# Application of Sedigraph-III Particle Size Analyzer: A new trend in studies of depositional environments

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## Abstract

The deposits of Sina River have been studied to understand the nature of changes in the textural characteristics on the basis of Sedigraph III particle size analysis. The grain size analysis suggested that, texturally, the bank deposit sediments were found to be dominated by sand and silt with considerable amount of clay in some samples. The grain size parameters (mean size, sorting, skewness and kurtosis) show subtle to minor variations within the section. The major conclusion that emerges from the analyses is that no significant changes in the energy condition of the Sina River have been observed but some subtle to minor changes have been occurred.

**KEYWORDS:** Depositional environments, Grain size analysis, River sediments, Sedigraph Particle size Analyzer

## INTRODUCTION:

A depositional environment is such an area or site on the Earth surface where sediments are deposited. There are different kinds of depositional environments on the planet Earth and they are categorized on the basis of depositional agents such as riverine deposition, glacial deposition, aeolian deposition etc (Nichols, 2009). They are also classified as flood deposition, slack water deposition, lacustrine deposition, coastal and ocean deposition etc (Singhvi and Kale, 2009). Palaeoflood deposition on the banks of river and slack water deposition of the rivers provide significant information of palaeohydrological and palaoenvironmental conditions prevailed in the catchment area of the rivers. The depositional environments are characterized by a variety of grains (i. e. sediments). Grain size analysis is an essential tool for classifying sedimentary environments. Grain size is the most fundamental property of sediments which provides valuable information about transport history and depositional conditions of the agents (Boggs, 2006). It also gives clues to the sediment province and energy conditions of the transporting agents. The results derived through particle size analysis could be used to reconstruct the past environmental and climatic conditions of a particular region (Catuneanu, 2006).

Palaeoflood hydrology is the reconstruction of the magnitude and frequency of recent, past, or ancient floods using geological evidence (physical effects of floods i.e. flood deposits) (Baker, 2008). However, the term and concepts of palaeoflood hydrology were formally introduced by Kochel and Baker (1982). Over the last 30 years, palaeoflood hydrology has achieved recognition as an interdisciplinary branch of geomorphology and hydrology (Benito and Thorndycraft, 2005). The fluvial systems are sensitive to climatic changes (i.e. monsoon) and they respond to such changes by changing their morphology and sedimentation pattern. Therefore, fluvial deposits are used to study a detailed record of river responses to climatic and environmental changes on different spatio-temporal scales (Kale et al., 2010). The fluvial deposits preserved in

the overbank sites are largely the records of flood events. The stratigraphical, sedimentological and chronological studies of such deposits provide information on the flood events and palaeohydrological conditions of the river (Sridhar, 2008).

Traditionally, the grain size analysis of any deposition is carried out using standard sieve method for coarser particles and pipette method for finer fraction, those smaller than 62 mm (micrometers) (Guy, 1969). Especially, pipette method is very tedious and time consuming because it takes several hours to perform grain size analysis. Traditional methods require large amount of sediment samples. Also, the results obtained through pipette analysis are not much accurate as this method is manual. In comparison, Sedigraph particle size analysis is a new and scientific method over traditional methods. Sedigraph is an X-Ray based instrument and operates on principle of Stockes' law of settling velocity (Skinner, 2000). It is a convenient, time saving, reliable and highly accurate method for determining particle size distribution. It requires very low amount (i.e. only 4 gm) of sediment sample to perform analysis. For pipette analysis, large quantity of sediments required. In this method sediment particles are mixed with water in a cylinder and then sediments are allowed to settle down under the influence of gravity. As sedimentation progress, the subsamples are withdrawn from the cylinder at specific time interval and depth. Sediments concentration in these subsamples are ten determined applying Stokes' Law of settling velocity. This takes more time and requires more personals. In comparison, SediGraph particle size analysis method is time saving and gives high accuracy of data.

The past climatic and environmental conditions have been reconstructed by several workers on the basis of grain size analysis of different kinds of deposits i. e. Kale and Rajaguru (1987), Rajaguru et al. (1993), Joshi and Kale (1997), Enzel et al. (1999), Jain and Tondon (2003), Basavaiah et al. (2004), Pant et al. (2005), Shanker et al. (2006), Achyuthan et al. (2007), Juyal (2009), Kotlia et al. (2010), Prasad et al. (2014), Magar (2014).

The primary aim of this study, therefore, is to understand the textural characteristics of the Sina of bank deposits using SediGraph III particle size analyzer and to evaluate the applicability of the Sedigraph particle size analyzer in the study.

## MATERIAL AND METHODS:

In order to understand the nature of changes in the textural characteristics of the Sina River bank deposits, following methodology has been adopted.

### *Laboratory analysis:*

The laboratory analysis includes various kinds of methods and techniques. The experimental work and analyses were carried out at different research places. In the present study, the grain size (textural) analysis was carried out by two methods. For coarse sediments standard mechanical sieving was performed at the research centre in Geography, Prof. Ramkrishna More College, Akurdi, Pune. For finer fraction, analysis was undertaken using Sedigraph-III Particle Size Analyzer at the Department of Geography, Savitribai Phule Pune University, Pune and Indian Institute of Geomagnetism, Panvel.

***Sedigraph analysis (for fine grains):***

Before textural analysis, sediment samples were prepared. First of all approximately 150-200 gm of sediment sample was dried in the oven at 100-120$^0$ C for two days. After drying, samples were taken out from the oven and clumps broken, using pestle and mortar. Enough force was applied to separate the grains from one another, but breaking the individual grains was avoided. The dry ground sediment samples were placed onto a 0.250 mm sieve and sieving was carried out carefully.

The samples were passed through a 0.250 mm sieve because the range of Sedigraph-III Particle Size Analyzer is from 0.1 micron to 0.300 mm and the size of the last sieve used for mechanical sieving was 0.250 mm.

Out of the sieved sediment sample through 0.250 mm sieve, four grams of sediment sample was taken, into which 50 ml Hexametaphosphate solution was poured to separate coagulated particles. Then, Ultrasonic Dispenser was run for about 2 minutes to disintegrate particles from each other. The processed sample was then poured into mixing chamber of Sedigraph-III Particle Size Analyzer and the analyzer was run for 1 hour for whole process of particle size analysis. The data of particle size analysis was automatically collected on attached computer to the analyzer. The collected cumulative weights of grain size were plotted on the probability graph paper and the grain size parameters such as mean, sorting, skewness and kurtosis were derived. The sand (4 □ to -1 □), silt (4 □ to 8 □) and clay (<8 □) percentages were also calculated with the help of collected cumulative weights of grain size.

**RESULTS:**

The percentage of sand, silt and clay of sediment samples collected Sina River bank deposits is given in Table. 1. The data show that the sediments are dominated sand sized particles which constitute about 65.2% in the samples. The percentage of sand ranges between 16.7 and 96.2%. By and large, Percentage of silt and clay comprises equal in amount in the sediments. Silt constitutes about 19.85% whereas clay constitutes only 14.9%. Clay denotes a very low proportion in the samples ranging between 0.3 and 54.9% in the samples. Silt has a substantial (19.85%) proportion in the samples. The percentage of silt in the samples varies between 3.4 and 42.9% (Table. 1). This reveals that river sediments are characterized by coarser material.

The highest and lowest percentage of clay was observed at depths of 440 cm and 140 cm respectively from the top. From the data presented in the Table1, it is clear that generally, the lowermost part is characterized by high proportion of clay. The topmost layer shows abundance of coarser particles, this indicates some variation in the energy condition of the river during deposition.

Table 1. Textural classes of Sina River deposits obtained through Sedigraph particle size analyzer.

| Sample No. | Depth (cm) | Sand% | Silt% | Clay% |
|---|---|---|---|---|
| 1 | 0 | 73.9 | 17.7 | 8.4 |
| 2 | 10 | 87.0 | 8.3 | 4.6 |
| 3 | 20 | 86.9 | 8.0 | 5.2 |
| 4 | 40 | 76.8 | 14.8 | 8.4 |
| 5 | 60 | 76.3 | 17.5 | 6.2 |
| 6 | 80 | 87.8 | 7.5 | 4.7 |
| 7 | 100 | 87.4 | 8.1 | 4.6 |
| 8 | 120 | 74.0 | 16.6 | 9.4 |
| 9 | 140 | 93.5 | 6.2 | 0.3 |
| 10 | 160 | 50.2 | 34.2 | 15.6 |
| 11 | 180 | 88.1 | 7.2 | 4.7 |
| 12 | 190 | 50.8 | 35.1 | 14.1 |
| 13 | 200 | 70.0 | 20.6 | 9.4 |
| 14 | 240 | 96.2 | 3.4 | 0.4 |
| 15 | 260 | 83.1 | 12.7 | 4.2 |
| 16 | 280 | 88.0 | 7.3 | 4.8 |
| 17 | 300 | 26.6 | 42.9 | 30.5 |
| 18 | 320 | 34.5 | 40.0 | 25.5 |
| 19 | 330 | 77.8 | 14.1 | 8.1 |
| 20 | 340 | 38.1 | 33.9 | 28.0 |
| 21 | 360 | 33.6 | 36.9 | 29.5 |
| 22 | 370 | 92.4 | 6.9 | 0.8 |
| 23 | 380 | 36.1 | 29.5 | 34.4 |
| 24 | 400 | 38.8 | 30.1 | 31.1 |
| 25 | 420 | 30.6 | 28.3 | 41.1 |
| 26 | 440 | 16.7 | 28.4 | 54.9 |
| | **Average** | 65.2 | 19.85 | 14.9 |
| | **Minimum** | 16.7 | 3.4 | 0.3 |
| | **Maximum** | 96.2 | 42.9 | 54.9 |

The cumulative grain size frequency curves of the river deposits have been shown in the fig. 1. These curves can be divided into two distinct parts. The curves shifted towards the vertical axis indicate high concentration of coarser (i.e. sand) particles whereas curves deviated in downward direction are characterized by finer fraction. This also reflected in the histogram of the average weight percentage of grain size classes. The curves of sample no. 25 and 26 shows higher proportion of clay particles as these curves leaned towards the horizontal axis. The curves deviated in the upward direction denotes near about 80% of grain size is concentrated in the 0-4 phi class.

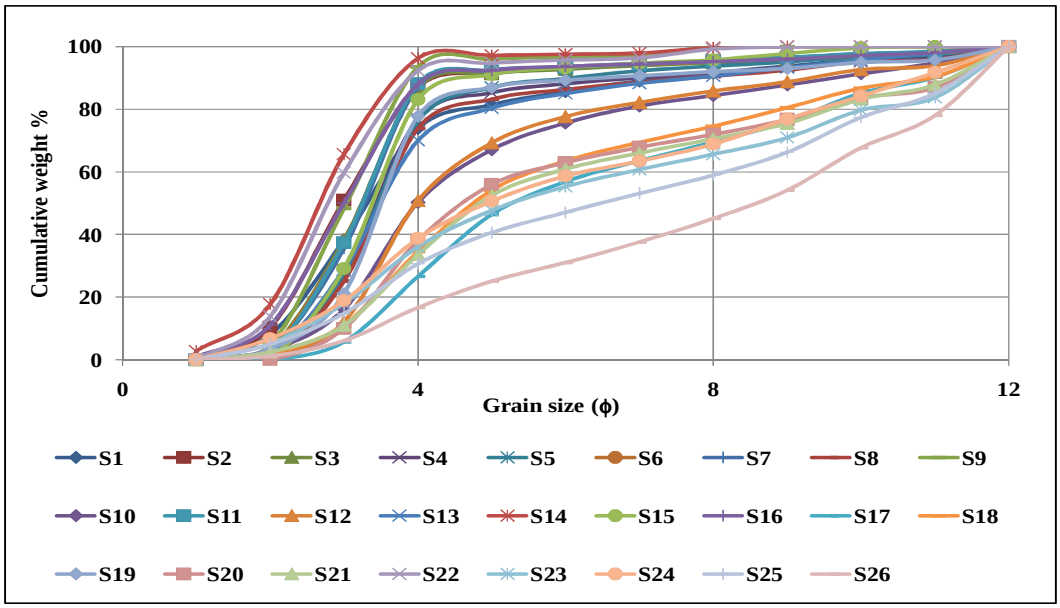



Fig. 1. Cumulative weight percentage grainsize curves

The pie diagram of the textural classes (Fig. 2 A) clearly indicates that the sediments of Sina River deposits contain high percentage of sand which is about 65.2%. The silt constitutes near about 19.85% and percentage of clay is very low in the deposit which is only 14.95%. The Fig. 2 (B) shows that the grainsize distribution of river bank deposits and from the bar graph it is noticed that the sediments are unimodal in nature. It means that the particles of sediments are mainly concentrated in one textural class i.e. sand (-1 to 4 □). The sediments size between 5 and 12 □□comprises very low proportion of grain size distribution. This distribution of grain size of sediments indicates some variation in the energy condition and flow of the river may be due to the changes in the monsoon condition.

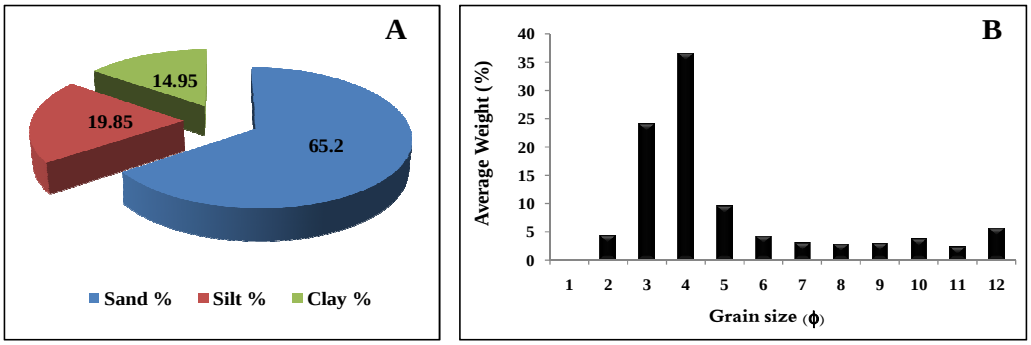



Fig. 2. A) Divided circle of textural classes and B) Bar graph of grain size distribution

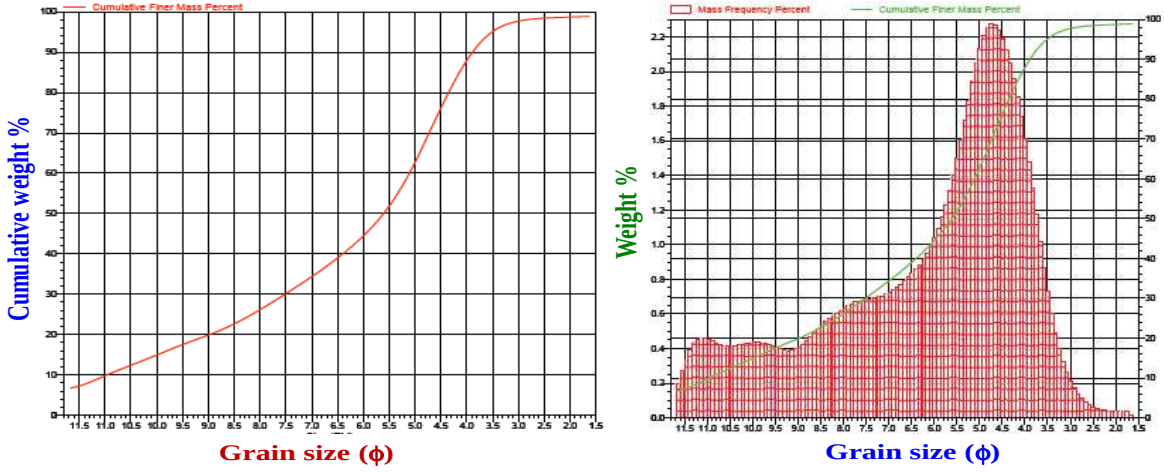
## DISCUSSION AND CONCLUSIONS:

The reconstruction of past climatic and environmental conditions has been made by using different continental and marine archives such as various deposits, ice cores, tree rings, speleothems etc. The depositional archives like fluvial, glacial, Aeolian, marine, lacustrine etc. have been used to obtain the information about palaeoclimatic and environmental changes. There are different kinds of proxies (grain size distribution, pollens, magnetic minerals, isotopes etc) which are preserved in the depositional bodies. These proxies provide some qualitative and quantitative information about past climatic and hydrological conditions (Singhvi and Kale, 2009).

The grain size distribution is one of the mostly used methods in the investigations of depositional environments. The researchers in India and other parts of the world have been using this technique from several decades. Generally, pipette method has been used to carry out grain size analysis but in the recent decades x-ray based scientific instruments are widely used to perform textural analysis. In the present study, an x-ray based Sedigraph particle size analyzer was used to carry out grain size analysis. The results provided by Sedigraph are very accurate and reliable. It provides grain size distribution up to 14 □ (very very fine clay). The grain size distribution data, cumulative frequency curve, histogram, selected percentiles etc. have been automatically collected in the attached computer (Fig. 3). The results of present study show that the Sedigraph particle size analyzer is very applicable and reliable in the study of depositional environments.

Fig.3 Cumulative grain size frequency curve and Histogram provided by Sedigraph.

The grain size analysis of Sina River deposits carried out by Sedigraph particle size analyzer shows that the sediment has more concentration of sand as compared to silt and clay. Clay constitutes very low proportion in the sediment samples. Sedigraph has




been used by many researchers and scientist of the research centers such as Department of Geography and Geology, SPPU, Pune, Indian Institute of Geomagnetism, Panvel etc. Therefore, textural analysis using scientific instruments has great potential in the field of sedimentological and soil sciences.

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