The plotting positions may be computed by Weibull method (Dalrymple, 1960) as:

$$Pp = m*100/(n+1) \qquad \text{-----------------------}(3)$$

where, Pp = plotting position of EI value in per cent chance,

m = rank number when the data are arranged in descending order with highest event marked as I, and

n = total number of years for which the data are available.

Results and Discussion

Distribution of monthly and seasonal Erosion Index Values

The monthly, seasonal and annual EI values for 18 stations were computed and presented in Table 1. It is observed from the Table that 3 to 38% of total EI values of 9 locations is contributed through south-west monsoon (i.e. June - September) and other 9 stations contributed 40 to 79% of total EI value during this period. It is further observed that 32 to 72% of total EI values contributed through north-east monsoon (October - December) except three locations *viz.* Salem, Tirupattur and Vellore where the EI contribution is 12 to 22 % only. The annual EI values can be used to determine annual soil loss under specific rainfall pattern. With monthly and seasonal EI values a farm manager can determine at which points in his cropping system additional conservation practices would be required to achieve greatest saving of soil. The monthly and seasonal erosion index distribution data can also be used to evaluate the erosion control effectiveness of specific crop rotations and management practices under specific location rainfall pattern.

Iso - erodent map of Tamil Nadu

Iso-erodents are lines joining areas with equally erosive rainfall (Wischmeier, 1962). The annual erosion index values of 18 stations given in table 1 were not sufficient to establish a closer path of iso-erodents. To get an additional computed values of erosion index, linear relationship were established between average annual/seasonal (June - September and October - December) rainfall and there erosion index values for Tamil Nadu and were plotted against average annual and seasonal (June - September and October - December) rainfall respectively (Fig. 1a, lb and lc). Derived relationship were as follows :

Annual : $Y = 98.40 + 0.438\ x$ (S.E. = 0.079, r = 0.820) ------ (4)

Seasonal (June-September): $Y = -13.16 + 0.806\ x$(S.E. = 0.100, r = 0.908)----- (5a)

(October - December) :$Y = -65.96 + 0.612\ x$(S.E. = 0.064, r = 0.926) ------ (5b)

Where,

y = average annual/seasonal erosion index in equation (4), (5a) and (5b).

x = average annual/seasonal rainfall (mm) in equation (4), (5a) and (5b) respectively.

The above derived regression lines and average annual/seasonal (June - September and October - December) rainfall data were used to approximate the erosion index values of 65 locations fairly distributed to represent the whole of Tamil Nadu. These index values were then mapped along with those obtained from 18 stations and the iso-erodents were drawn for annual and seasonal EI respectively and presented in Fig. 2,3 and 4.

The number identifying each iso-erodent is the numerical value of erosion-index along the line. Points lying between the indicated iso-erodents may be approximated by linear interpolation. The iso-erodent map shows that the annual erosion-index values ranged from 299 at Tuticorin to 835 at Nagapatinam. The seasonal (June - September) erosion index values ranged from 16 at Pamban to 423 at Tirupattur while seasonal (October - December) from 58 Karur to 555 at Nagapatinam. Variation in erosion index values reflects the diversity of rainfall erosion potential in different parts of Tamil Nadu.

Location values of rainfall factor, R for its use in the Universal Soil Loss Equation (USLE) may be taken directly from the iso-erodent map given in Fig. 2. Seasonal (June - Sepetember and October - December) iso-erodent map (Fig. 3&4) shows the erosion potential distribution patterns in south-west and north-east monsoon respectively. In Tamil Nadu about 60% of annual erosion index values are caused by seasonal rains. Thus distribution of erosion index values clearly indicates that most of the erosive rain occurs during the rainy season. Hence, a special attention is required to give adequate protection to soil during these months.

Probability values of the Erosion index

Wischmeier (1959) states that annual values of the erosion index follow a long-normal frequency distribution. The value of erosion index which are expected to exceed, on the average, one year in two, five and ten years were computed for 18 stations. Range of EI relative to average erosion index and specific probability values for 50% (2 year return period), 20% (5 year return period) and 10% (10 year return period) were given (Table 2).

In order to estimate average annual soil loss, the value of the factor, R, must equal the average annual value of the erosion index at that location. If desired, however, some specific return period value of the erosion index, other than the annual average, may be substituted for R in the average, may be estimated by assigning 5 years return period value of erosion index for R factor in the universal soil loss equation.

Erosion Index distribution curves

The annual erosion index values do not completely describable the differences in rainfall erosion potential during different months of year. Under field conditions, distribution of erosive rainstorms within the year in relation to the existing vegetative cover and crop residue effects is very important. From the erosion index values given in Table 1, distribution curves were prepared for 18 stations and shown in Fig. 5. In this, the average monthly erosion nidus values expressed as percentage of the annual erosion index that is to be expected within any particular crop stage period may be found by reading the curve at the last and first of chosen period and subtraction. This information is useful (i) to determine as to how the erosivity varies during the year/season at any given location and (ii) for planning of soil conservation farming systems.

Fig. 5 gives the variations in the distribution pattern of rainfall erosivity from location to location. For example, at Vellore the rainfall erosivity from the month of January to May is only 7.5 per cent of the total yearly EI value. The rainfall picks up in the month of June and continues with considerable intensity upto the month of December. During this period 72 per cent of the total EI is contributed. This information about rainfall erosivity within the

Table 1. Average monthly and annual erosion index values (metric units) of Tamil Nadu.

Station	Months												Annual EI	Seasonal EI June-Sept.	Jun.-Sept. (south-west moonsoon) as % of annual	Seasonal EI Oct-Dec.	Oct.-Dec. (north-east moonsoon as % of annual
	January	February	March	April	May	June	July	August	September	October	November	December					
Coimbatore	-	0.9	3.4	14.3	101.4	21.3	10.5	6.1	37.3	17.9	113.7	5.3	332.1	75.2	22.6	136.9	41.2
Cuddalore	4.5	7.4	0.2	1.1	10.6	7.1	65.8	83.2	102.8	189.5	164.2	53.0	689.4	258.9	37.6	406.7	59.0
Kallakurchi	-	13.0	0.2	1.5	15.8	13.8	35.0	48.2	84.4	65.8	106.9	6.8	391.8	181.8	46.4	179.5	45.8
Kannyakumari	-	21.7	10.4	101.4	19.8	24.2	6.1	28.4	1.9	71.0	182.1	94.0	561.0	60.6	10.8	347.1	61.9
Karur	-	2.0	6.4	21.7	58.4	10.4	33.2	20.0	98.1	41.4	13.3	3.5	308.4	161.7	52.4	58.2	18.9
Kodaikanal	0.3	6.8	9.6	63.3	34.2	18.1	30.7	23.0	64.2	55.0	52.4	10.4	368.1	136.0	36.9	117.9	32.0
Kovilpatti	-	12.1	6.7	29.5	29.3	36.5	13.4	24.4	45.2	90.4	125.5	8.9	421.9	119.5	28.3	224.8	53.3
Maduari	0.2	3.1	4.6	19.8	39.9	17.3	96.5	34.5	131.6	123.4	115.1	3.5	589.5	279.9	47.5	242.0	41.1
Meenambakkam	14.8	19.8	0.9	0.1	3.5	38.4	80.2	30.6	133.2	129.8	171.6	49.2	672.1	282.4	42.0	350.6	52.2
Nagapatinam	1.7	19.4	4.5	52.4	24.8	28.2	47.8	36.8	63.6	175.9	207.4	172.0	834.5	176.4	21.1	555.3	66.5
Nungambakkam	3.3	-	-	-	6.8	31.2	71.6	89.7	80.0	126.8	153.1	111.9	674.4	272.5	40.4	350.6	52.2
Palani	-	35.8	-	12.3	83.4	2.7	0.1	-	28.5	115.3	59.3	10.0	347.4	31.3	9.0	184.6	53.1
Pamban	13.5	59.8	3.2	43.6	19.1	0.1	2.4	0.1	13.0	103.3	135.9	131.4	525.4	15.6	3.0	370.6	70.5
Salem	-	3.0	5.5	8.4	68.2	56.3	66.5	79.4	102.8	77.5	32.7	2.1	502.6	305.0	60.7	112.3	22.4
Tirupattur	-	-	1.8	10.2	35.7	25.7	88.6	122.3	185.9	34.9	25.0	5.6	535.7	422.5	78.9	65.5	12.2
Tuticorin	0.2	10.5	2.1	34.1	18.2	1.1	3.0	-	14.9	50.9	115.2	49.2	299.4	19.0	6.3	215.3	71.9
Vellore	-	4.2	0.4	22.3	15.4	27.7	141.6	88.6	159.2	54.9	33.2	17.7	565.2	417.1	73.8	105.8	18.7

Table 2. Observed range and 2, 5 and 10 years return period values of EI_{30} (metric units) for 18 stations of Tamil Nadu.

Location	Average annual EI	Values of Erosion Index (EI)			
		Observed range	Return period*		
			2 year	5 year	10 year
Coimbatore	332	131-854	270	480	650
Cuddalore	689	385-1331	635	890	1080
Kallakurchi	392	114-700	343	560	740
Kannyakumri	561	323-826	540	700	800
Karur	308	121-587	278	420	540
Kodaikanal	368	175-693	340	500	610
Kovilpatti	422	207-602	400	540	640
Maduari	672	287-1416	600	910	1150
Meenambakkam	835	323-1224	750	1080	1300
Nagapatinam	674	564-807	665	760	810
Nungambakkam	347	294-405	345	400	440
Palani	525	153-1152	425	780	1080
Pamban	503	193-965	455	680	840
Salem	547	194-954	480	780	1000
Tirupattur	536	485-616	530	560	600
Tuticorin	299	116-531	270	420	540
Vellore	565	408-787	550	680	760

* Return period = 100/Per cent chance.

year is essential for planning suitable measures of soil and water conservation. A good conservation programme would strive to keep the ground covered with vegetation or protect it by other means in the month of maximum rainfall erosivity.

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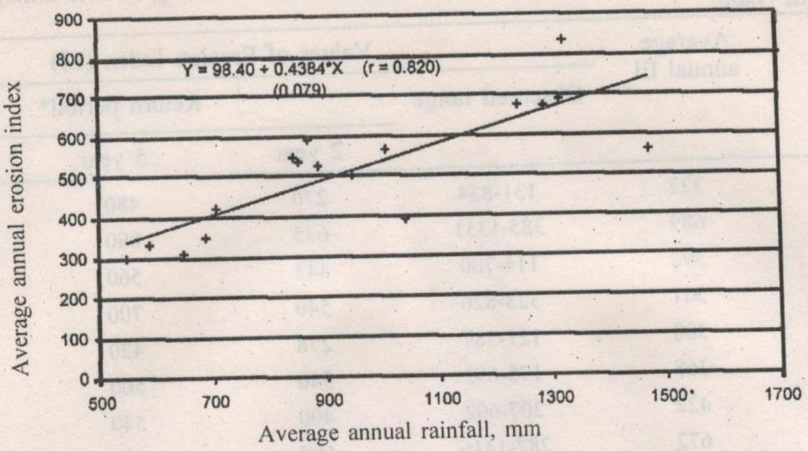

Fig. 1a. Relationship of annual rainfall to annual erosion-index - Tamil Naud

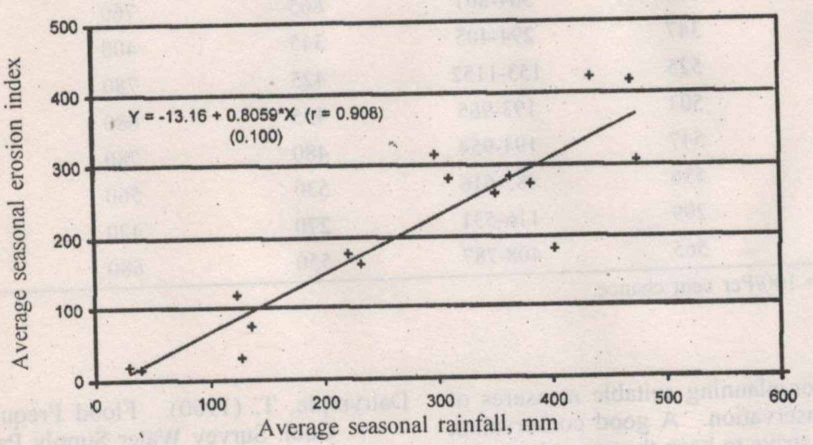

Fig. 1b. Relationship of seasonal (June - Sept.) rainfall to seasonal erosion-index - Tamil Nadu

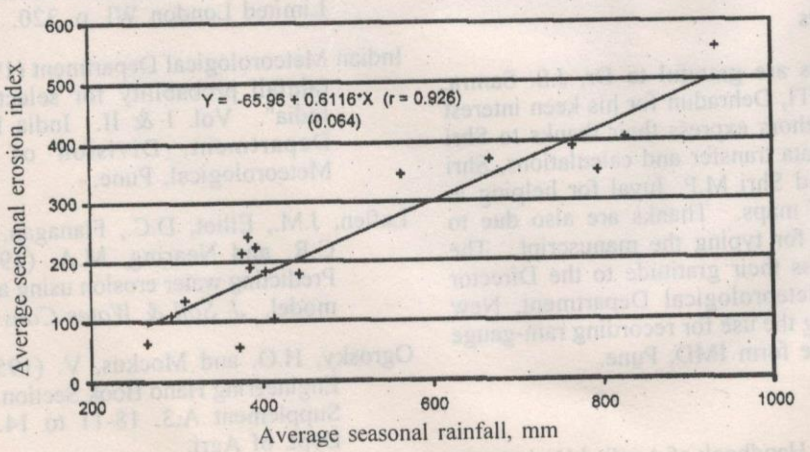

Fig. 1c. Relationship of seasonal (Oct. - Dec.) rainfall to seasonal erosion-index - Tamil Nadu

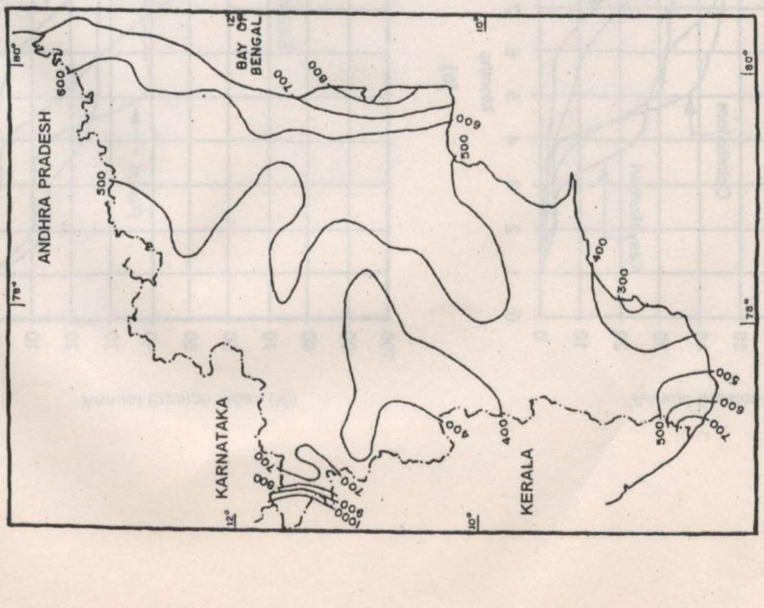

Fig. 2. Iso-erodent map of Tamil Nadu on annual basis

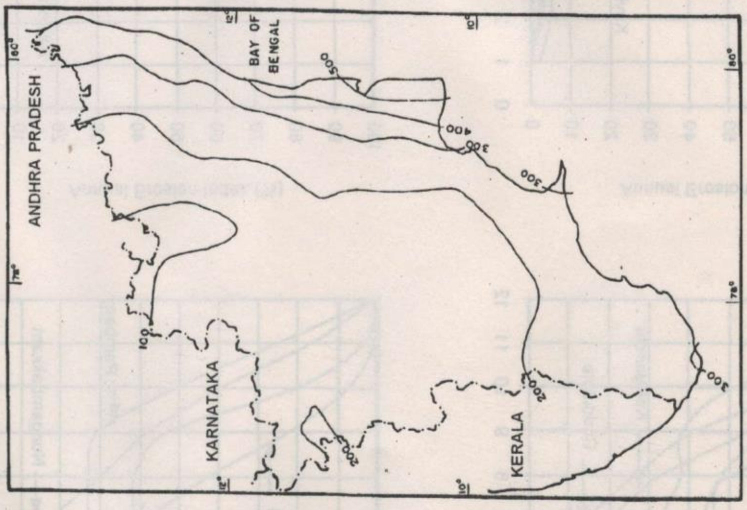

Fig. 3. Iso-erodent map of Tamil Nadu on seasonal (June-September) basis

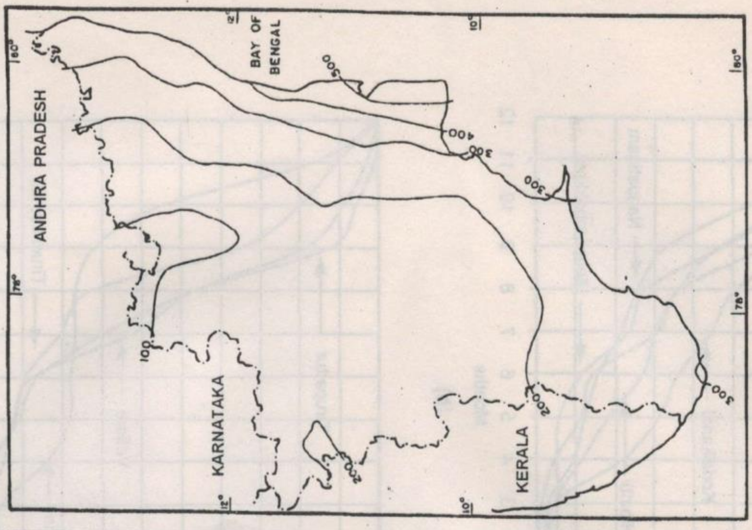

Fig. 4. Iso-erodent map of Karnataka on seasonal (October-December) basis

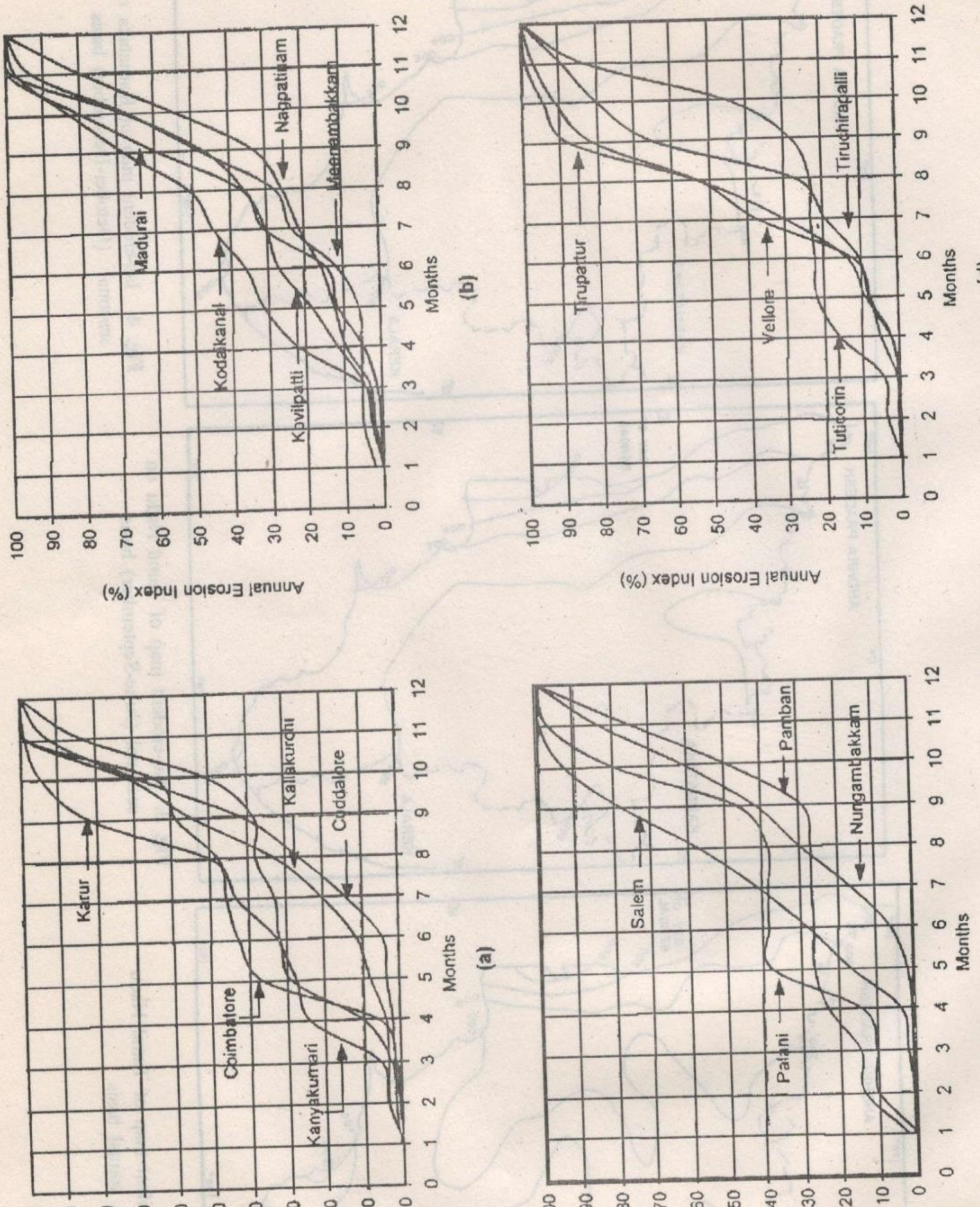

Fig. 5. Erosion-index distribution curves of different stations in Tamil Nadu

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Drying characteristics of grape varieties

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Abstract : The effect of direct sun-drying and solar drying of fourteen varieties of grapes were studied in terms of moisture content, drying rate, total soluble solids (TSS) and acidity. A saving in time of 40% could be achieved in a solar cabinet drier as compared to open sun drying. Appreciable change in TSS and no difference in citric acid were observed between the products dried under the two methods. The dehydration ratio, dehydration ratio, rehydration coefficient and the moisture content of rehydrated product were also determined. (***Key words :*** *Solar cabinet drier, Drying rate, Dehydration, Rehydration).*

Raisin constitutes an important item in the dried fruits consumed in India. While raisin made with white seedless grapes are used for a variety of table purposes, black grapes are generally used in bakery products. These grapes while drying undergo many changes and the drying behaviour of each of these vary according to their varietal difference. Moreover, drying need to be modernized to get good quality product at low processing cost. Though attempt were made earlier (EI Haggan and Kelwa, 1994) to dry the grapes continuously by using mechanical driers and solar driers, the effect of drying method on the drying characteristics of different varieties of grapes were not studied. Hence a study was made to dry fourteen varieties of grapes (both black and white) directly under sun and by using a solar cabinet drier and their drying characteristics were studied.

Materials and Methods

In order to improve the quality and increase the effect of the process, the drying was carried out in a solar cabinet drier and the results were compared with that of the sun-drying process.

The solar drier used consisted of a wooden rectangular base (2m x 1m) divided lenghwise into parallel channels of equal width. The box was glazed at the top to provide screening effect against Ultra-Violet light and to reduce photo-degradation of the drying product. The bottom and sides are well insulated and the interior surfaces are coated with black paint to absorb maximum solar radiation. Holes at the base and a chimney at the top were provided to permit natural convection of air.

Fourteen varieties of grapes, *viz.,* Sonaka1, Sonaka2, Thompson seedless, Phakdi, Arkahans, Anab-e-shahi, Manik chaman, Arkavati, Arka kiran, Gulabi, Bangalore blue 1, Bangalore blue 2, Arkashyam and Kiran were freshly harvested from the orchard of Raichur campus (UAS, Dharwad) at an average moisture content of 82 per cent (w.b) and