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Grain Size Analysis of Punem Lake

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ABSTRACT: The present study aims to establish the stratigraphy of the lake bottom and to reconstruct the sedimentological history of Punem Lake. Eutrophication is one of the serious issues for the surface water bodies and deteriorates the conditions of lake. So, this study aims to identify the grain size distribution of the lake which would help in providing a precise understanding of the lake and the various deposits lying beneath it. Sedimentcores are taken from the entire area of Punem Lake. Altogether 16 core samples are analysed. The grain size of all sediment samples collected from Punem Lake is measured following the method of Folk and Ward (1957) which includes mean, median, sorting, skewness and kurtosis. GRADISTAT which is a grain size distribution and statistics package for the analysis of unconsolidated sediments is used for the study. The lithologs of all the cores are plotted using Rockwork 16.0 and the unit of the depth of the core sediment from the depth of the water is plotted in centimeter. From the grain size analysis it is found that sediment deposition in Punem Lake is fine grained and usually vary significantly from very fine-grained sand to clay with small fractions of fine sand. Variability in the values of mean size of Punem Lake indicates either fluctuation in the kinetic energy or climatic change. However, mean grain size suggests low energy condition of the Punem Lake. Thus, this depicts that the energy of the depositional medium of the sediments of Punem Lake is low because of the dominance of finer sized sediments comprising of silt and clay as sediments usually become finer with decrease in energy of the transporting medium. Sediments have grains of varying sizes and are evidence of sediments that have been deposited fairly close to the source area and that they have not undergone much transport.

Keywords: Punem Lake, sediments, grain, mean, sorting, skewness, kurtosis.

INTRODUCTION

Sediments play an important role in reconstructing the environmental history of lakes. The development of lake ecosystems in the past can be reconstructed from stratigraphic analysis of sediment cores based on a range of sedimentary parameters [2, 12, 22]. Due to differential erosion, transportation and deposition, sediments laid down in different depositional environments may possess distinctive grain size distributions.

Grain size is a fundamental property of sediments that may tell us much about their origins and history. The grain size distribution of sediments mainly reflects the conditions in the depositional environment along with the processes acting in it and the energy level of those processes. By determining the grain size distribution it is possible to hypothesize about the environment of deposition and so to utilize this technique as a tool for environmental reconstruction [11]. Quantitative analysis of the size distributions of sediments is necessary for detailed comparison between samples and to discover significant relationship between sediment properties and geologic processes or settings [15].

Grain size study is important as it is a fundamental measure of sediment and sedimentary rocks. It is the quantification of the size of the sedimentary particles. The grain size of sediments depends upon the nature of the source rocks and the transporting agent and hence the size of the sediments reflects the mechanism of erosion and transportation.

The present study aims to establish the stratigraphy of the lake bottom and to reconstruct the sedimentological history of Punem Lake.

STUDY AREA

Punem Lake is located in Thoubal district of Manipur and its area is about 1.041km^2. It lies between the latitudes 24.67541°N to 24.68993°N and longitudes 93.97998°E to 93.99150°E (Fig. 1) at an altitude of 786 m above mean sea level (MSL).

The lake is a shallow perennial water body, bounded on other sides by two areas *viz.,* Waithou Lake proper and Cheksabi Lake. The main feeder lines of the lake are the rivers draining down via Ningthibi Canal, the region of confluence of Imphal and Thoubal rivers. The morphometric as well as ecological survey indicate the advanced eutrophication going on in the lake [4].

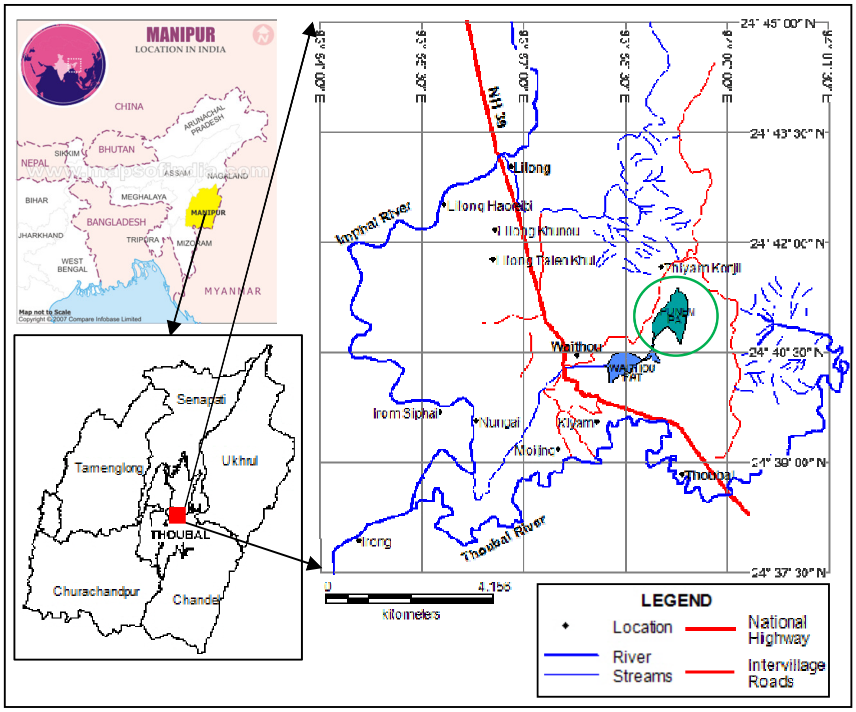


Fig. 1. Location map of Punem Lake.

METHODOLOGY

Sediment cores are taken from the entire area of Punem Lake. Altogether 16 core samples are analysed (Fig. 2). The grain size of all sediment samples collected from Punem Lake is measured following the method of Folk and Ward (1957) [8]. Sediments in the Punem Lake usually vary significantly. Depositions in the accumulation areas are with a water and organic content, and are mainly fine grained.

Since the sediments in Punem Lake are fine grained with particle size less than 75 microns, sieve analysis is not done. So, in order to determine the distribution of clay and silt particles, hydrometer analysis is performed for the study. Since silt particles will fall out of the suspension first, followed later by the clay particles, the relative amounts of silt and clay-sized particles can be determined [18].

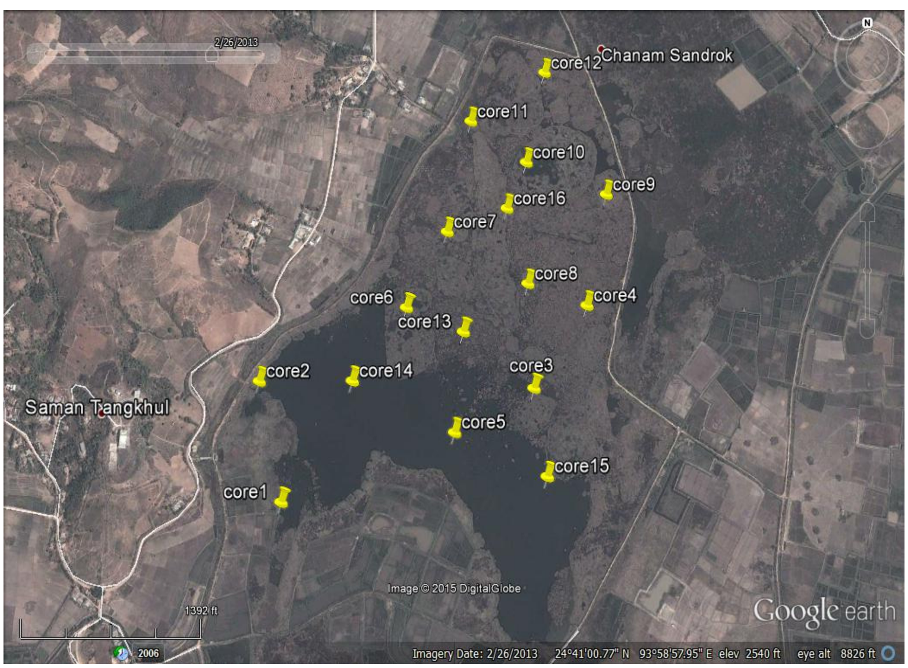


Fig. 2. Core locations at Punem Lake.

Granulometric parameters namely mean, sorting, skewness and kurtosis are used to decipher the depositional environments of sediments as there is a great relationship between grain size distribution and the depositional environments.

GRADISTAT which is a grain size distribution and statistics package for the analysis of unconsolidated sediments is used for the study. The programme runs in Microsoft Excel and the grain size statistics are calculated using the GRADISTAT software [3] applying the logarithmic Folk and Ward method. The statistical parameters calculated include mean, median, sorting, skewness and kurtosis using the formula given by Folk and Ward (1957) [8]. GRADISTAT also calculates the fraction of sediment from each sample by size category viz. coarse sand, medium sand, fine sand, very fine sand, very coarse silt, coarse silt, medium silt, fine silt, very fine silt and clay based on a modified Wentworth (1922) [23] size scale. Grain size statistical parameters and graphic representations are given in phi units.

RESULTS AND DISCUSSION

From the grain size analysis it is found that sediment deposition in Punem Lake is fine grained. Sediments in the Punem Lake usually vary significantly from very fine-grained sand to clay with small fractions of fine sand.

Udden–Wentworth grain-size scale (Last and Smol 2001) [13] is used for the present study. Using Gradistat, the grain sizes are distributed as fine sand (F-Sand), very fine sand (VF-Sand), coarse silt (C-Silt), medium silt (M-Silt), fine silt (F-Silt), very fine silt (VF-Silt) and clay. The statistical parameters are analysed using the Folk and Ward (1957) method [8]. The lithologs of all the cores are plotted using Rockwork 16.0 and the unit of the depth of the core sediment from the depth of the water is plotted in centimeter. The grain sizes are plotted in terms of 0-100 percent. The figure of the stratigraphic grain distribution and statistical parameters of core1 plotted is shown in Fig. 3.

Bivariate scatter plot is then plotted against mean and skewness, sorting and mean and sorting and skewness. The deposition for the sediments of Punem Lake is determined using the bivariate plots by plotting one statistical parameter against another and determining the correlation between the statistical parameters.

Bivariate plot of core 1 is shown in Fig. 4 which does not show good correlation between the statistical parameters *i.e.* mean vs skewness, sorting vs mean and sorting vs skewness. The sediments are fine silt to clay layers with small fractions of fine sand.

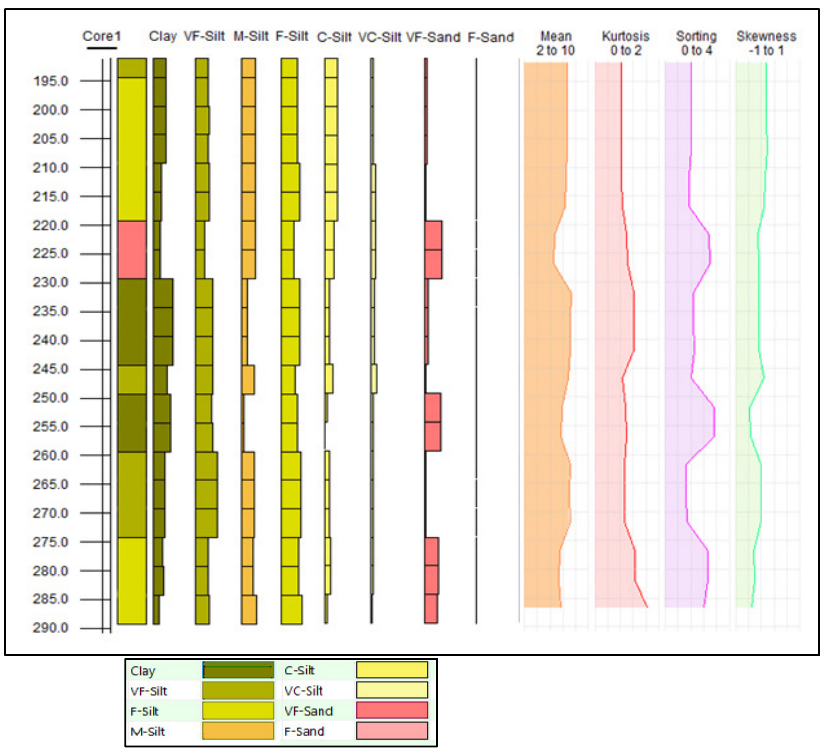
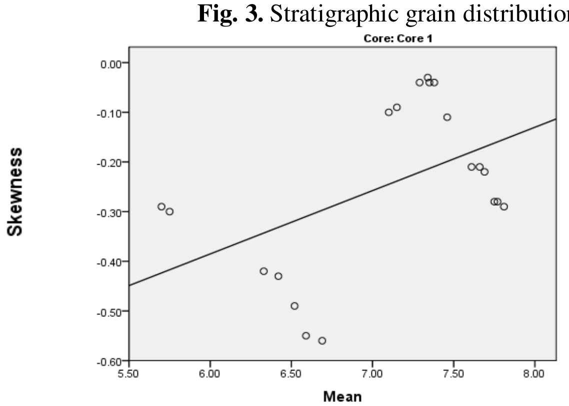


Fig. 3. Stratigraphic grain distribution and statistical parameters of core 1.

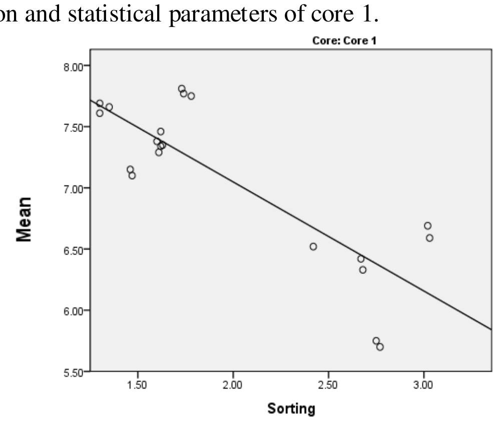
Table 1: Udden-Wentworth grain size scale (modified from Friedman *et al*., 1992 [9], after Last and Smol 2001b [13]).

Limiting Particle Diameter (ϕ units)	(mm)	(μm)	Descriptive Terms		
−11	2048		Very Large	Boulder	Gravel
−10	1024		Large	Boulder	Gravel
−9	512		Medium	Boulder	Gravel
−8	256		Small	Boulder	Gravel
−7	128		Large	Cobble	Gravel
6	64		Small	Cobble	Gravel
−5	32		Very Coarse	Pebble	Gravel
−5	16		Coarse	Pebble	Gravel
−3	8		Medium	Pebble	Gravel
−2	4		Fine	Pebble	Gravel
−1	2		Very Fine	Pebble	Gravel
0	1		Very Coarse	Sand	
+1	0.5	500	Coarse	Sand	
+2	0.25	250	Medium	Sand	
+3	0.125	125	Fine	Sand	
+4	0.0625	62.5	Very Fine	Sand	
+5	0.03125	31.25	Very Coarse Silt	Coarse Silt	Mud
+6	0.01563	15.63	Coarse Silt	Medium Silt	Mud
+7	0.00781	7.81	Medium Silt	Fine Silt	Mud
+8	0.00391	3.91	Fine Silt	Very Fine Silt	Mud
+9	0.00195	1.95	Very Fine Silt	Clay	Mud
			Clay	Clay	Mud

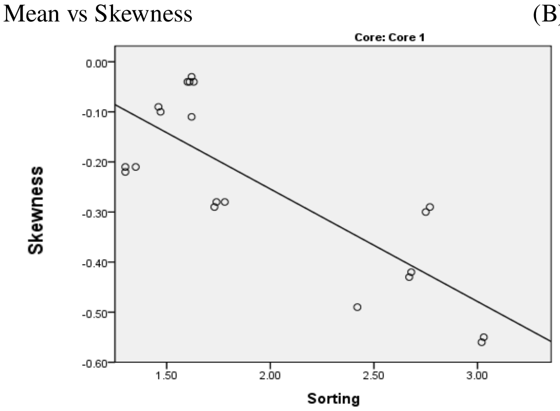
Fig. 3. Stratigraphic grain distribution and statistical parameters of core 1.



(A) Mean vs Skewness



(B) Sorting vs Mean



(C) Sorting vs Skewness.

Fig. 4. Bivariate scatter plot of Core 1.

Grain size distribution patterns are similar for cores 4, 9,10,11,12 and 16 which are located at the north eastern side of Punem Lake. The upper layer of sediments in the core at ~3.00 m to 3.68 m comprises of very fine to fine sand particles. But at the bottom upto ~3.95 m it consists of clay and very fine silt particles and beneath it with small fractions of very coarse silt. Cores 3, 5, 8, 13 and 15 at a depth of about 2.75 m to 3.20 m which is located at the central deepest part of the lake have similar grain size distribution dominated by clay particles in the sediments. As for cores 2, 6, 7 and 14 which lies in the north western part of the lake, the top layer of sediments at ~1.54 m to 3.46 m comprises of very fine sand particles and the bottom sections upto ~3.96 m are depicting clay and very fine silt distributions. The grain size distribution of core 1 in the south western part of the lake is quite different from the other cores since it is located just at the periphery of the lake where the area is just adjacent to the paddy fields. The sediments predominantly consist of fine silt particles. The upper layers of core 1 at ~1.95 m to 2.20 m is represented by fine silt particles and the towards bottom parts at ~2.30 m to 2.90 m by silt-clay particles with small fraction of very fine sand at the middle portion at ~2.20 m to 2.30 m. Granulometrically, the sediments of Punem Lake are fine grained, moderately to very poorly sorted and very platykurtic to extremely leptokurtic in character. Sediments are positively, negatively as well as nearly symmetrically skewed.

Granulometric analysis also shows that the sediments of Punem Lake consist of fine sand, silt and clay particles. Besides as shown in the 3-dimensional view of all core logs in Punem Lake (Fig. 5), the sediments are predominantly consisted of silt and clay particles.

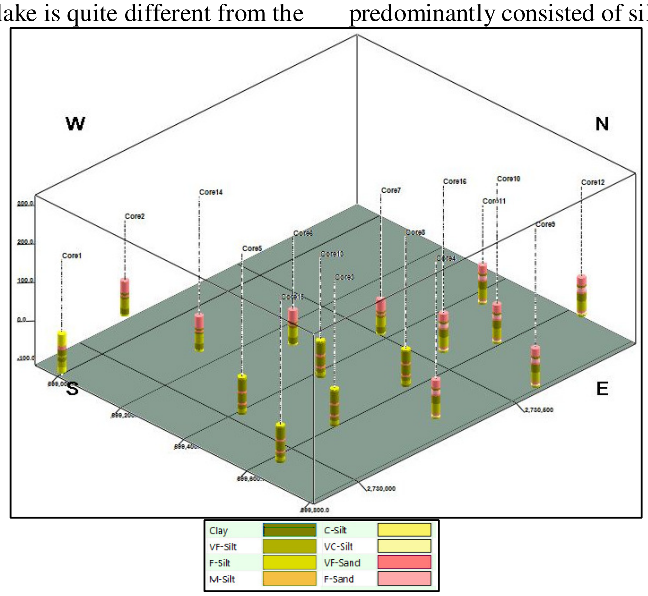


Fig. 5. 3-Dimensional view of all the core logs in Punem Lake.

Grain size analyses show that the mean grain size of Punem Lake varies from 2.170 to 9.309 ϕ and is directly related to the kinetic energy of the depositional basin. The mean grain size increases in the lake center and the bottom sediments comprise of finer grained particles. The sediment layers of Punem Lake dominantly consists of fine grained silt and clay population along with a subordinate coarse population of fine and very fine sand particles. The presence of coarse material produces the negative skewness. The presence of finer particles suggests that the sediments are deposited under low energy condition, as sediments usually become finer with decrease in energy of the transporting medium [6,7]. Also, fine grained textures typically indicate deposition in quiet water. In general, it takes higher energy or higher water velocity to transport larger grains. Variability in the values of mean size of Punem Lake indicates either fluctuation in the kinetic energy or climatic change. However, mean grain size suggests low energy condition of the Punem Lake. Thus, this depicts that the energy of the depositional medium of the sediments of Punem Lake is low because of the dominance of finer sized sediments comprising of silt and clay.

Sediments in Punem Lake are represented by moderately to very poorly sorted primarily because of fluctuating energy levels. The variations in sediment sorting of Punem Lake may be probably due to differences in water turbulence, variability in the velocity of the depositional current and variation in the sediment influx. The mixing of sediments under high energy conditions and under low energy conditions has affected the sorting of sediments. Poorer sorting indicates variable current velocities and turbulence during deposition, while good sorting indicates smooth, stable currents. Majority of grain sizes from 2.170 to 8.00 ϕ is poorly to very poorly sorted which shows that the sediment sizes are mixed in large variance i.e. sediments have grains of varying sizes and are evidence of sediments that have been deposited fairly close to the source area and that they have not undergone much transport. This is indicative of low energy current which is also supported by Blott and Pye, 2001. While sediments greater than 8.00 ϕ which are in the clay range are better sorted, increasing mean size indicates moderate sorting.

Skewness value of the sediments shows very negative or coarse skewed to very positive or fine skewed distributions. Sediments weighted towards the coarse end are said to be negatively skewed and sediments weighted towards the fine end are said to be positively skewed. Positive values of skewness indicate that the samples have a tail of fines that is those with a large proportion of fine materials are positively skewed. Negative values indicate a tail of coarse grains that is those with a large proportion of coarser materials is negatively skewed. Negatively skewed sediments indicates higher energy of the depositing agent, and are subjected to transportation for a smaller length of time whereas positively skewed sediments imply the prevalence of low energy environment transported for a greater length of time. Variation in the sign of skewness is due to varying energy conditions of the depositional environments. Deviations from the symmetrical distribution are caused by mixing of at least two grain sub-populations. Skewness is attributed to the deposition of different kinds of sediments from different depositional conditions that existed from time to time in the same environment. This is also supported by works done by different authors [10, 16, 19]. According to Duane (1964)'s suggestion [5], a mixture of negatively to positively skewed curves would indicate a fluctuating energy state of the depositional media.

Kurtosis value of Punem Lake is found to vary from very platykurtic to extremely leptokurtic peakedness with majority of the sediments to be platykurtic in nature. When the central part has a flatter slope than the average of the two extremes, the total distribution is said to be platykurtic or to have a negative kurtosis value. Platykurtic nature and very platykurtic showed extreme peakedness with respect to the normal distribution, which shows that all size fractions of grain size are mixed up [20]. The mixing oftwo populations in sub-equal amounts results the platykurtic curve.

The leptokurtic nature of the sediments accounting to high positive kurtosis is probably due to the intermixture of coarse and fine particles. The leptokurtic behavior of the sediments also indicated the variations of the energy conditions of the environmental set up of depositions of the sediments. Leptokurtic character reflected the extreme skewness values, either positive or negative, indicating concentration of coarser and finer grained materials finally showing the impact of fluctuation of energy condition in the deposition of the sediments from most of the formations [17]. Accumulation of finer materials show the influence of moderate to low energy conditions in the environmental set up showing the leptokurtic character of the sediments [14]. Low kurtosis values are more apt to occur in poorly sorted distributions while, high kurtosis values are more apt to occur in well-sorted distributions. High kurtosis and skewness values can be generally interpreted as a large amount of reworking adjacent to the point of deposition of the sample. High kurtosis values or equivalent combined with very fine grain size indicate low energy level reworking. The variations in the kurtosis values are a reflection of the energy conditions of the depositing medium and the dominance of finer size of platykurtic nature of the sediments (Baruah *et al.,* 1997) [1].

Changes in sorting, skewness and kurtosis are caused by mixing of grain sub-populations. Low skewness and kurtosis combined with poor sorting in Punem Lake indicate a much smaller amount of reworking. Either high or low energy level reworking would be indicative of a short supply of material or at least that the supply is below the transporting capacity of the geologic agent in the area of deposition and that deposition is taking place at a slow rate [21]. Bivariate scatter plots plotted for all the cores in Punem Lake show very good correlation between the statistical parameters. There is a good correlation between mean and skewness which shows that mean size plays a vital role in depicting the deposition pattern of the sediments.

In Punem Lake there is a predominance of silt and clay size particles which highlight the prevalence of low energy condition of the deposition of sediments as sediments usually become finer with decrease in energy of the transporting medium. Sorting becomes better with increasing mean size indicating moderately sorted grain size. Due to the presence of fine sand particles in the sediments that are poorly to very poorly sorted shows variability in size and is evidence of sediments that have been deposited fairly close to the source area and that have not undergone much transport.

CONCLUSION

Punem Lake is a shallow fresh water lake and the grain size analysis reveals that the sediments are fine grained which comprises of fine sand, silt and clay particles from the source located near the lake. Granulometric analysis of the present study suggests that sediments of the Punem Lake texturally comprises of fine sand, silt and clay particles with values ranging from 2.17 to 9.30 ϕ. From the interpretation of graphic mean, it is found that the sediment of Punem Lake is made up predominantly of silt and clay with small amount of fine sand which lies between fine sand and clay on the Udden-Wentworth scale. Thus, the energy of the depositional medium of the sediments of Punem Lake can be said to be low because of the dominance of finer sized sediments comprising of silt and clay.

Sorting is strongly dependent on mean size. Sediments in Punem Lake are represented by moderately sorted to very poorly sorted grains where the value ranges from 0.511 to 3.27 ϕ which shows that the sediment sizes are mixed in large variance. On the average, the sediments of Punem Lake are poorly sorted which indicates a fluctuating current strength and are evidence of sediments that have been deposited fairly close to the source area and that they have not undergone much transport.

Skewness result of the lake shows very negative or coarse skewed to very positive or fine skewed distributions. The fine skewed nature of the sediments of Punem Lake suggests the prevalence of low energy environment and is subjected to transportation for a greater length of time during the deposition of fine sediments. While, coarse skewed sediments imply the prevalence of high energy environment transported for a smaller length of time. A mixture of negatively to positively skewed curves indicates a fluctuating energy state of the deposition of sediments in Punem Lake.

Kurtosis is distributed from very platykurtic to extremely leptokurtic peakedness. But majority of the sediments of Punem Lake are platykurtic in nature. The mixing of two populations in sub-equal amounts results in aplatykurtic curve. Platykurtic and very platykurtic nature of peakedness in kurtosis show that all size fractions of grain size are mixed up. As a result, skewness and kurtosis values exhibit greater variability.

Bivariate plot also shows very good correlation between the statistical parameters. Good correlation between mean and skewness is found which shows that due to predominance of silt and clay particles in Punem Lake there is prevalence of low energy condition of the deposition of sediments as sediments usually become finer with decrease in energy of the transporting medium. Sorting becomes better with increasing mean size indicating moderately sorted grain size. Due to the presence of fine sand particles in the sediments poorly to very poorly sorting is also noted which shows that sediments have grains of varying sizes and are evidence of sediments that have been deposited fairly close to the source area and that they have not undergone much transport.

FUTURE SCOPE

Deep core extraction could not be furnished due to lack of sophisticated sediment corer. So, there is a scope of deep coring of the lake sediments for future studies. Also, dating of the lake sediments can further be conducted to establish the paleoenvironment of the lake.

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REFERENCES

[1]. Baruah, J., Kotoky, P. and Sarma, J. (1997). Textural and geochemical study on river sediments: a case study on the Jhanji River, Assam. *J. Indian Assoc Sedimental,* **16**, 195-206.

[2]. Berglund, B. E. (Ed.). (1986). Handbook of Holocene Palaeoecology and Palaeohydrology. John Wiley and Sons, New York.

[3]. Blott S. J., and Pye, K. (2001). GRADSTAT: A grain size distribution and statistics package for the analysis of unconsolidated sediments. *Earth surfaces processes and landforms*, **26**, 1237-1248.

[4]. Chanu, S. R., Chingkhei, R.K., Sanoujam, M. and Kumar, A. (2014). Lake Sediment Thickness Estimation Using Ground Penetrating Radar. *IJRET*, **3**, 09, Sep 2014, pp.42-46.

[5]. Duane, D. B. (1964). Significance of skewness in recent sediments, Western Pamlico Sound, North Carolina. *J Sediment Petrol, 34*(4): 864-874.

[6]. Eisema, D. (1981). Supply and deposition of suspended matter in the north sea. *Special Publication of the International Association of Sedimentologists,* **5**, 415-428.

[7]. Folk, R. L. (1974). Petrology of sedimentary rocks. Austin Texas: Hemphili Publication, Company, p. 182.

[8]. Folk, R. L. and Ward, W. C. (1957). Brazos River Bar: A study in the significance of grain size parameters. *Journal of Sedimentary Petrology*, Vol. **27**, No. 1, pp. 3-26.

[9]. Friedman, G. M., Sanders, J. E. and Kopaska-Merkel, D. C. (1992). Principles of Sedimentary deposits: *Stratigraphy and Sedimentology*, **14**, New York: Maxwell Macmillan International.

[10]. Gujar, A. R. (1996). Heavy mineral placers in the near shore areas of south Kongan, Maharashtra: their nature, distribution, origin and economic evaluation. Dissertation Tip, Tamil University, Thanjavur, 234.

[11]. Lario, J., Spencer, C., Plater, A. J., Zazo, C., Goy, J. L. and Dabrio, C. J. (2002). Particle size characterization of Holocene back- barrier sequences from North Atlantic coasts (SW Spain and SE England). *Geomorphology*, **42**, 25-42.

[12]. Last W. M, and Smol J. P (Eds.) (2001). Tracking Environmental Change Using Lake Sediments. Vol. **1**, Basin Analysis, Coring, and Chronological Techniques. Kluwer Academic Publishers, Dordrecht, The Netherlands.

[13]. Last W. M, and Smol J. P. (Eds.) (2001). Tracking Environmental Change Using Lake Sediments. Vol. 2: Physical and Geochemical Methods. Kluwer Academic Publishers, Dordrecht, The Netherlands.

[14]. Leeder, M. R. (1982). Sedimentology. George Allen and Unwin Pub. Ltd., London.

[15]. Lewis, D. W. (1984). Practical Sedimentology. Hutchinson Ross Publishing Co., Stroudsburg, PA, 229.

[16]. Mohan, P.M. (1990). Studies on texture, mineralogy and geochemistry of the modern sediments of the Vellur estuary, Cochin University of Science and Technology, Cochin, 192.

[17]. Prabhakara, R. A. (2001). Grain size parameters in the interpretation of depositional environments of coastal sediments between Bendi Creek and Vamsadhara River, East Coast, India. *Jour. Indian Assoc. Sedimentologists,* **20**, 106-116.

[18]. Prieto-Portar L. A. (2009). Geotechnical Laboratory Notes, web.eng.fiu.edu/prieto, Miami.

[19]. Rajamanickam, G. V. (1983). Geological investigations offshore heavy mineral placers of Kongan coast, Maharashtra, India. Unpublished PhD Thesis, Indian School of Mines, Dhanbad, 258.

[20]. Rita, C., Ramanathan, A. L and Adhya, T. K. (2014). Patterns of seasonal variability in granulometric characteristics of Bhitarkanika Mangrove – estuarine complex, East coast of India. *Indian Journal of Marine Sciences,* Vol. **43** (6), pp. 1077-1084.
[21]. Robert, A. C. (1961). Geologic interpretation of grain-size distribution measurements of Colorado plateau sedimentary rocks. *The Journal of Geology,* Vol. **69**, No. 2, pp. 121-144.
[22]. Vaasma T. (2010). Grain-size analysis of lake sediments: Research methods and applications. Published PhD Thesis, Tallinn University.
[23]. Wentworth, C. K. (1922). A scale of Grade and class Terms for clastic Sediments. *The Journal of Geology,* **30**(5): 377-392.