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RESEARCH ARTICLE

GRANULOMETRIC ANALYSIS OF CHANNEL SEDIMENTS OF SATI RIVER BASIN, DISTRICT GADCHIROLI, MAHARASHTRA, INDIA

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Abstract

Ten sediment samples from the Sati River basin in Gadchiroli District, Maharashtra, were analysed in detail for grain size to assess their textural and statistical characteristics, including mean, standard deviation, skewness, and kurtosis, as well as to understand their depositional patterns. The basin spans approximately 842.60 square kilometres, covering catchments from the northeast to the southwest. The sieve technique was used for grain size analysis, and a cumulative curve was generated by plotting grain size against cumulative weight percentage. The computed values for inclusive graphic skewness, median, mean, standard deviation, and kurtosis suggest that the sediments primarily consist of coarse-grained sand, are platykurtic, moderately sorted, and nearly symmetrically skewed. The interrelation of these parameters confirms the unimodal nature of the sediments, with coarse-grained sand being dominant. The C-M plot and log probability curves indicate that sediment transport occurs mainly through saltation and suspension. Overall, granulometric analysis confirms the fluvial origin of these sediments.

Introduction:-

The Sati River is located in central India and spans an area of approximately 842.60 square kilometres. The river flows from northeast to southwest and is 55 km long overall. The river joins the Wainganga River as a tributary of the Triveni River. The Sati River flows toward the plains after rising in the Satpura Range or the area's uplands. Near its source, the river may have a steep gradient, which frequently causes high-energy flow and causes the nearby rock and soil to erode.

Study Area

The area of study include mainly ten villages along the sati river which is the Yerkadi (Ye),Hetinagar (He), Palasgad (Pa), Mendha (Ma), Kurkheda (Ku), Aandhdi (Aa),Belgao (Be), Kharkada (Kh), Kadholi (Ka), and last one is the Vairagad (Va).

Methodology:-

Ten sediment samples were collected from distinct villages along the course of the Sati River. At the time of sampling, the riverbed was completely dry. The samples consisted of loose sediment mixtures, including clay, silt,

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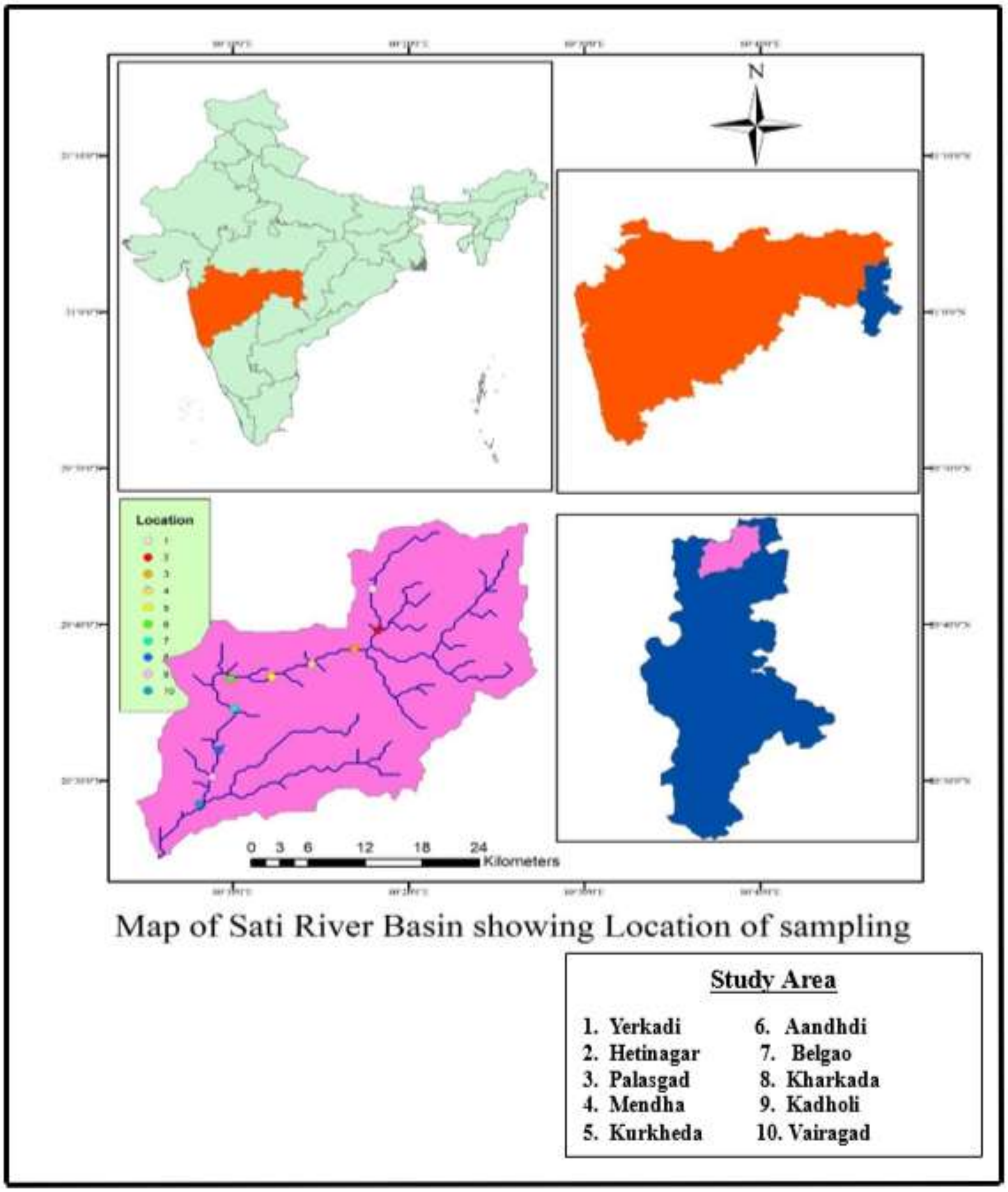
and, and gravel. To separate boulders and pebbles, a 2 mm mesh sieve was used. The coning and quartering method was employed for sample collection. In the laboratory, various chemicals were used to clean the samples, which were then stored for drying. Grain size analysis was conducted on the dried samples using the sieving technique, commonly applied to determine the particle size distribution of sand. To remove carbonate and organic matter, 10% HCl and 0.6% oxalic acid were added to each sample, while sodium hexametaphosphate was used to disperse grain aggregates. For sieve analysis, 100 grams of the prepared sample were used.Starting with 16 mesh (-0.5 Φ), 18 mesh (0 Φ), 35 mesh (1.00 Φ), 60 mesh (2.0 Φ 0), 120 mesh (3.00 Φ), 230 mesh (4.00 Φ), and bottom pan < 230 mesh, the sieves were arranged in ascending order of phi (Φ). They were then shaken for 30 to 40 minutes. The weight percentage of frequency data is the weight retained on each sieve. Following that, the weight percentage was changed to cumulative weight percentage, which Folk (1980) suggested being used to calculate a number of statistical parameters. (Tables 1 and 2)



Map No. 1:- Study Area.

Table 1:- Cumulative weight percentage frequency of the sediments sample from different area.

Village											
Mesh Size	Phi Value	Ye	He	Pa	Me	Kur	Aa	Be	Kh	Ka	Va
16	-0.5	6	18	16	24	18.5	19	14.5	9	8.5	16
18	0	10.5	30	24	33	27	29	26	14.5	15	22.5
35	1	54	79.5	64	66	61	77	72.5	54.5	53	63
60	2	98	99.5	95	96	79	98.5	97.5	96.5	95.5	97.5
120	3	99	99.75	99	99.5	98	99.5	99	99.5	99.5	99
230	4	99.69	99.77	99.7	99.69	99.5	99.53	99.5	99.67	99.68	99.29
Bottom Pan	4.25	99.85	99.99	99.76	99.61	99.6	99.58	99.75	99.68	99.74	99.74

Frequency curve:
The cumulative weight percentage of sediments is plotted. The graph in showingmoderate sorting of grain having wide range of size i.e., very coarse to fine grain however the amount of fine grain content is very low whereas high percentage of coarse sand is observed in all the samples.

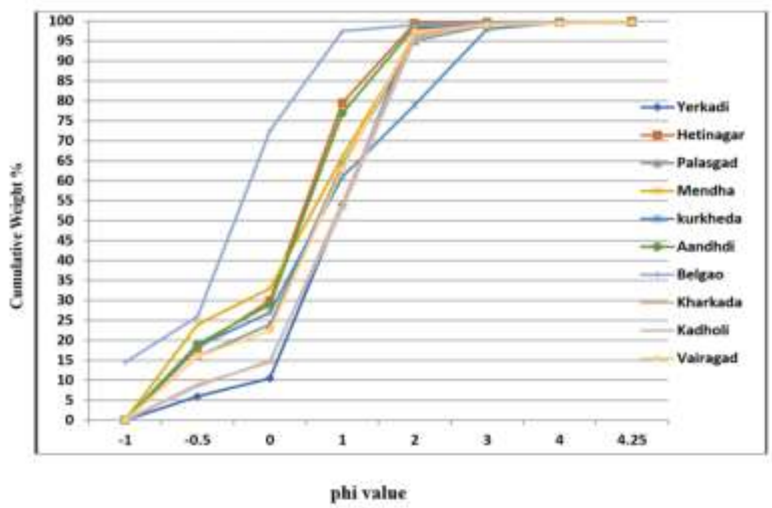


Figure 2:- Cumulative curve showing trend of all samples.

Result and Discussion:-
The table showing graphic measures and Statistical parameters. The graphic measure and statistical parameters are calculated by using different formulas.

Table 2:- Graphic Measure and Statistic Parameter of Sample.

Village/ Phi value	Φ91	Φ84	Φ75	Φ50	Φ25	Φ16	Φ5	Φ1	Mz	σI	Sk_1	K_G	C in micron	M in micron
Ye	1.9	1.7	1.5	0.9	0.35	0.2	-0.6	-0.9	0.93	0.75	-0.07	0.89	500	550
He	1.75	1.2	0.9	0.4	-0.3	-0.55	-0.8	-0.95	0.35	0.82	0.005	0.87	500	800
Pa	2	1.6	1.4	0.6	0.1	-0.5	-0.2	-0.9	0.56	0.85	0.1133	0.69	500	700
Me	1.95	1.55	1.25	0.5	-0.5	-0.6	-0.85	-0.9	0.48	0.91	0.005	0.65	500	750
Ku	2.9	2.5	1.75	0.65	-0.15	-0.55	-0.85	-0.95	0.86	0.84	0.2	0.80	500	700

Aa	1.9	1.3	0.9	0.45	-0.2	-0.55	-0.75	-0.9	0.4	0.86	0.007	0.98	500	800
Be	1.9	1.4	1.1	0.5	0	-0.45	-0.8	-0.95	0.48	0.87	0.0135	1.00	500	750
Kh	1.95	1.7	1.5	0.9	0.25	0.1	-0.7	-0.95	0.9	0.80	-0.103	0.86	500	550
Ka	2	1.75	1.5	0.95	0.25	0.1	-0.25	-0.9	0.93	0.75	-0.213	0.73	500	550
Wa	1.95	1.6	1.45	0.65	0.1	-0.4	-0.7	-0.9	0.61	0.90	-0.091	0.80	500	700
Average				0.65					0.65	0.835	-0.0133	0.827		

Statistical Parameter

Graphic Median ($^{\Phi}$50):

The graphic median, represented by the Φ50 value, indicates the point at which half of the sediment particles by weight are coarser and the other half are finer. The values obtained from the graph range from 0.4Φ to 0.95Φ, with an average of 0.65Φ, suggesting that all samples contain a higher proportion of coarse sand fractions.

Graphic Mean (Mz):

The graphic mean represents the central tendency and is determined using a given formula.

$$Mz = \frac{\Phi16 + \Phi50 + \Phi84}{3}$$

The calculated values range from 0.35ϕ to 0.93ϕ, with an average of 0.65ϕ, indicating the coarse-grained nature of the sediment. Similar to the graphic median, all sample values fall within the coarse category.

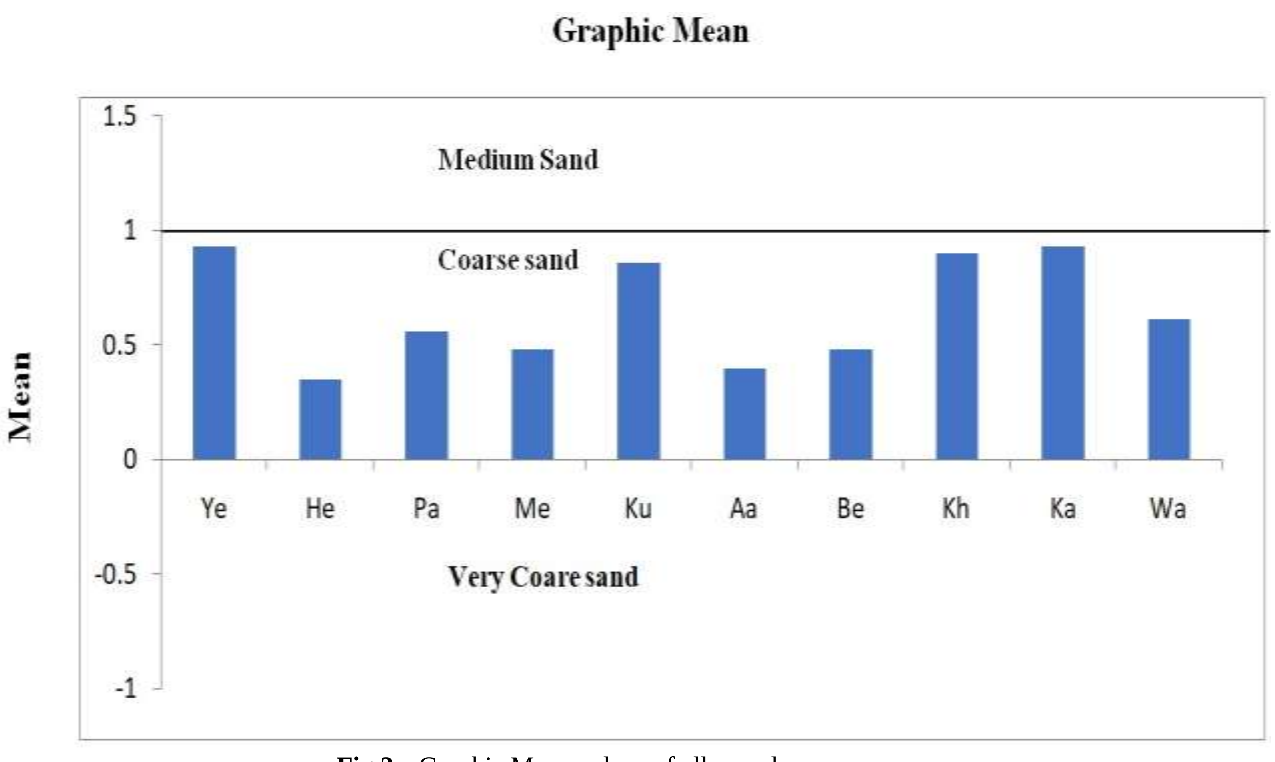


Fig 3:- Graphic Mean values of all samples.

Graphic Standard Deviation (σ_I)

The graphic standard deviation quantifies the sorting or consistency of particle size distribution and is determined using a specific formula.

$\sigma I = \{(\Phi84-\Phi16)4\} + \{(\Phi95-\Phi5)/6.6)\}$

The nature of sorting of grains with respect to range of values is give below.

< 0.35 Φ	very well sorted
0.35 to 0.50 Φ	well sorted
0.50 to 0.71Φ	moderately well sorted
0.71 to 1.0Φ	moderately sorted
1.0 to 2.0 Φ	poorly sorted
2.0 to 4.0 4Φ	very poorly sorted
>4.0Φ	extremely poorly sorted

The range of calculated values of graphic standard deviation is from 0.75 to 0.91, with an average value of 0.835 i.e. moderately sorted category. (Fig 4).

Standard Deviation

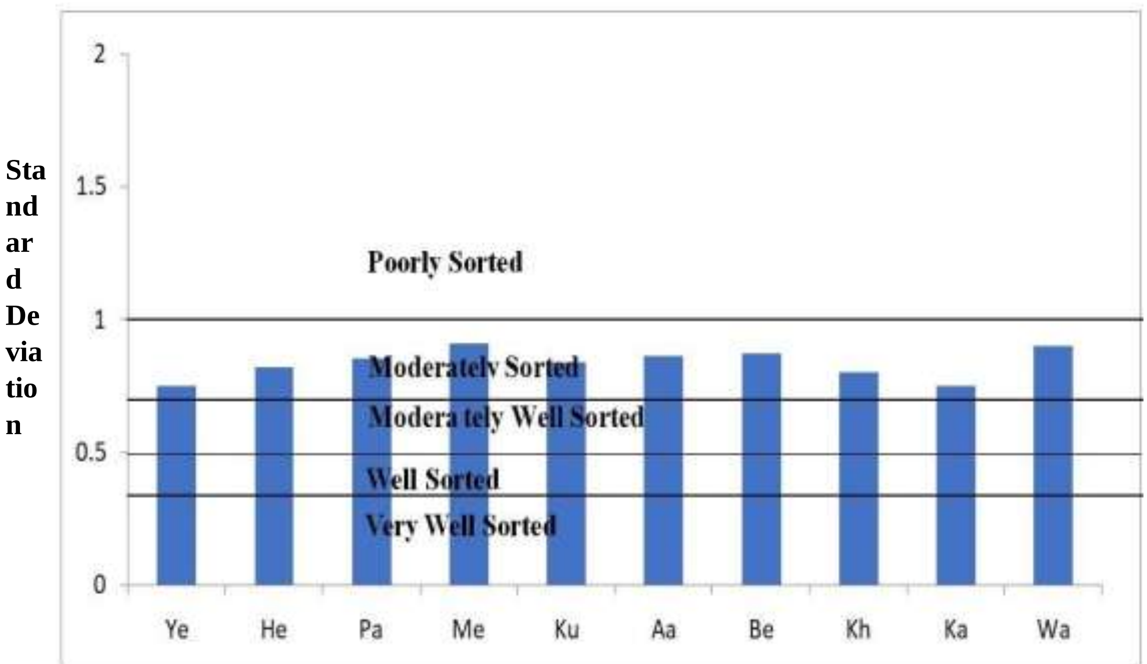


Figure 4:- Graphic Standard Deviation Values of Sample.

Inclusive Graphic Skewness (Sk_I)

Inclusive graphic skewness evaluates the asymmetry of the particle size distribution. A negative skewness indicates a greater concentration of material in the coarse tail, while a positive skewness signifies more material in the fine tail. It is determined using a formula.

$$Sk_I = \frac{\phi16+\phi84-2\phi50}{2(\phi84-\phi16)} + \frac{\phi5+\phi95-2\phi50}{2(\phi95-\phi5)}$$

The nature of skewness with respect to range of value is given below:

1.0 to 0.3	Very fine skewed
0.3 to 0.1	Fine skewed
+0.1 to -0.1	Near symmetrical
-0.1 to -0.3	Coarsed skewed
-0.3 to -0.1	Very coarsed skewed

The obtained values range from -0.213 to 0.1133, indicating a near-symmetrical skewed category, signifying the dominance of coarse-grained material in the sediment mixture. However, there are two exceptions: Kurkheda, which falls under the fine-skewed category, and Kadholi, which falls under the coarse-skewed category (Fig. 5).

Skewness

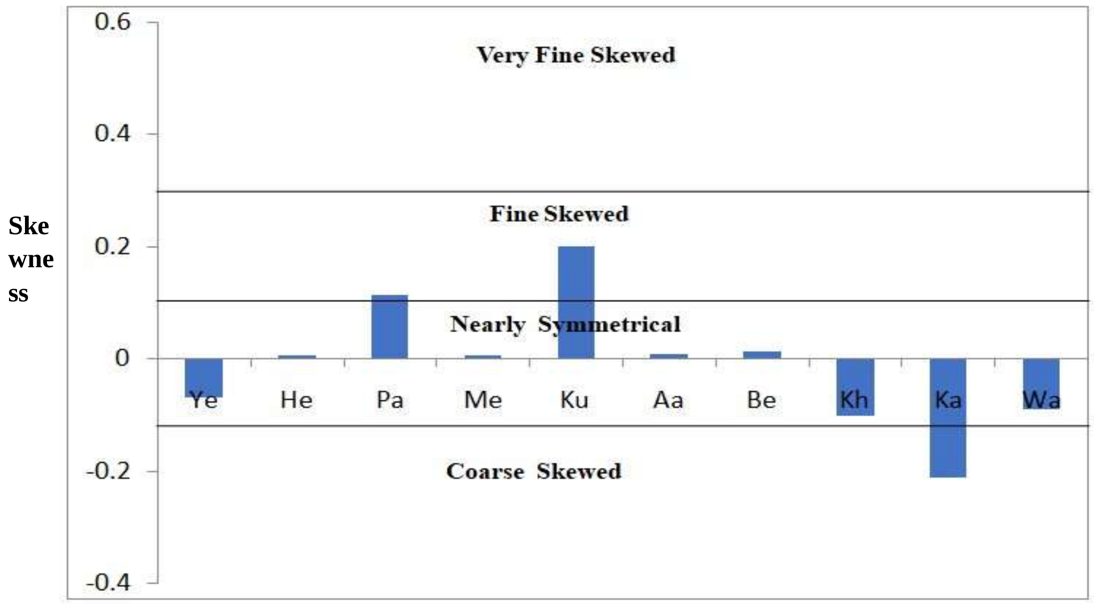


Figure 5:- Graphic Skewness Values of all Sample.

Inclusive Graphic Kurtosis (K_G)

Inclusive Graphic Kurtosis measures the ratio of sorting between the tails and the central portion of the distribution. When the central portion is better sorted than the tails, the frequency curve is classified as excessively peaked or leptokurtic. Conversely, if the tails are better sorted than the central portion, the curve is considered flat-peaked or platykurtic.The Inclusive Graphic Kurtosis calculated by using given formula.

The value of rang with respect to nature of distribution is given below:

$$K_G = \frac{\phi 95 - \phi 5}{2.44(\phi 75 - \phi 25)}$$

<0.67	Very platykurtic
0.67 to 0.90	Platykurtic
0.90 to 1.11	Mesokurtic
1.11 to 1.50	Leptokurtic
1.50 to 3.00	Very leptokurtic
>3.00	Extremely leptokurtic

The obtained values range from 0.65 to 1.00, with an average of 0.827, indicating a platykurtic distribution.

Kurtosis

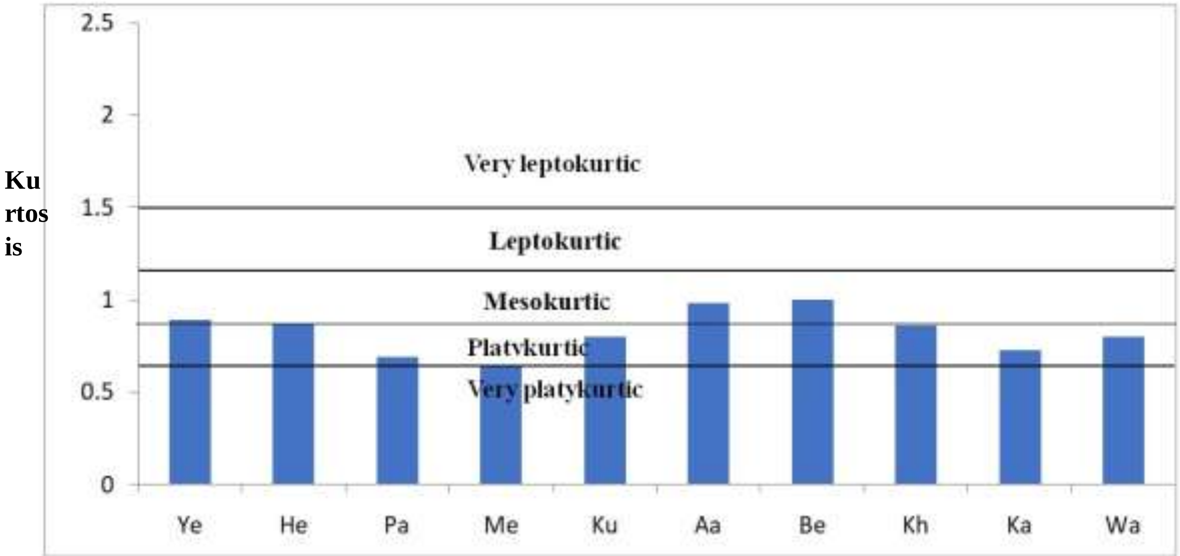


Figure 6:- Graphic Kurtosis.

Bivariate plots

Bivariate plots illustrate the interrelationship between specific size parameters and are valuable for interpreting sedimentation patterns, modes, and depositional environments (Folk and Ward, 1957). The obtained graph of mean versus standard deviation shows a clustering of points within a narrow mean value range along the right limb of the inverted V-shaped trend established by Folk and Ward (1957), indicating larger grain sizes (Fig. 7).

The mean versus skewness curve reflects a proportional admixture of two sediment size classes—gravel and sand—forming a sinusoidal pattern (Folk and Ward, 1957). The plotted values predominantly fall within the positively skewed area, corresponding to the coarse sand size range (Fig. 8).

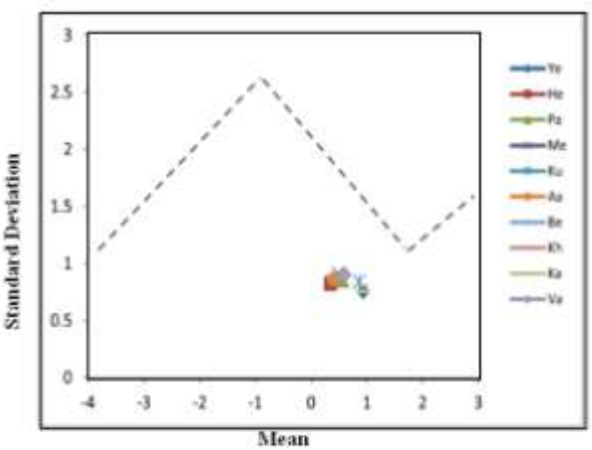


Fig 7:-Mean vs standard deviation.

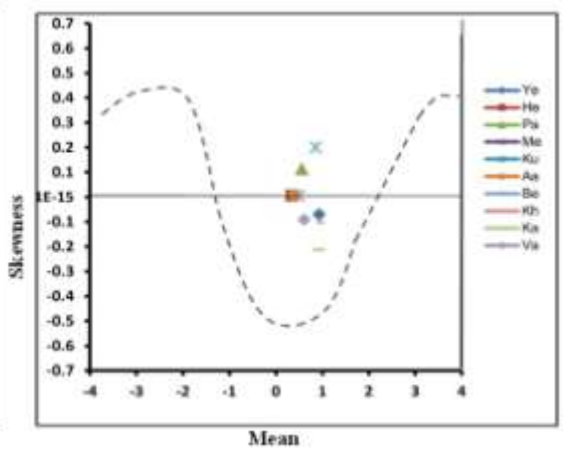


Fig 8:- Mean vs skewness.

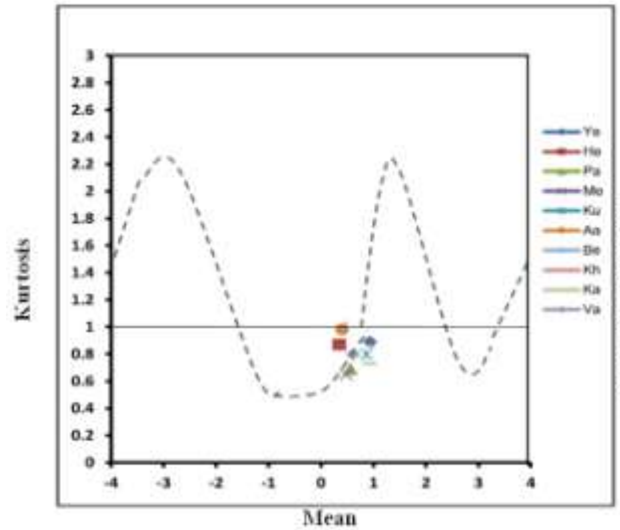


Fig 9:-Mean vs Kurtosis

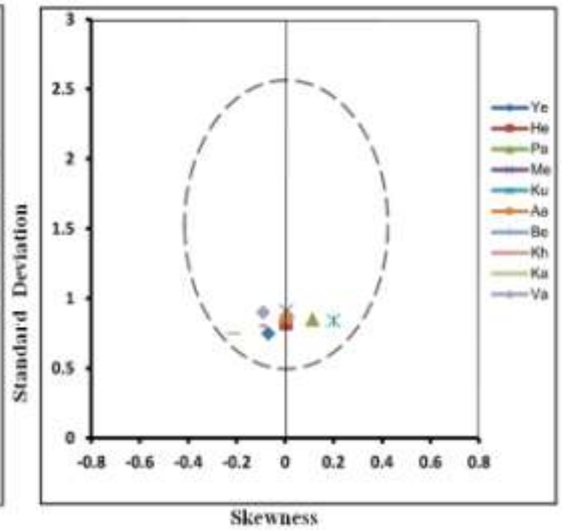
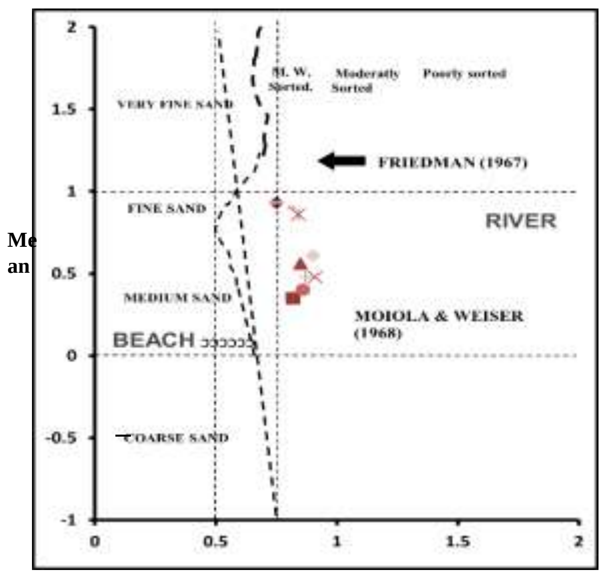
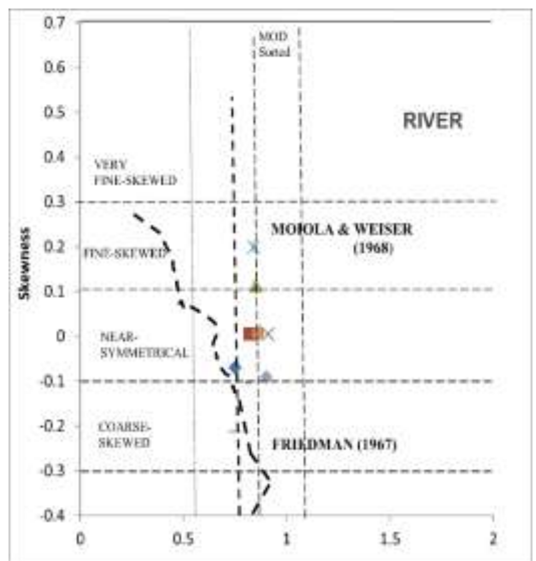


Fig 10:-Skewness vs standard deviation.



Standard Deviation

Figure 11:- Standard Deviation vs mean.



Standaerd Deviation

Figure 12:- Standard Deviation vs skewness.

The relationship between mean size and kurtosis is complex and largely theoretical (Folk and Ward, 1957). According to the model plot by Folk and Ward (1957), the mixing of two or more sediment size classes influences the sorting of peaks and tails, which determines the kurtosis index. The present plot indicates a dominance of the platykurtic category (0.90ϕ to 1.11ϕ), followed by the mesokurtic category (0.67 to 0.90), within the size range of 0 to 1.0ϕ, signifying a sediment mixture primarily composed of coarse sand (Fig. 9).

The graph of skewness versus standard deviation exhibits a scattered pattern forming a nearly circular ring (Folk and Ward, 1957). This may result from either unimodal sample with good sorting or an equal mixture of two modes. The plotted values clearly show symmetrically skewed and moderately sorted grains positioned within the circular trend (Fig. 10).

Additionally, the graphs of standard deviation versus mean and standard deviation versus skewness, as proposed by Moiola and Weiser (1968) and Friedman (1961, 1967), were used to validate the results. These plots are effective in distinguishing between river and beach sediments. As anticipated, the analyzed sediments align with the characteristics of river sediments, as described by Moiola and Weiser (1968) and Friedman (1961, 1967) (Figs. 11 & 12)

C-M Pattern

Passega (1957, 1964, and 1977) introduced the C-M plot to assess the hydrodynamic tractive forces influencing sediment deposition. This plot represents the relationship between 'C,' the coarsest one-percentile value (in microns), and 'M,' the median value (in microns), on a log probability scale. The plotted data show that most values are clustered in the extreme right corner, with C values below one. This suggests that the majority of sediments were primarily transported through saltation and suspension (Fig. 13) (Passega and Byramjee, 1969).

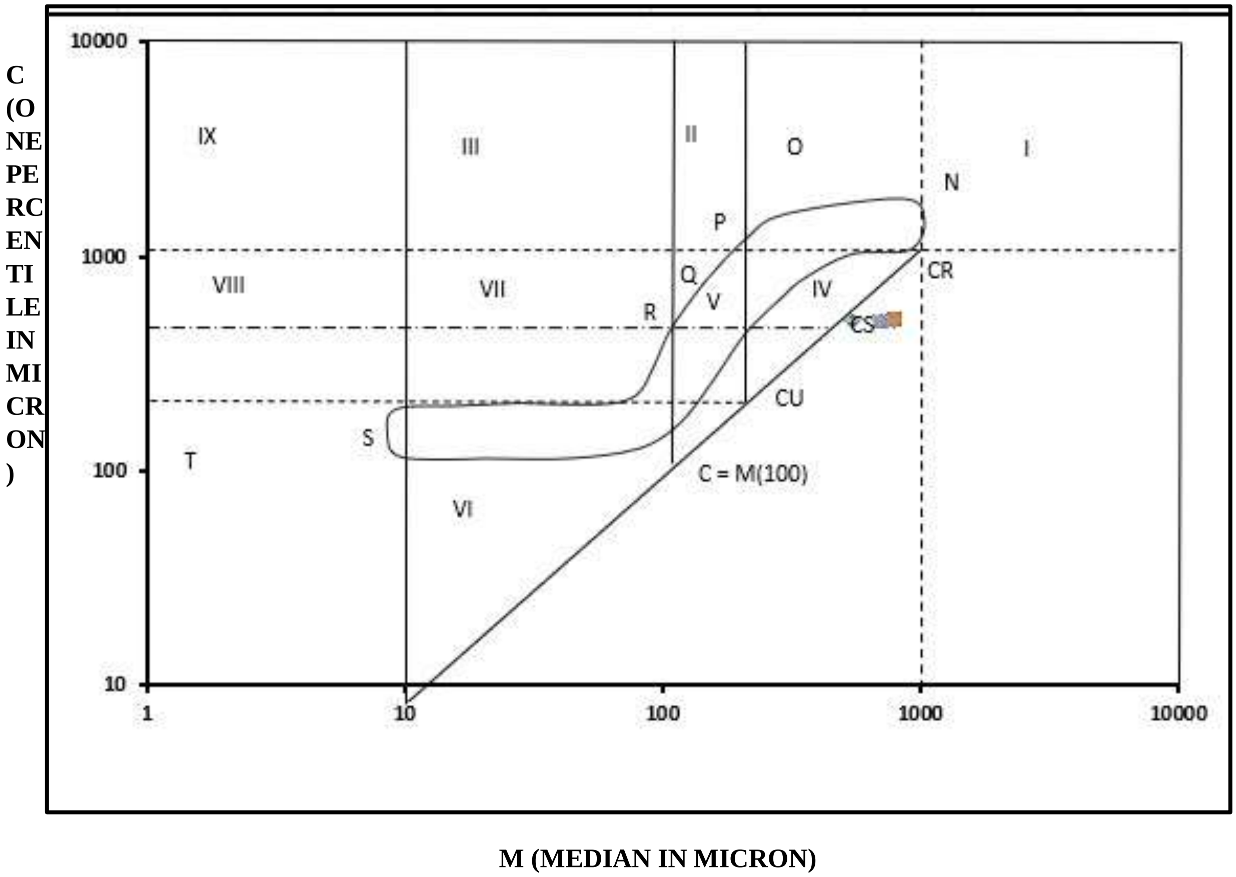
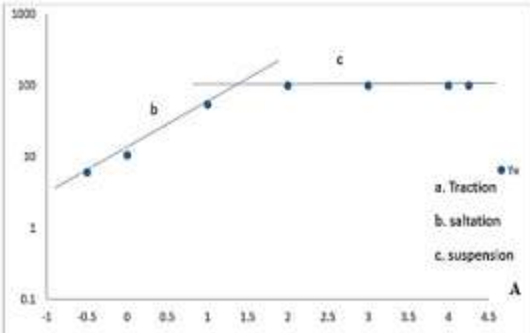


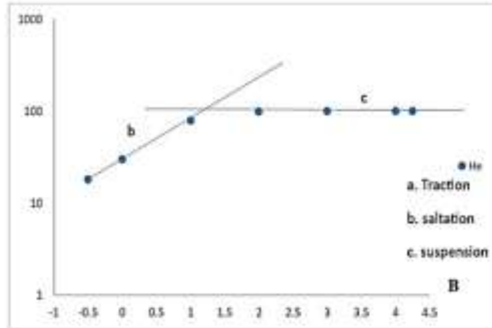
Fig. 13:- C-M Plot.

Log Probability Curves

The Log Probability Curves, proposed by Visher (1969), represent cumulative grain size distribution on probability paper and are highly useful for distinguishing sediment transport modes, including traction, saltation, and suspension.The plots of the analysed samples clearly indicate that saltation is the dominant transport mechanism in most cases, though suspension is also observed (Fig. 14). The dominance of the saltation population in the present plot aligns with the established trend of modern fluvial deposits described by Visher (1967).



Phi value



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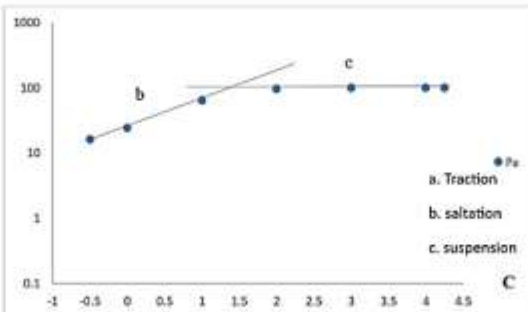

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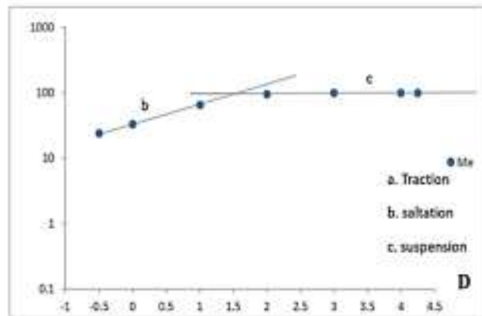

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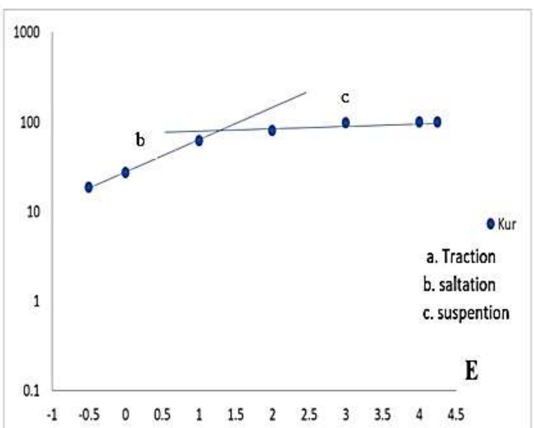
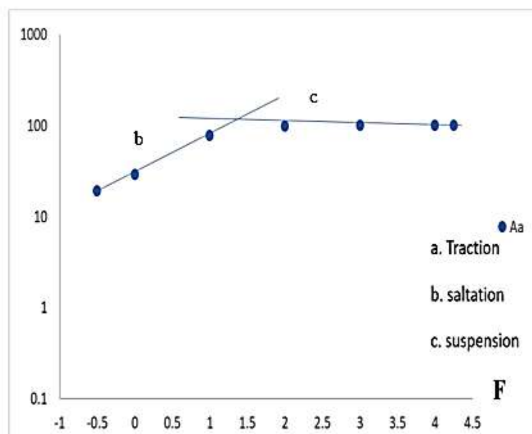


phi value



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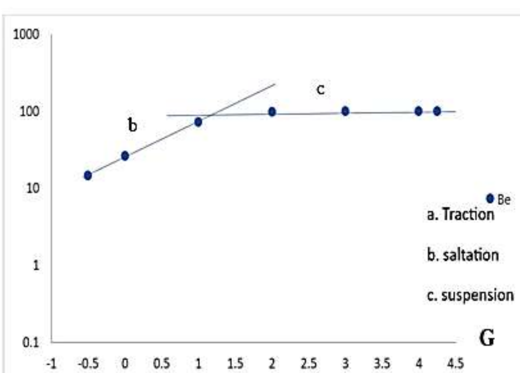

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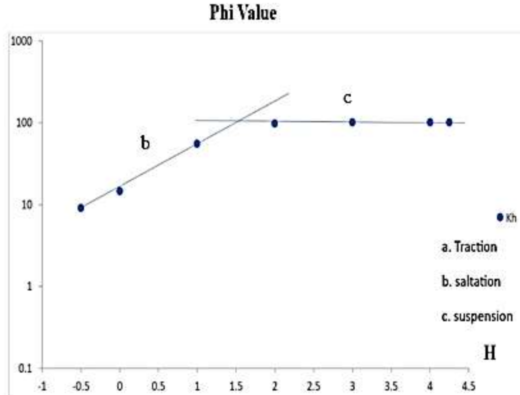

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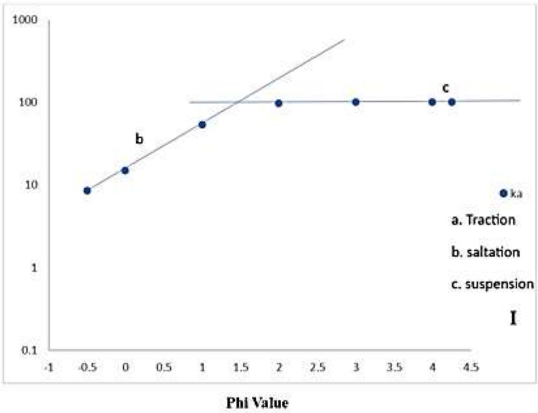

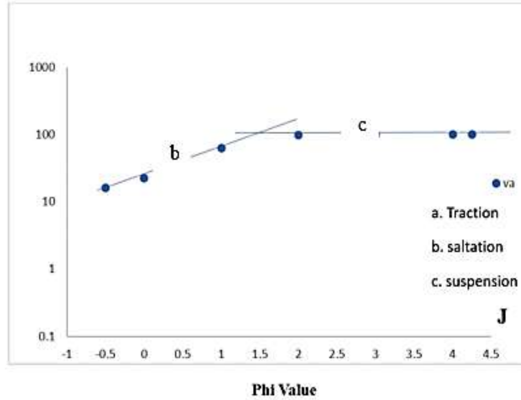

Fig. 14:-Arithmetic curves (A-J) showing the trend of traction (a), Saltation (b) and Suspension (c) populations of all the samples.

Conclusion:-

1. The total number of ten sample of sediments admixture are collected from sati river basin and analyse for their textural, statistical parameter.
2. The value from frequency curveis indicating of presence of coarse sand. The graphic mean values are also indicating the presence of coarse sand. The sediment in general showing moderate sorting category and shows symmetrical skewed curve. Most of the sediments are platykurtic in nature.
3. The interrelationship plots of mean, standard deviation, skewness, and kurtosis, as proposed by Folk and Ward (1957), have been analysed. These plots consistently indicate that coarse-grained sediments dominate the principal mode.
4. The plots of standard deviation versus mean and standard deviation versus skewness, following Moiola and Weiser (1968) and Friedman (1967), were also examined. These plots confirm the fluvial origin of the sediments.
5. The log probability curve suggests that most sediments were transported primarily through saltation and suspension.

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