Chapter 46
Textural Variation of Sediments in the Course of a Small River: A case study from Khurar River, Khajuraho, Chhaterpur District, Madhya Pradesh, India

S. Kanhaiya and B.P. Singh

Abstract Textural (grain size) analysis is one of the parameter that helps in determining sedimentary environment. In the present investigation, texture was analysed from sixteen stations in the Khurar River, Madhya Pradesh. Grain size analysis was carried out employing mechanical sieving method using a sonic shaker. Frequency and cumulative frequency curves were prepared from the grain size data on centimetre and arithmetic probability papers, respectively. The phi values were determined and used to calculate the statistical parameters such as mean, standard deviation, skewness and kurtosis. It is found that the mean value varies from -0.63 to 0.80 with a graphic mean distribution ranging from -0.27 to 0.40 φ, indicating that the size of the river sand is very coarse- to coarse-grained. The standard deviation (sorting) shows a range of 0.69 to 1.65 φ, while the skewness values of the sediment samples range from 0.19 to 0.29 φ, thus indicating the presence of fine fraction to near-symmetrical fraction in the population. The kurtosis varies between 1.03 and 1.09 φ, indicating that 25% of the samples are leptokurtic, 6.25% are very leptokurtic, 50% are mesokurtic and 12.5% are platykurtic. The platykurtic nature in few cases suggests mixing of the sediments from two sources. Bivariate plots prepared combing different textural parameters were used to interpret their behaviour in the river sediments. C-M plot was also prepared to understand the dominant mode of transportation in the Khurar River sediments. In this river all the sediments are dominantly characterized by the rolling process of deposition. This study reveals that sorting varies from poorly sorted to moderately well sorted from upstream to downstream part of the river may be because of dominance of winnowing and selective sorting in the lower reaches of the river.

Keywords Grain size • Kurtosis • Standard deviation • Sieving • Skewness

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46.1 INTRODUCTION

Texture (grain size) is the most fundamental property of sediment particles, affecting their entrainment, transport and deposition [1]. It helps in determining depositional environment, besides others. Grain size analysis provides important clues to the sediment transportation history, depositional conditions and provenance [2, 3]. In this study, the stream sediments of Khurar River, have been collected (starting from upstream to downstream direction) and analysed. Grouped data of grain sizes, obtained by sieving technique are presented in a table. Different modes of sediment transportation have been identified by plotting the cumulative frequency distributions of grain sizes on probability paper. The net distribution is then divided into traction load (coarsest fraction), saltation load (medium fraction) and suspension load (finest fraction). The textural parameters were then computed graphically following Folk and Ward [2] and Friedman [3].

46.2 GENRAL AND GEOLOGICAL FEATURES OF THE RIVERS

The Khurar River flows exclusively on Archean rocks of Bundelkhand carton. This comprises over ~29, 000 km^2 area in north-central India. The carton consists of slivers of Archean greenstone successions within granitoids and gneisses. The origin of the Khurar River originates from the Beni Sagar reservoir (Lat. 24°48' 3.5" N and Long. 79°52'59.6" E), village Saddupura (Maharajganj) near Khajuraho town in Chhaterpur district, Madhya Pradesh, India. This river is serving as one of the tributaries of Ken River (tributary of river Yamuna). It is a small river and the length of the river is about 34 kilometres. It confluences with Ken river at Ghadiyal pond, near renneh fall in the area of Panna tiger reserve (Lat. 24°54' 13.9" N and Long. 80°2'6" E) and flows from SW to NE direction (Figure 46.1). The width of the river is ranging from 5 to 15 meter and average velocity is 2.5 meter/second. There are many small braid-bars (2-4 m large) in the middle of the channel.

46.3 SAMPLING AND METHODOLOGY

A total of forty-eight sediment samples from sixteen stations those occurs on the braid-bars were collected in the entire course of the Khurar River at an interval of about one kilometre(Figure.46.1). Sampling sites were positioned by GPS and all the samples were collected in the mid channel of the river and two hundred gram by weight. One each sample from each station was utilized for sieving analysis by coning and quartering method. Sieves being spaced at definite intervals were arranged on half phi (φ) intervals starting from 10 mesh (-1 φ), 14 mesh (-0.5 φ), 18 mesh (0 φ), 25 mesh (0.5 φ), 35 mesh (1.0 φ), 60 mesh (2.0 φ), 120 mesh (3.0 φ),

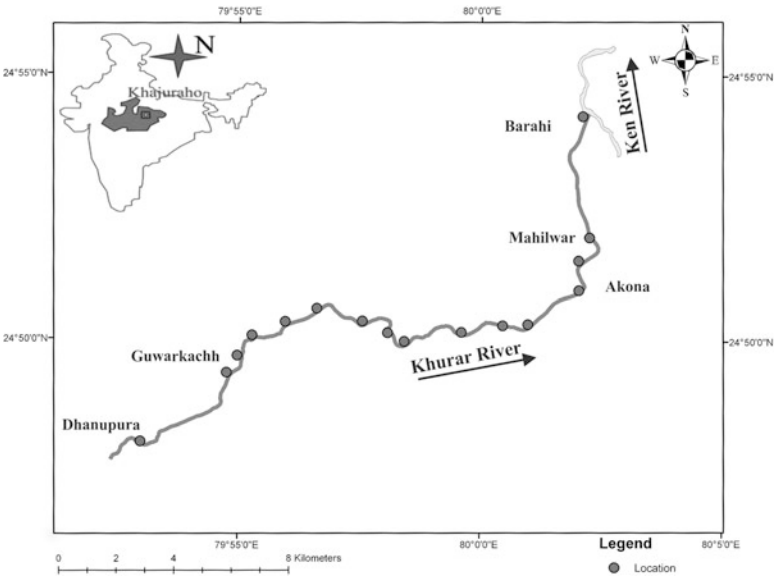

Fig. 46.1 Sampling location of the Khurar River

170 mesh (3.5 φ), 230 mesh (4.0 φ), and shook for fifteen minutes followed by weighing of each retained fraction. Individual weight percentages were recalculated to hundred for making them percentage. The frequency curves were prepared on simple graph paper. Cumulative curves were plotted on arithmetic probability graph paper. The graphic parameters proposed by Folk and Ward [1], C-M plot to evaluate the hydrodynamic force working during the deposition proposed by Passega [4] and log-probability values proposed by Friedman [3] were calculated from the percentile values (in Φ units) of the cumulative curves. Following folk and ward [2] bivariate plots were plotted considering various textural parameters.

46.3.1 Grain Size Distribution and Cumulative Frequency Curves

Grain size analysis is a classical tool and provides additional information regarding sediment transport, energy conditions and depositional environment .Various textural parameters such as graphic mean, standard deviation (sorting), skewness and kurtosis have environmental significance and are useful for understanding syn sedimentary hydrodynamic factors of transportation and deposition in a basin [2–4]. Frequency curves show that most of the samples are bimodal in nature, except few unimodal ones. On the basis of frequency curves it is observed that the sizes of the sediments are ranging from very coarse to coarse-grained. Sediments are ranging from poorly sorted at starting points and moderately-sorted to moderately well-sorted as we go towards confluence point of the river with Ken River (Figure. 46.2). The cumulative

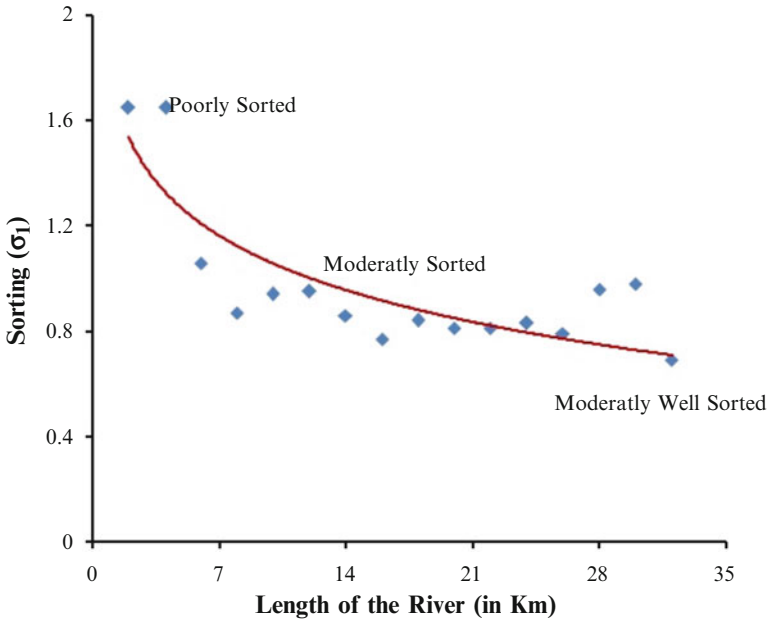

Fig. 46.2 Sorting of the sediment with length of the river

frequency curve show three to four segments in each case representing traction, saltation I, saltation II and suspension fraction within the sediments. In general, the traction and saltation loads dominate over the suspension load.

46.3.2 Log-probability Curves

Log-probability curves proposed by Visher [5] had been plotted on the log probability (ordinate) paper indicate the mode of transportation of sediments within a depositional medium [5]. These plot indicates two or three straight line rather than a single straight line. Each segment of the curve is interpreted to show different sub population of grain that were transported simultaneously but by different ways i.e. suspension, saltation and traction bed load. Grain size probability plots for river sands are uniquely segmented into three differently sloped components because river move material in three ways: by suspension, by saltation and as bedload [5]. All the sixteen samples had been plotted on log probability paper and compared with established trend for modern and ancient fluvial deposits proposed by Visher [5], generally showing the dominance of saltation with traction and suspension domain also. These plots also indicates sorting of the sediment, where most of the sediments are moderately shorted probably due to prolonged transport and winnowing processes. In the present case, the sediments show moderate sorting even in the coarse of short distance may be because of winnowing and selective sorting of the sediments within the river.

46.3.3 Textural Parameters and Their Inter-relationship

All the textural parameters were calculated from cumulative curves, based on different phi values. The formula given by Folk and Ward [2] is regarded as most suitable and used for calculation of different textural parameter in the present study. In the studied samples, the mean size varies from -0.63 to 0.80φ, the sorting varies from 0.69 to 1.65φ, the skewness varies from -0.23φ to +0.29φ i.e. near-symmetrical to very fine-skewed and the kurtosis varies from 0.69 to 1.77φ**.** The inter-relationship plots between different parameters are recognisance tool to interpret various aspects of depositional environment [3]. Following folk and ward [2], six bivariate scatter plots are prepared by the combination of various textural parameters. The entire bivariate scatter plots suggest bimodal nature of sediments and a dominance of the sand mode mixed with a very small amount of silt.

46.3.4 C-M Plot

In the present study C-M plot proposed by Passega [4] is used to understand the dominant mode of transportation and the environment of deposition. All the hydrodynamic forces working during the deposition of the sediments have been analysed and interpreted by C-M plot [4]. The C and M show that these parameters are indicators of hydraulic conditions under which sediments are deposited. C-M diagrams in which C is the one-percentile, M the median of the grain-size distribution, characterize the coarsest fractions of the samples [6]. Percentile of the size distribution (C) in microns had been plotted against the median of the size distribution in microns (M) for the sediments (Figure. 46.3). It is observed that all the river sediments are above the CR line existing in segment N-O of the pattern. It

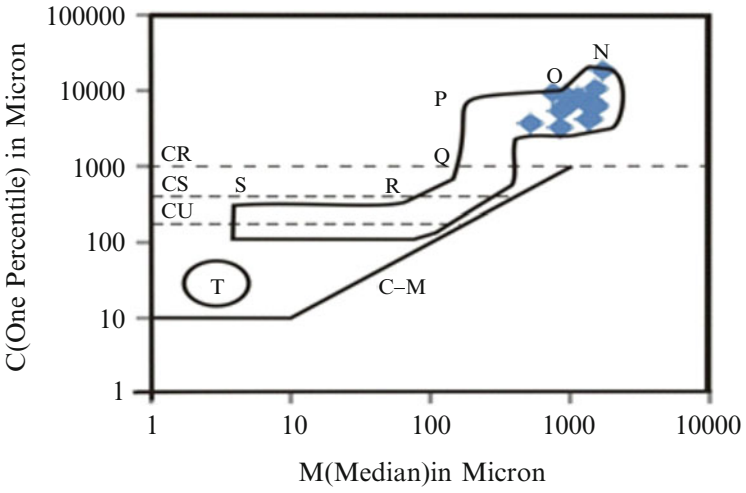

Fig. 46.3 C-M plot showing concentration of points in upper left corner

indicates fairly well sorted sediments, almost entirely transported by rolling. Thus, the sediments dominated by coarse and very coarse sand deposited by the process of rolling in the Khurar River.

46.4 CONCLUSIONS

The frequency curves are dominantly indicative of coarse to very coarse-grained nature of the sediments. The graphic mean value indicates the more or less equal distribution of both very coarse and coarse sand-size particles. In general, the samples show poor sorting in beginning followed by moderate sorting to moderately well sorting at last site where the river Khurar confluences with river Ken. In most of the samples, both peak and tails are equally sorted giving rise to mesokurtic condition. All the bivariate plots between mean, skewness, kurtosis and standard deviation are indicative of bimodal nature of sediments, among them sand-size (very coarse to coarse) is dominant with subordinate silt. All the sediments of Khurar River are characterized by the rolling process of deposition. The log-probability curves of samples are showing dominance of saltation with traction and suspension. The change of sorting from poorly-sorted to moderately-sorted and moderately well- sorted suggests that the winnowing and selective sorting is possible even in the small river depending upon the hydrodynamic conditions of the river.

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