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Research Article

STUDIES ON TEXTURAL CHARACTERISTICS OF JIADHAL RIVER SEDIMENTS, DHEMAJI DISTRICT, ASSAM, NORTH EAST INDIA

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ABSTRACT

The Jiadhal river originates in the Himalayan mountains of the West Siang District of Arunachal Pradesh and subsequently debouches its sediments into the plains of the Brahmaputra River Valley in the Dhemaji District of Assam. Here the river acquires a braided and aggradational character and is characterized by extensive sedimentation. This paper investigates the textural characteristics of the channel sediments of the Jiadhal river in Dhemaji, Assam.

The grain-size frequency distribution indicates a unimodal (i.e., sand) nature of the sediments, with the modal size ranging between 1ϕ and 3.5ϕ. The statistical size parameters (Folk and Ward, 1957) further indicate the sediments to be moderately sorted to well sorted (σ_i=0.43ϕ to 0.90ϕ), negative to very positively skewed (Sk_i= - 0.21ϕ to 0.35ϕ) and very platykurtic to very leptokurtic (K_G=0.61ϕ to 1.98ϕ) in nature. The CM plot of the Jiadhal river sediments indicate transportation of the sediments by suspension, saltation and rolling.

INTRODUCTION

Sediment textures deal with various aspects of size, shape and three dimensional arrangements of the constituent grains of a sediment or sedimentary rock. These properties are closely related to the mode of transport and energy of the transporting medium. In case of sediment size, statistical size parameters such as Graphic Mean (Mz), Inclusive Graphic Standard Deviation (σ_i), Inclusive Graphic Skewness (Sk_i) and Graphic Kurtosis (K_G) have been used affectively to understand the mechanisms of transportation and deposition of the sediments, as well as to differentiate between various depositional environments of recent as well as ancient sediments. These are evident from the works of Folk and Ward (1957); Friedman (1961, 1965, 1966, 1967, 1969); Passega (1964); Sahu (1964); Moiola and Weiser (1968); Thompson (1968); Coleman (1969); Singh and Bharadwaj (1991). This study examines the characteristics of grain size and related parameters of sediments of the Jiadhal river in the Dhemaji District of Assam.

Study Area

The Jiadhal river, is a northern sub-tributary of the river Brahmaputra and originates in the sub-Himalayan mountains in West Siang District of Arunachal Pradesh at an altitude of 1247m above mean sea level. The river basin falls within the states of Arunachal Pradesh and Assam. It lies between latitude 27° 15' N and 27° 45' N, and longitude 94° 15' E and 94° 40' E and Survey of India Toposheets number 83 I/6, 83 I/7, 83 I/8 and 83 I/10.

The river flows through a narrow gorge in Arunachal Pradesh before it enters the plains of Assam in the Dhemaji District. The initial part of its flow in Assam is of braided pattern which subsequently bifurcates into two channels before it crosses the National Highway no. 15. The river is known as “Kumotiya” between the Railway line and Gogamukh-Ghilamara P.W.D. road, beyond which it is known as the “Sampara” river. The river finally debouches itself into the river Brahmaputra near Selamukh. After construction of an embankment over the “Kherkutiya suti” in 1965-66, the river now connects to the Subansiri River.

MATERIALS AND METHODS

For the present study, a total of 40 samples were collected from 13 trenches which were excavated at various locations in channel bars found along the Jiadhal River. Sampling was done following “channel sampling method” in relatively thick beds (thickness >30 cm) while “spot sampling” was done for beds

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with thickness less than 30 cm. The representative samples were carefully collected in labeled polythene bags.

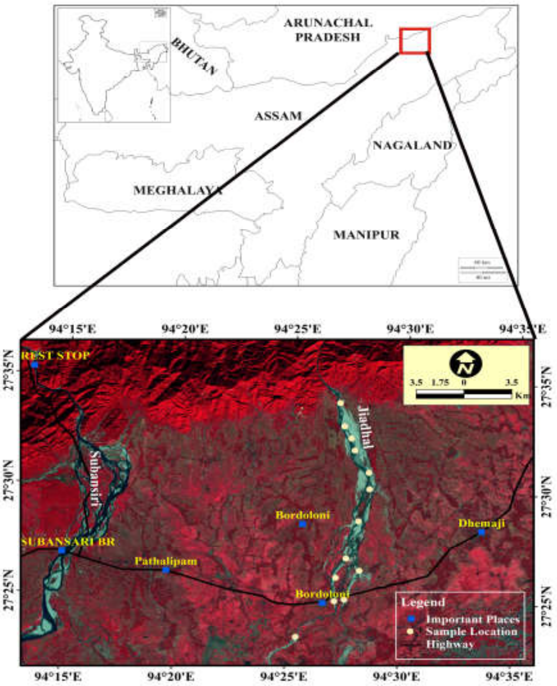

Figure 1 Landsat-8 satellite imagery showing location of the vertical section. (Image downloaded from https://earthexplorer.usgs.gov/)

The exact trench locations are noted with the help of a handheld GPS receiver.

In the laboratory, the sediments were subjected to size analysis following the composite sieve and pipette method (Krumbein and Pettijohn, 1938). The samples were air dried and reduced to about 100gm by the process of coning and quartering. The air-dried samples were now subjected to sieving in ½ phi size interval ASTM sieves for sieving in Ro-Tap sieve shaker for 10 minutes for optimum separation. The weight of individual size fractions retained in each sieve was determined and used for further calculations of statistical size parameters (Folk and Ward, 1957) and other associated parameters.

The generated laboratory data were interpreted following standard works of sedimentologists such as Folk and Ward (1957); Passega (1964); Cadigan (1961); Moiola and Weiser (1968); Passega and Byramjee (1969).

OBSERVATION AND DISCUSSION

The textural parameters of the sediments were studied on the basis of their grain-size frequency distribution curves, bivariant plots of statistical size parameters, and C-M pattern plots. The salient features observed in these plots are -

Frequency Curves

Frequency Distribution Curves (FDC) are pictorial representation of weight percentage of different fraction of sediments.

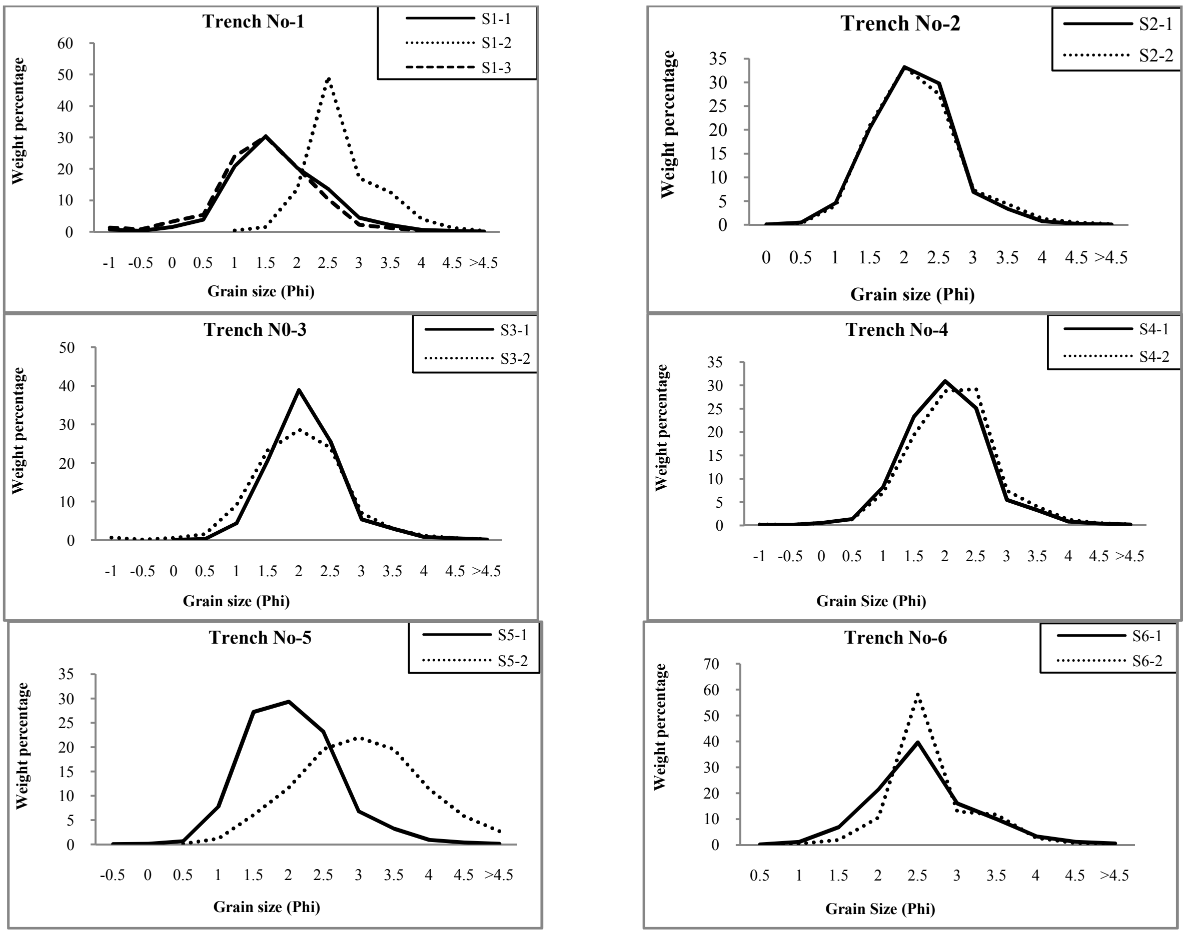

Figure 2 Frequency distribution curves of Jiadhal River.

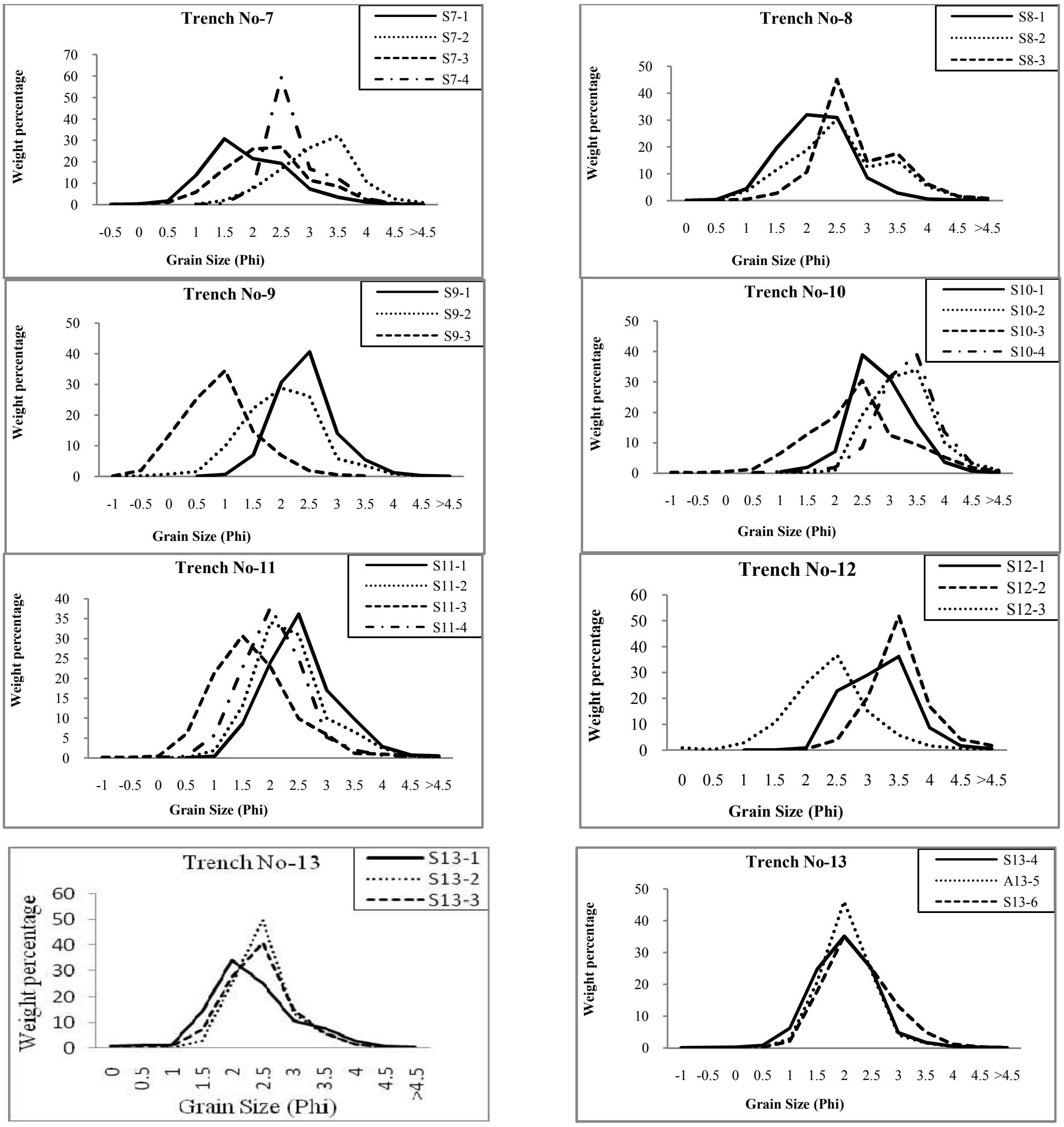

Figure 2 (Contd…)

FDC are used to describe the nature of sediments. It is observed that out of the total 40 samples, a dominant group comprising 95 percent of the total, show unimodal character and having modal class ranging from 1ϕ to 3.5ϕ (Coarse to very fine sand), while a few (5 percent) are show slightly bimodal character with a primary mode 2ϕ to 2.5ϕ (Medium to fine sand) and a secondary mode at 3.5ϕ (Fine sand).

The presence of unimodal sediments indicates their deposition under more or less uniform energy conditions. Bimodality in some of the curves indicates variation in the velocity of the depositing agent or deficiency of certain grain size in the size range of source materials (Sahu, 1964).

Grain size analysis

The grain size distribution of accumulating sediments and their statistical measure reflect the change in energy level and supply (Cadigan, 1961).

These statistical measures of the frequency distribution can be determined graphically. Using the cumulative frequency curves drawn on probability paper, the Phi values of different percentile points (P_1, P_5, P_{16}, P_{25}, P_{50}, P_{75}, P_{84}, P_{95}) are determined, which are then used for computing of statistical size parameters *viz*, Graphic Mean Size (Mz), Inclusive Graphic Standard Deviation (σ_i), Inclusive Graphic Skewness (Ski) and Graphic Kurtosis (K_G), following the method of Folk and Ward (1957).

Graphic Mean Size (Mz)

This parameter reflects the overall average size of the sediments as influenced by the source of supply, environment of deposition etc. The overall mean size is found to range between 1.30ϕ and 3.20ϕ (i.e., medium to very fine sand). It is observed that the sediments from the upstream part of the study area are medium sand (Trench no. 1,2,3,4,5,) while the downstream portion of the area is characterized by fine to very fine sand. Thus a lateral fining of sediments from the upstream towards the downstream direction in the area is evident.

Inclusive Graphic Standard Deviation (σ_i)

This parameter measures the sorting of sediments and indicate the fluctuation in the kinetic energy of the depositional media (Sahu, 1964). The values of σ_i range between 0.43 to 0.90 indicating well sorted to moderately well sorted nature. A majority (~ 95%) of the sediments are moderately well sorted. The moderately well sorted nature of the sediments indicate prevalence of high energy condition in the depositional basin (Chauhan, 2014).

Inclusive Graphic Skewness (Sk_i)

The Graphic Skewness is the measure of symmetry of distribution of coarse or fine sediments. The Skewness values range in between -0.21ϕ to 0.35ϕ, indicating a negatively skewed to very positively skewed size frequency distribution. Nearly 55% of the sediments are near symmetrical skewed, 32.2 % showed positive skewness, 10% samples showed very positive skewness, and 2.5 % of the samples showed negative skewness.

Graphic Kurtosis (K_G)

Graphic Kurtosis (K_G) is a quantitative measure which is used to describe the departure from normality of a size-frequency distribution. It is a ratio between the sorting in the "tails" of a grain-size frequency distribution to that in the central portion of the distribution. The values of graphic kurtosis range from 0.61 to 1.98, indicating very platykurtic to very leptokurtic nature. The percentages of samples under different categories are as follows: very platykurtic 2.5%, mesokurtic 60%, leptokurtic 35% and very leptokurtic 2.5%.

Bivariant analysis

The inter-relationship of statistical size parameters often reflects various aspects of their depositional environment, since the textural parameters of the sediments are often environmentally sensitive (Folk and Ward, 1957; Passega, 1957; Friedman, 1961, 1967; Moiola and Weiser, 1968; Visher, 1969).

Table 1 Grain size parameters of Jiadhal River sediments

Samle no	Mean Size (Mz)	Remarks	Standard deviation (σ_i)	Remarks	Skewness (Sk)	Remarks	Kurtosis (Kg)	Remarks
S1-1	1.47	MS	0.76	MSo	0.15	PSk	0.98	MKg
2	2.53	FS	0.74	MSo	0.05	NS	1.98	VLKg
3	1.30	MS	0.71	MSo	-0.04	NS	0.98	MKg
S2-1	1.90	MS	0.55	MSo	0.05	NS	1.02	MKg
2	1.93	MS	0.61	MSo	0.14	PSk	1.13	LKg
S3-1	1.83	MS	0.69	MSo	0.15	PSk	1.17	LKg
2	1.73	MS	0.69	MSo	0.08	NS	1.09	MKg
S4-1	1.73	MS	0.67	MSo	0.10	NS	1.05	MKg
2	1.87	MS	0.69	MSo	-0.04	NS	1.09	MKg
S5-1	1.77	MS	0.63	MSo	0.17	PSk	1.13	LKg
2	2.80	FS	0.90	MSo	0.11	PSk	0.96	MKg
S6-1	2.33	FS	0.66	MSo	0.08	NS	1.13	LKg
2	2.47	FS	0.51	MSo	0.19	PSk	1.39	LKg
S7-1	1.67	MS	0.72	MSo	0.32	VPSk	0.94	MKg
2	2.47	FS	0.67	MSo	0.14	PSk	0.96	MKg
3	2.07	FS	0.79	MSo	0.10	NS	1.07	MKg
4	2.90	FS	0.66	MSo	-0.21	NSk	1.13	LKg
S8-1	1.87	MS	0.59	MSo	0.16	PSk	0.97	MKg
2	2.33	FS	0.83	MSo	0.05	NS	0.85	LKg
3	2.57	FS	0.64	MSo	0.31	VPSk	1.08	MKg
S9-1	2.20	FS	0.52	MSo	0.06	NS	1.05	MKg
2	1.73	MS	0.67	MSo	0.10	NS	1.18	LKg
3	2.17	FS	0.64	MSo	-0.01	NS	1.08	MKg
S10-1	2.57	FS	0.51	MSo	0.19	PSk	1.16	LKg
2	2.97	FS	0.55	MSo	0.01	NS	1.05	MKg
3	3.10	VFS	0.52	MSo	0.00	NS	1.23	LKg
4	2.20	FS	0.89	MSo	0.02	NS	1.08	MKg
S11-1	2.23	FS	0.65	MSo	0.29	PSk	1.17	LKg
2	2.07	FS	0.60	MSo	0.23	PSk	1.02	MKg
3	1.80	MS	0.57	MSo	0.0	NS	1.23	LKg
4	1.40	MS	0.70	MSo	0.07	NS	1.05	MKg
S12-1	2.93	FS	0.48	MSo	-0.13	NSk	0.61	VPKg
2	3.20	VFS	0.44	MSo	0.06	NS	1.31	LKg
3	2.10	FS	0.62	MSo	0.02	NS	1.08	MKg
S13-1	2.13	FS	0.71	MSo	0.27	PSk	1.09	MKg
2	2.17	FS	0.55	MSo	0.01	NS	1.05	MKg
3	2.20	FS	0.47	WSo	0.35	VPSk	1.31	LKg
4	1.70	MS	0.52	MSo	0.06	NS	1.05	MKg
5	1.77	MS	0.43	WSo	0.23	PSk	1.02	MKg
6	2	MS	0.60	MSo	0.05	NS	0.91	MKg

MS-Medium Sand, FS-Fine Sand, VFS- Very Fine Sand, MSo-Moderately Sorted, WSo-Well Sorted, NSk-Negatively Skewed, NS-Near Symmetrical, PSk-Positively Skewed, VPSk-Very Positively Skewed, VPKg-Very Platykurtic, MKg-Mesokurtic, LKg-Leptokurtic, VLKg-Very Leptokurtic

An attempt has been made here to utilize these bivariant plots to study their interrelationships in the Jiadhal river sediments.

The bivariant plot of Mean size (Mz) vs Inclusive Graphic Standard Deviation (σ_i) indicates a negative correlation between them. Sorting increases with decrease in grain size of the sediments (Fig. 3A). The plot of Mean size (Mz) vs Inclusive Graphic Skewness (Sk_i) indicates a positive correlation between them. Grain size increase and skewness also increase (Fig 3B). The relation between Mean size (Mz) vs Graphic Kurtosis (K_G) values indicates a slightly positive correlation (Fig-3C).

The plot of Inclusive Graphic Standard Deviation (σ_i) and Skewness (Sk_i) for the Jiadhal river sediments exhibit no distinct correlation amongst them. It shows almost a horizontal trend line (Fig. 3D).

The plot between Standard Deviation (σ_i) vs Kurtosis (K_G) shows that both statistical size parameters are independent of each other. It shows almost a horizontal trend line (Fig. 3E).

The plot between Skewness (Sk_i) and Kurtosis (K_G) also does not show any correlation between the two parameters. A flat curve showing no change in K_G with increase in Sk_i is observed (Fig. 3F)

C-M Pattern

The CM patterns (Passega 1957, 1964; Passega and Byramjee, 1969) help in understanding the transportation mechanism as well as the depositional environment of sediments with respect to their size and energy level of the sediment transport media. It also throws light on process and characteristic agents that were responsible for the formation of clastic deposits.

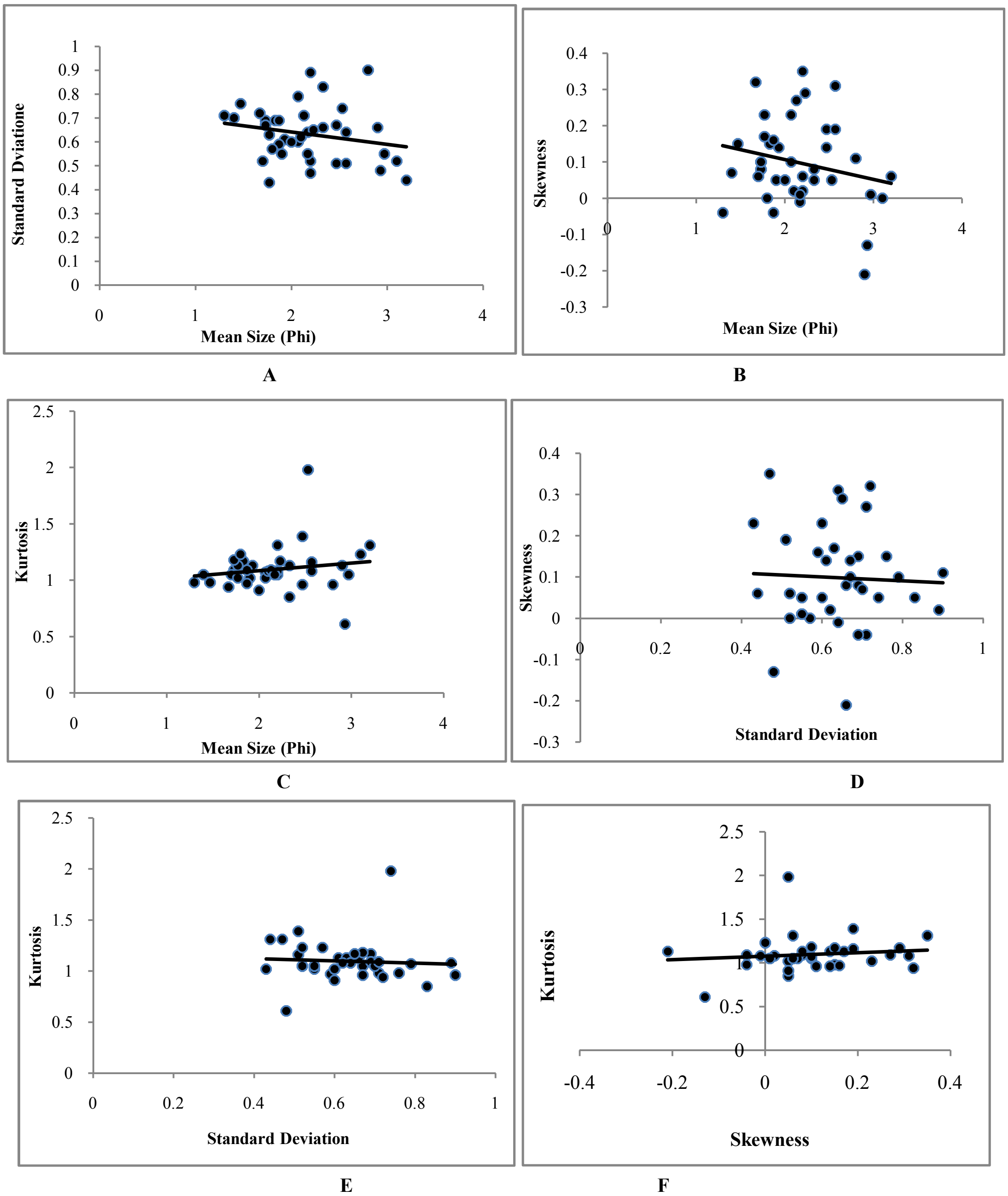

Figure 3 Scatter plots of the Jiadhal River sediments. (A) Mean size vs Standard deviation, (B) Mean size vs Skewness, (C) Mean size vs Kurtosis, (D) Standard deviation vs Skewness, (E) Standard deviation vs Kurtosis, (F) Skewness vs Kurtosis

In the present study an attempt has been made to identify the mode of deposition of sediments of the Jiadhal river by means of their CM pattern. Passega (1957) interpreted the distinct pattern of CM plots in terms of different mode of transportation by plotting coarsest first percentile grain size (C) and the median size (M) of sediment samples on a double log paper. The relation between C and M is the effect of sorting by bottom turbulence. CM pattern represents a complete model of tractive current (depositional processes) as shown by Passega (1964) which consist of several segments viz. NO, OP, PQ, QR and RS represent different modes of sediment transport.

The CM plot of the present study shows that most of the samples fall in PQ segment, indicating their transport through graded suspension with some rolling sediments. Some samples fall in the QR segment indicating transportation by graded suspension (saltation) while two samples fall in OP segment, indicating their movement as rolling with some amount as suspension sediments. The samples fall under I, IV and V segments, indicating their movement both by rolling and suspension modes.

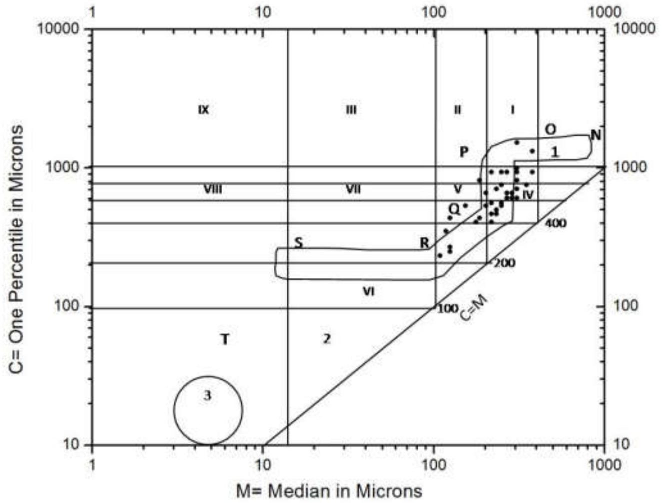

Figure 4 C-M Patten of the Jiadhal River sediments.

Index

1 Traction current deposits
2 Turbidites
3 Quite water suspension deposits
NO- Rolling sediments
OP- Rolling sediments with some suspension sediments
PQ- Graded suspension with some rolled sediments
QR- Graded suspension (saltation) deposits
RS- Uniform suspension
T- Pelagic suspension
Segments I, II, III, and IX are denoted by C>1 mm, Rolled Sediments
Segments IV, V, VI and VII are denoted C<1 mm, Suspended Sediments
The pattern for turbidity current runs parallel to C=M

CONCLUSIONS

The textural parameters indicate that the Jiadhal river sediments are medium to very fine sand (1.30 ϕ to 3.20 ϕ); well sorted to moderately sorted (0.43 to 0.90); negative to very positive skewed (-0.21 to 0.35); very platykurtic to very leptokurtic (0.61 to 1.98). The variation in mean size medium to very fine sand indicates fluctuation in the energy of the depositional environment. This is also reflected in variation of standard deviation from well sorted to moderately well sorted. This might be attributed to addition of finer materials to coarser material in varying proportion at different location.

The bivariant plot of graphic mean size and inclusive graphic standard deviation shows a negative correlation i.e. sorting increase with decrease of grain size. Mean size vs skewness shows a positive correlation that is with increase in grain size, skewness also increases. The plot of standard deviation vs kurtosis shows a slightly positive correlation among them. The other parameters have not showing any significant correlation between them.

The CM plot of Jiadhal river sediment indicates rolling, saltation and suspension mode of transportation and deposition of the sediments.

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