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RECONSTRUCTION OF RAINFALL AND RUNOFF CONDITIONS IN THE CATCHMENT AREA OF PASHAN TANK: BASED ON STRATIGRAPHICAL AND TEXTURAL ANALYSIS

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Abstract

In the present study, an attempt has been made to study the sedimentary deposit of Pashan Tank applying textural and stratigraphical methods of geoscience. Lithostratigraphical observations during the fieldwork of one meter thick sedimentary section does not revealed considerable changes in the thickness of the layers, texture, colour and structure. The grain size analysis of 23 sediment samples suggested that, texturally, the tank deposit sediments were found to be dominated by medium silt to fine silt with considerable amount of clay in some samples. By and large, the uppermost unit is characterized by high percentage of finer fraction and bottom part shows high amount of sand particles. The grain size parameters (mean size, sorting, skewness and kurtosis) show subtle to minor variations within the section. This indicates that no significant changes in the rainfall and runoff conditions have been occurred during the period of deposition of the sediments into the Pashan Tank.

Keywords: Textural analysis, sediments, rainfall and runoff, Pashan Tank

Introduction:

One of the ways of understanding the fluvial response to climatic changes is by investigating the fluvial archives of small catchments (Brown, 2003). Rivers draining large catchments are affected by several geo-environmental factors, such as, climate change, tectonic activity, base level changes, weathering, erosion, etc. Hence, this makes the study of sedimentary records of large rivers very complex, and it is often difficult to ascertain the dominant factor(s) leading to deposition and the source of sediments.

In comparison, the factors contributing to the variations in the process of transportation and deposition in small catchments are few and all the sediments are locally derived. Therefore, investigations of fluvial archives in small catchments have proved to be valuable in the palaeoenvironmental reconstructions (Brown, 2003). Further, the study of the size composition and other sedimentological characteristics of the lake sediments preserved in the foothill zones can provide valuable information on the hydrodynamic conditions prevailing on the hillslopes and the catchment area at the time of deposition (Pettijohn, 1975; Collinson and Thompson, 1989). Due to high potential of lacustrine deposits for palaeoclimatic reconstructions, several studies on the lacustrine deposits have been carried out by Indian workers (Bhattacharyya, 1989; Kusumgar et al. 1992; Kajale and Deotare, 1997; Enzel, 1999; Chauhan et al. 2000; Ghosh and Bhattacharya, 2003; Phartiyal et al. 2003; Basavaiah et al. 2004; Chakraborty et al. 2006; Shankar et al. 2006) during the last two to three decades (Kale et al., 2003; Singhvi and Kale, 2009).

Therefore, the main objctive of present paper is to study the sedimentary deposits of the Pashan Tank to understand the rainfall and runoff conditions prevailed during the deposition of the sediments.

Pashan Tank: An Introduction

The Pashan Tank (18o 32 N and 73o 47 E) is located near Pashan in the Pune City (Fig. 1). According to the Gazetteer of Bombay Presidency (1885), the Pashan Reservoir was made in 1867-68.The altitude of this area varies between ca. 600 and 763 m ASL. The region experiences semi-arid type of climate receiving about 700 mm of average annual rainfall. The catchment area of the tank is 17.75 km2. To the north of tank Sutarwadi and Baner villages are located and to the northeast of tank Pashan is located while to the south of tank Bavdhan khurd and Bavdhan budruk are situated (Fig. 1).

In the SOI toposheet (47 F/14), it is observed that Ram nadi originates from Pashan tank and it meet to the Mula river near Baner.

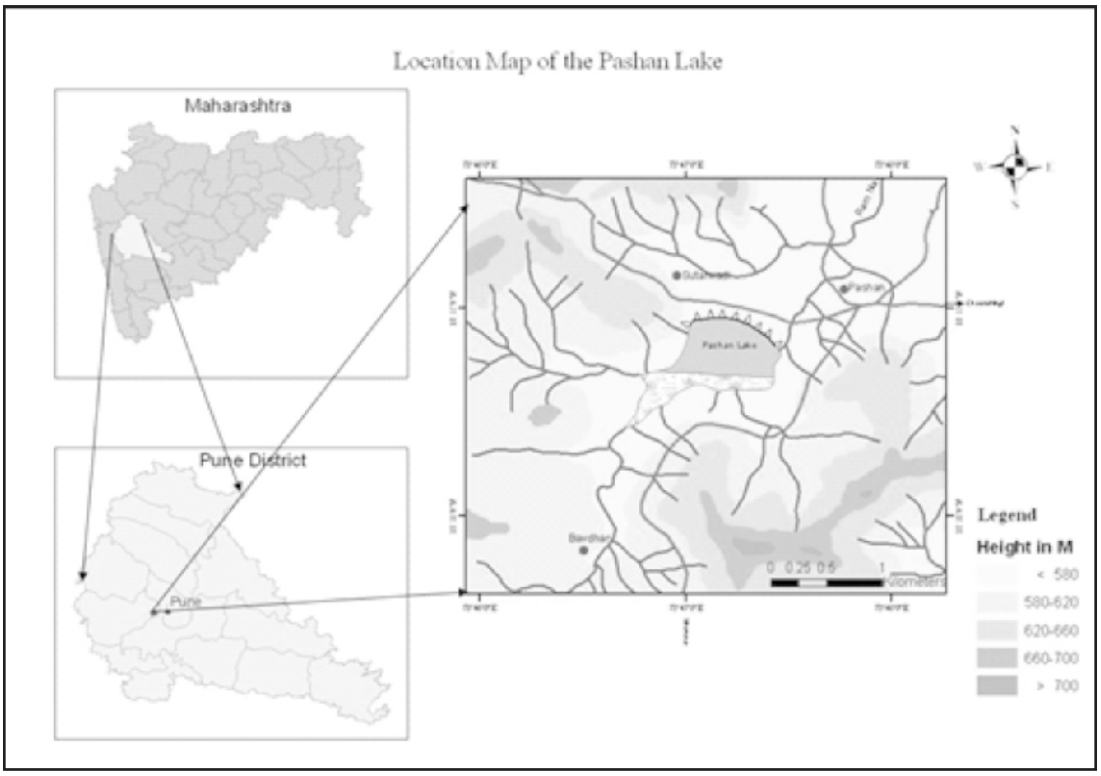

Fig.1. Map showing location of catchment area of the Pashan Tank

Methodology:

In order to study the changes in the stratigraphical and sedimentological characteristics of sediments with different time scale, the lithosection was made in the centre of the tank. Detailed stratigraphical studies were carried out after exposing the sediments. Total 25 sediment samples were collected at an interval of 4 cm from the exposed lithosection for grain size analyses.

For coarse sediments mechanical sieving was performed. A bunch of sieves was taken for sieving ranges from 1 f (0.5 mm) to 4 f (0.063 mm). The dried and weighed sediments (100 gm) were put into the uppermost (coarsest) sieve. A bunch of sieves was then shaken to an automatic sieve shaker for a period 10-15 minutes. After sieving was completed, the fraction of each sieve was then weighed. Any material passing the last sieve (0.063 mm) into the pan was also recorded. Then a four gram of sediment sample was taken collected in the pan for Sedigraph analysis. For finer fraction, analysis was undertaken using Sedigraph-III Particle Size Analyzer at the Department of Geography, University of Pune and Indian Institute of Geomagnetism,

The derived grain size data from sieve and Sedigraph analyses were merged and cumulative weight percentage of grain size was plotted on the probability paper. Then applying formulae given by Folk and Ward (1957), statistical parameters (mean size, sorting, skewness and kurtosis) were derived. Also textural classes such as % of sand, silt and clay were obtained. The stratigraphical and grain size data were synthesized to understand the nature of hydrodynamic changes prevailed in the catchment area of the Pashan Tank.

Results and discussion:

Stratigraphic observations:

For lithostratigraphical studies and collection of sediment samples a pit was excavated away from the margin towards the central part of tank. Due to presence of water the pit could not be taken very close to the tank wall. The total depth of the pit is about 1 m, and the section does not reveal distinct stratigraphical units. The lithosection and the lithostratigraphy of the pit is depicted in Fig. 2. The bottom 20 cm of the section comprises mostly silt and the upper and middle units are dominated by silt and clay (Fsm facies).

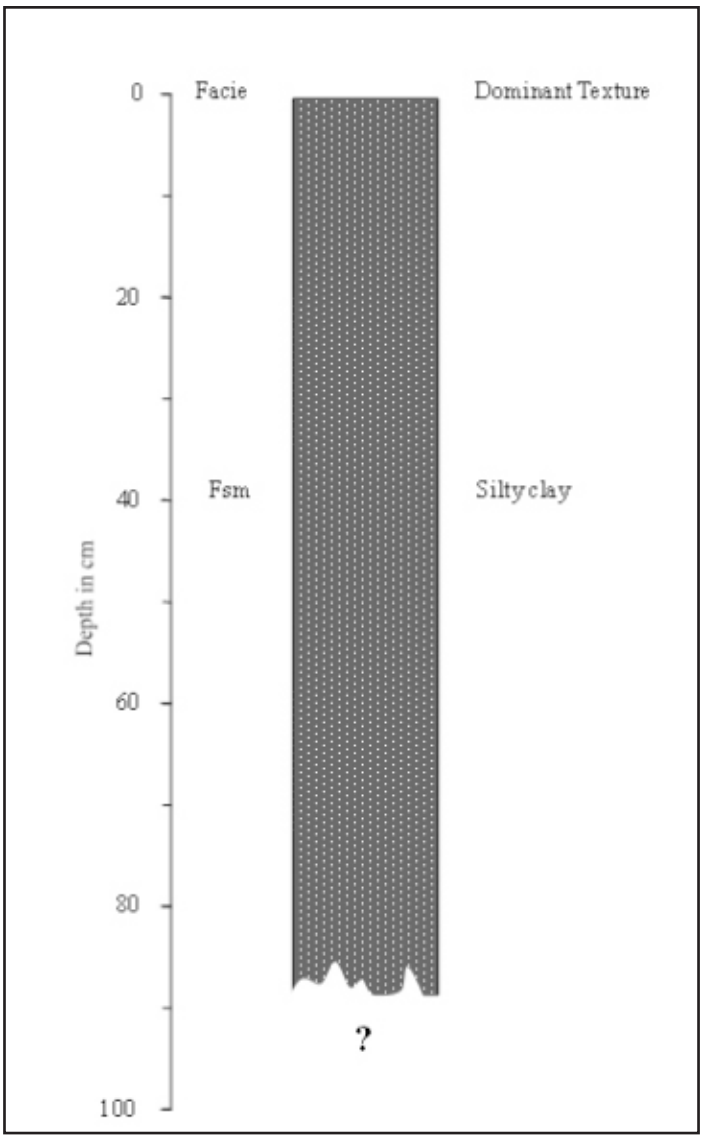

Fig. 2. Lithostrategraphy of the Pashan Tank deposits

Textural classes:

Table 1. Textural classes and grain size parameters of Pashan Tank deposits.

Sample	Depth (cm)	Sand%	Silt%	Clay%	Mean (ϕ)	Sorting (ϕ)	Skewness	Kurtosis
1	0	8.70	42.50	48.80	5.97	2.98	0.36	0.89
2	4	11.00	41.50	47.50	5.80	2.98	0.49	0.91
3	8	7.40	43.50	49.10	5.93	2.96	0.42	0.85
4	12	9.00	49.50	41.50	6.33	2.96	0.17	0.79
5	16	1.20	54.10	44.70	6.00	2.94	0.43	0.88
6	20	9.30	45.60	45.10	6.80	3.03	0.27	0.82
7	24	9.90	44.90	52.50	6.47	2.99	0.34	0.84
8	28	10.40	44.90	44.70	6.47	3.02	0.30	0.79
9	32	4.70	39.20	56.10	6.53	2.96	0.23	0.83
10	36	9.30	45.00	45.70	6.70	3.08	0.21	0.75
11	40	11.00	45.50	43.50	6.83	2.94	0.26	0.80
12	44	9.40	44.60	46.00	6.87	3.16	0.16	0.69
13	48	8.40	48.60	43.00	6.67	3.13	0.20	0.72
14	52	9.40	47.50	43.10	6.93	3.22	0.20	0.65
15	56	7.50	53.00	39.50	7.90	3.40	0.30	0.65
16	60	8.60	51.60	39.80	6.73	3.13	0.17	0.72
17	64	7.20	54.80	38.00	6.73	3.14	0.19	0.70
18	68	9.20	58.90	31.90	6.73	3.07	0.16	0.70
19	72	11.30	57.00	31.70	6.30	2.62	0.46	0.82
20	76	10.60	57.20	32.20	6.47	3.04	0.27	0.75
21	80	11.90	55.80	32.30	7.10	3.12	0.76	0.80
22	84	14.00	55.20	30.80	7.50	3.15	0.61	0.71
23	88	14.50	60.00	25.50	7.06	3.23	0.93	0.65
	Average	09.30	49.58	41.43	6.64	3.05	0.34	0.77
	Minimum	01.20	39.20	25.50	5.80	2.62	0.16	0.65
	Maximum	14.50	60.00	56.10	7.90	3.40	0.93	0.91

The result of textural analysis is presented in the Tables 1. The textural data show that the Pashan Tank sediments are dominated by silt (49.6%). Vertically, the silt percentage varies between 39.2 and 60% and sand percentage ranges from 1.2 to 15.7% (Table 1). The mean percentage of sand is 9.3%. The percentage of clay in the samples is relatively low, between 25.5 and 56.1%, and the average percentage of clay is about 41.4%.

Fig. 3 shows the vertical variation in the percentages of sand, silt and clay for Pashan Tank. The plot indicates that the highest percentage of clay (56.1%) is observed at the depth of 32 cm from the top and the lowest percentage of sand (1.2%) occurs at the level of 16 cm from top. It is evident from the plot that the percentage of clay increases and the percentage of silt decrease in the upward direction in the lithosection.

The cumulative grain size data of all the samples from Pashan Tank is plotted in Fig. 4. From the plot it is evident that the curve of sample 9 deviates downward from the other curves indicating a higher percentage of finer fractions and the curve of sample 23 is slightly shifts in the upward direction showing abundance of coarse material. The remaining curves are, more or less, identical.

From the histogram (Fig. 5) it is evident that high concentration (15-16%) of particles is observed in grain size classes of 4 and 5 f, while remaining grain size classes show nearly equal concentration (7-10%) of particles except at 12 f which indicates a low percentage (2.3%). By and large grainsize distribution shows unimodal in nature.

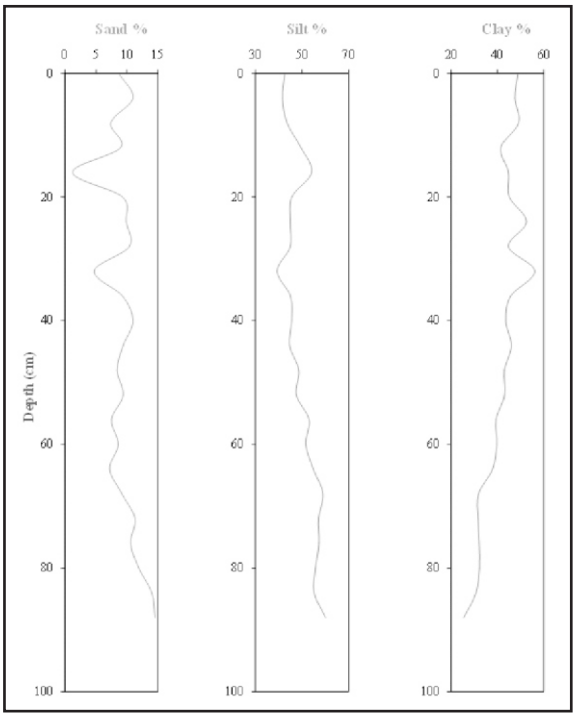

Fig. 3. Vertical variation in the textural classes of the Pashan Tank deposits

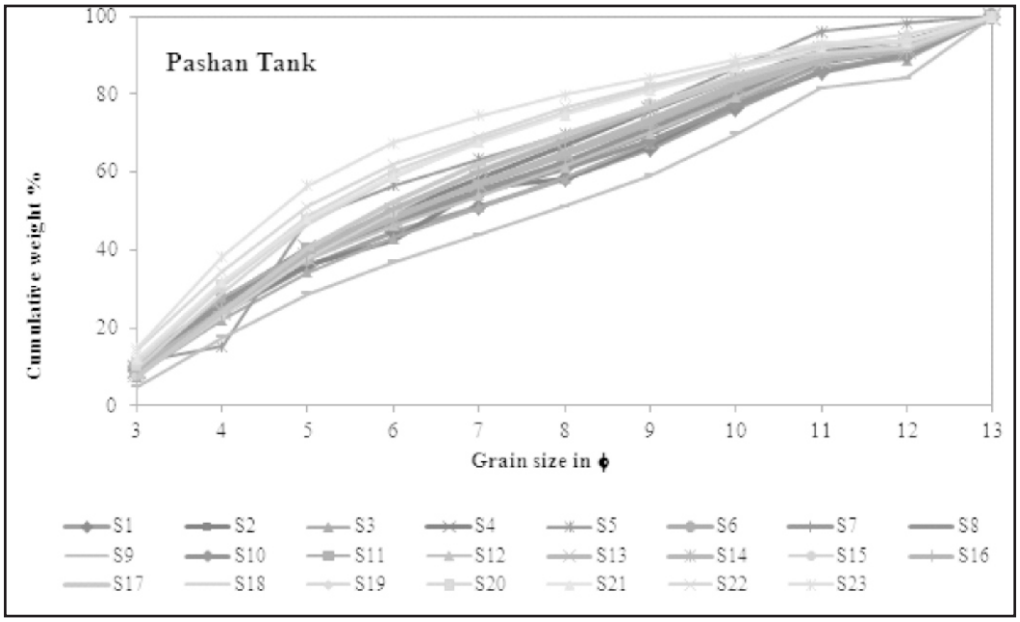

Fig. 4. Cumulative grain size frequency curves for the sediment samples of Pashan Tank showing grain size distribution

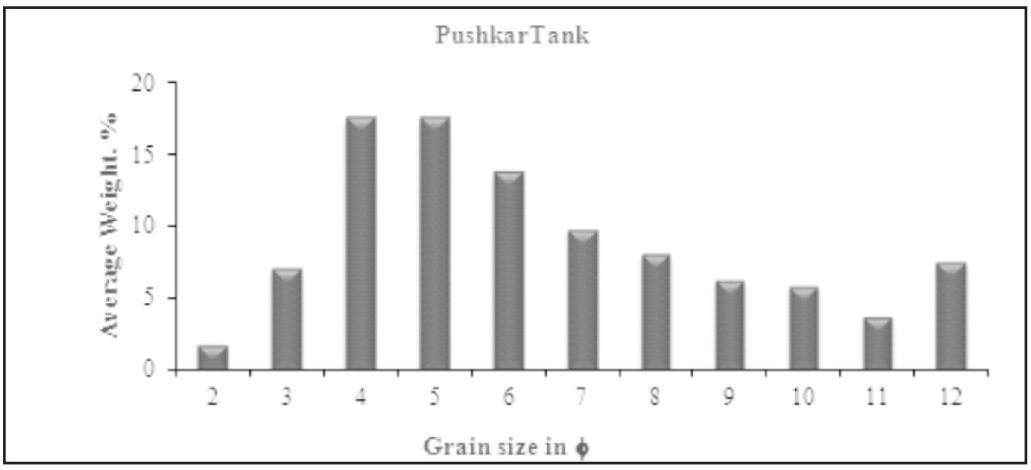

Fig. 5. Percentage distribution of sediments in different grain size classes

Grain size parameters:

The statistical parameters for Pashan Tank deposits are given in Table 1. From the data table it reveals that the mean grain size ranges between 5.8 and 7.9f. The values of the mean denote that the sediments fall in the category of medium silt to very fine silt. The sorting values fall between 2.62 and 3.4f, implying that the sediments are very poorly sorted and it means that there is much variation in the grain size. The skewness values range between 0.16 and 0.93. This indicates the abundance of fine material. The kurtosis values vary between 0.65 and 0.91 and suggest platykurtic distribution (Table 1). This reflects that there are no significant variations in the sediment size.

On the basis of the vertical variation in the parameters of grain size (Fig. 6), the profile can be divided into two major parts. The upper part up to a depth of 55 cm is characterized by an increase in mean size and sorting. The bottom part shows just the opposite trend in the statistical parameters (Fig. 6). The depthwise variation in the graphical measures does not exhibit any systematic trend or upward fining or upward coarsening sequence.

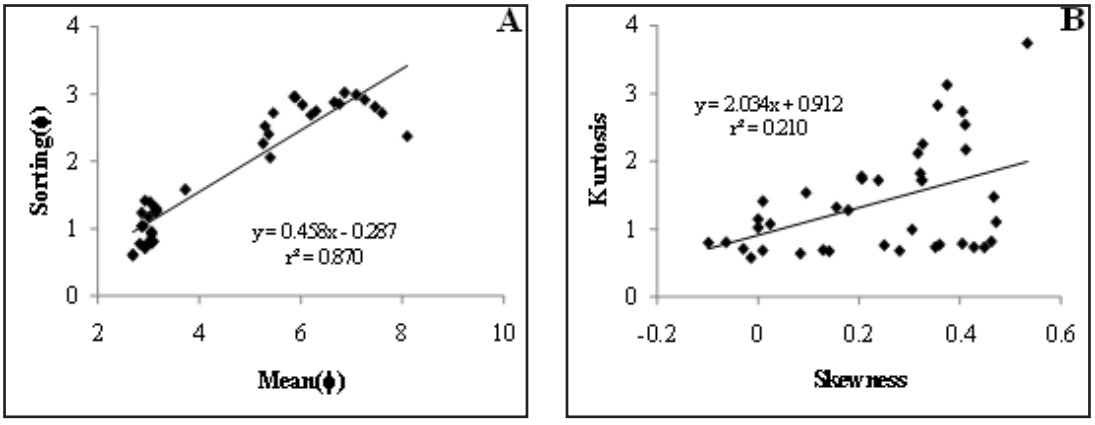

Fig. 7. Plot of mean size against sorting index and (B) skewness versus kurtosis

The plot of mean size against sorting (Fig. 7) shows positive correlation means as mean size (f) increases, the sediments become well sorted. The fine sediments are better sorted than coarser

sediments. This also reflected in the plot of skewness versus kurtosis (Fig. 7). As skewness increases, there is increase in the kurtosis.

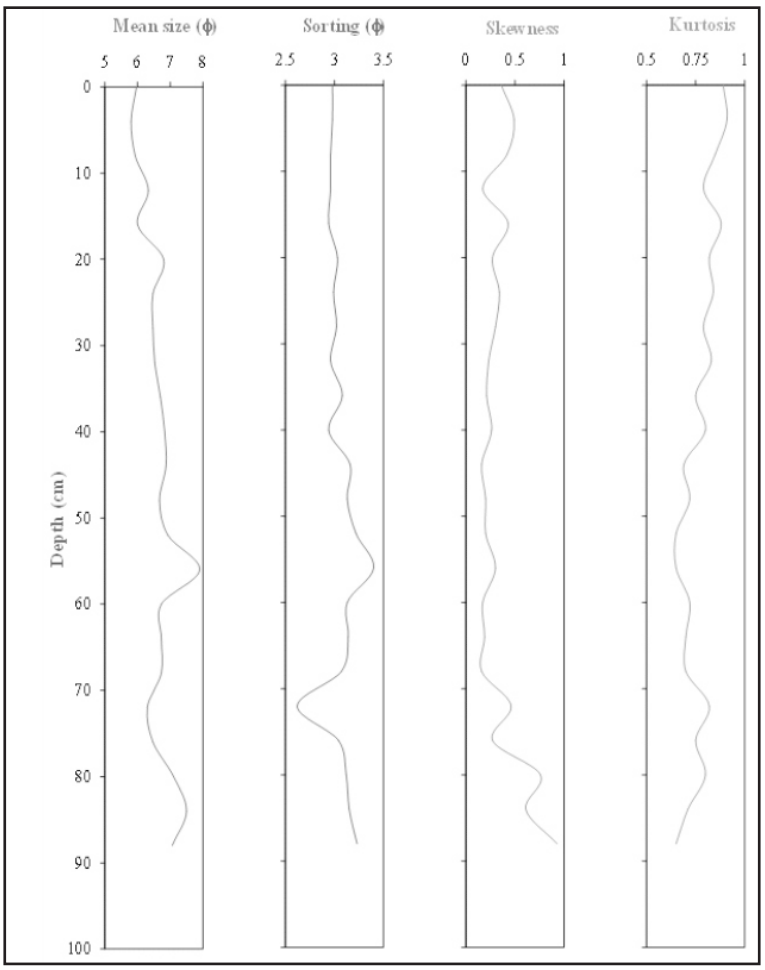

Fig. 6. Vertical variation in the grain size parameters for Pashan Tank lithosection

Conclusions:

The stratigraphical and textural characteristics of the Pashan Tank sediments have provided for the first time, the significant information about past hydrological conditions in the catchment area of the tank. The results of the study shows some minor variations in the properties of sediments and this can be attributed to the minor changes in the rainfall and runoff conditions. The results, also does not reveal any sedimentary unit with significant difference and overall profile does not exhibit any systematic trend in the sediment properties.

Finally, on the basis of results of the present study, we conclude that no significant changes in the hydrodynamic (i.e. rainfall) conditions have been occurred during the last century.

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