Textural Analysis of Soil Deposits from Archaeological Sites, Paturda and Bhon, District Buldhana, Maharashtra

Vaishali Kathale-Ladde
Engineering Sciences Department, SKN Sinhgad Institute of Technology & Science, Lonavala, 410401, India
*Email: vaishali.ladde@gmail.com
Received: 29.9.2024, Revised: 23.4.2025, 25.4.25, Accepted: 26.4.2025

Abstract

Soil texture is a key factor influencing the formation and characteristics of soil deposits. Defined by the relative proportions of sand, silt, and clay, soil texture provides critical insights into the depositional environment. In archaeological contexts, the textural analysis of ancient soil layers significantly aids in understanding the processes that contributed to site formation. This study focuses on the soil texture of deposits from two significant archaeological sites in Sangrampur Taluka, Buldhana District, Maharashtra—namely, the Early Historic site of Bhon and the Early Medieval site of Paturda. A total of 54 soil samples were collected and analyzed using the international pipette method to determine their textural composition. Both sites are strategically located along the banks of the Purna River, suggesting a strong geomorphological influence on soil deposition. The findings reveal that the archaeological deposits predominantly exhibit a silty loam texture, indicating the contribution of riverine alluvium in their formation. In contrast, the virgin and modern surface soils from the region are characterized by a silt texture, highlighting variations in depositional processes over time.

Keywords: textural analysis, soil deposit, formation processes, alluvium, international pipette method.

1. Introduction

Soil texture is the relative content of sand, silt, and clay particles in the soil with a particle size less than 2 mm. This classification is based on the United States Department of Agriculture (USDA) system. **Soil texture** plays a crucial role in influencing the physical, chemical, and biological properties of soil. It is a stable characteristic and an important parameter in archaeological studies for understanding the formation processes of ancient sites. In recent

The work was presented at J.ISAS meet at Pune on 30 July 2024 years, advanced analytical tools and techniques have been introduced to examine stratigraphic deposits in archaeology. However, few studies have explored **soil spectroscopy,** particularly **near-infrared spectroscopy**, to better understand cultural and natural site formation processes[1].

A **low-spectral-resolution field spectrometer[2]** operating in the visible and near-infrared range has been used to analyze archaeological soil deposits. Additionally, the **Laser Diffraction Method (LDM)[3]** is employed to determine soil particle size distribution. The results from LDM are generally consistent with traditional methods such as the sieve and pipette techniques. However, the **precision and reproducibility** of LDM are often limited[4], particularly due to the low sand content and incomplete dispersion of soil particles. Modern archaeological investigations are increasingly incorporating **digital tools[5]** to enhance the study and interpretation of soil and site formation.

For the present study soil samples from two sites were used for textural analysis; the Early Historic site of Bhon (760^{o} 39′ E, 200^{o} 55′ N) is located on the right bank of the river Purna and the Early Medieval site of Paturda (760^{o} 44′ E, 200^{o} 57′ N) is also located on the right bank of the river Wan, a tributary of river Purna in Sangrampur taluka of Buldhana District, Maharashtra. The location of site is shown in Fig. 1[6]. Bhon is an ancient urban settlement spread over an area of more than 10 hectares, whereas Paturda is a village settlement, and both are about 10 km apart from each other with different time periods[7-9]. Charcoal sample collected from Bhon dated by ^{14}C dating method[8] to 3[rd] century BC.

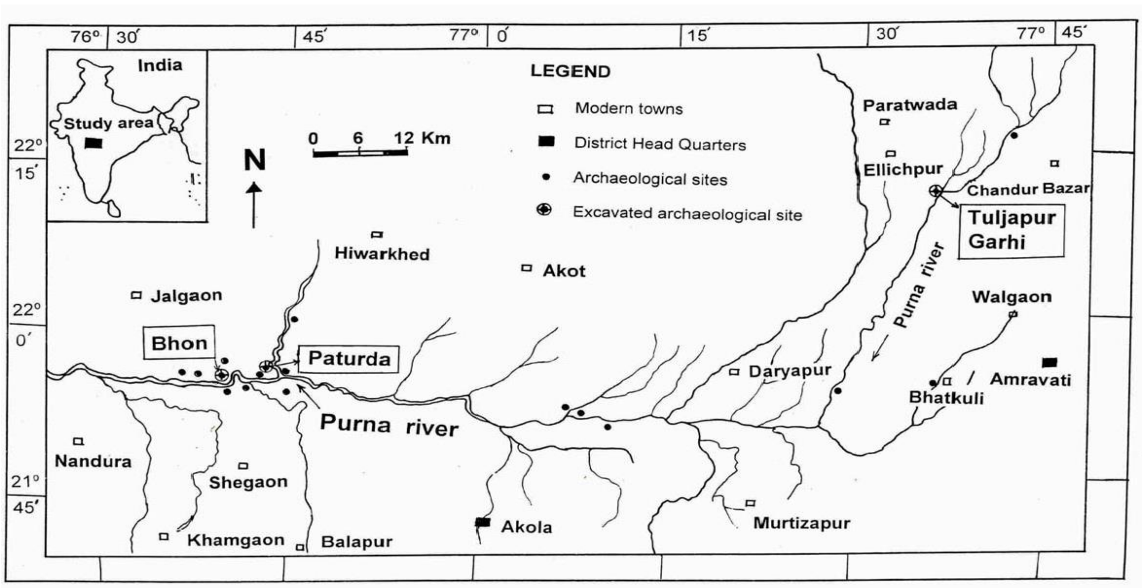

Fig. 1: Location map of sites under study; Bhon and Paturda

2.Materials and Methods

More than 200 samples were collected from excavated trenches, shown in Fig. 2[6], out of which 54 representative samples were selected from stratigraphic trenches as well as from horizontally exposed areas at the excavated sites from Bhon and Paturda for textural analysis. The modern soil samples and virgin soil samples were also collected for reference from both sites. Soil samples from stratigraphy were collected from the bottom to the top to avoid mixing the topsoil sample with the lower one. Samples were collected in the polythene bags and labelled with site name, serial number, and date.

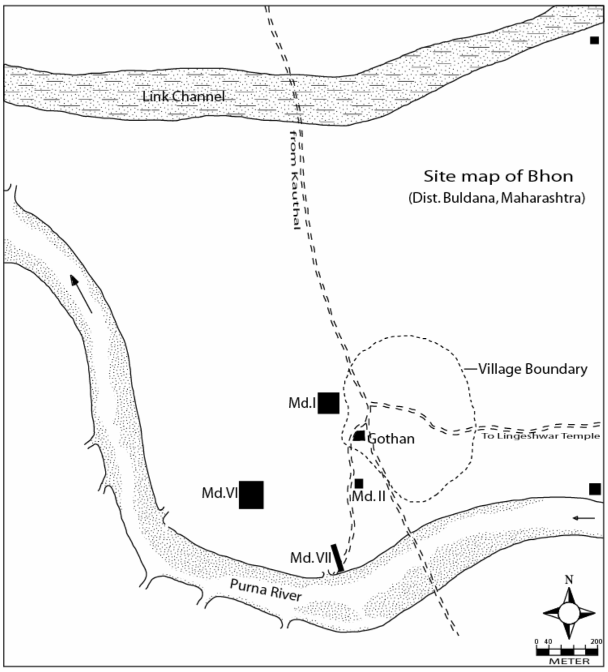

Fig. 2: Location of excavated trenches at Bhon

The proportion of sand (fine sand particles of 0.02 to 0.2 mm; coarse sand 0.2 to 2.00 mm), silt (particle size 0.002 mm to 0.02 mm), and clay (Particle size smaller than 0.002 mm) was determined by the International Pipette method[10-11] by using the standard classification of soil textural units. Different qualitative analysis methods are available to determine the soil texture, such as the hydrometer test, sedimentation, hand texture, and pipette method. For the present study, the international pipette method[10-11] was used. Even though it is time-consuming, was selected due to its more accuracy[12-13]

For preparing the soil sample for pipette method analysis, soil sample was treated with hydrochloric acid to remove all carbonates from the soil and filtered through Whatman No. 42 and washed with distilled water till the soil sample was free from acid. From the soil sample solution, coarse sand particles are separated by using 72 mesh sieve (0.21 mm). Then, the sample was transferred to a glass cylinder and diluted to a fixed volume. The sample was then stirred with a mechanical stirrer for uniform dispersion of soil particles. Soil fractions, clay, silt, and sand, were estimated by the international pipette method[10-12]. The soil texture was determined from the range of soil particles of different textural classes[13] given in Table 1 and USDA Textural Triangle[14] (Fig. 3).

Table 1: The range of soil separates into different textural classes

Textural class	Ranges of soil separates (%)		
	Sand	**Silt**	**Clay**
Sand	85 – 100	0 – 15	0 – 10
Loamy sand	70 – 90	0 – 30	0 – 15
Sandy loam	40 – 80	0 – 50	0 – 20
Loam	23 – 52	28-50	7-27
Silt loam	0 -50	50-88	0-27
Silt	0-20	80-100	0-12
Sandy clay loam	45-80	0-28	20-35
Clay loam	20-45	15-53	27-40
Silty clay loam	0-20	40-73	27-40
Sandy clay	45-65	0-20	35-45
Silty clay	0-20	40-60	40-60
Clay	0-45	0-40	40-100

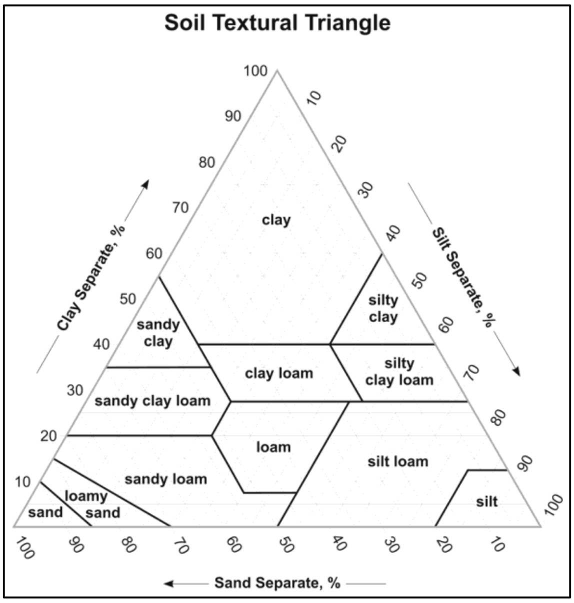

Fig. 3: Soil Textural Triangle diagram of the soil texture classes according to USDA

For the present study soil samples collected from the stratigraphic section at Paturda (Fig. 4) and the stratigraphic section from Trench B at Bhon (Fig. 5).

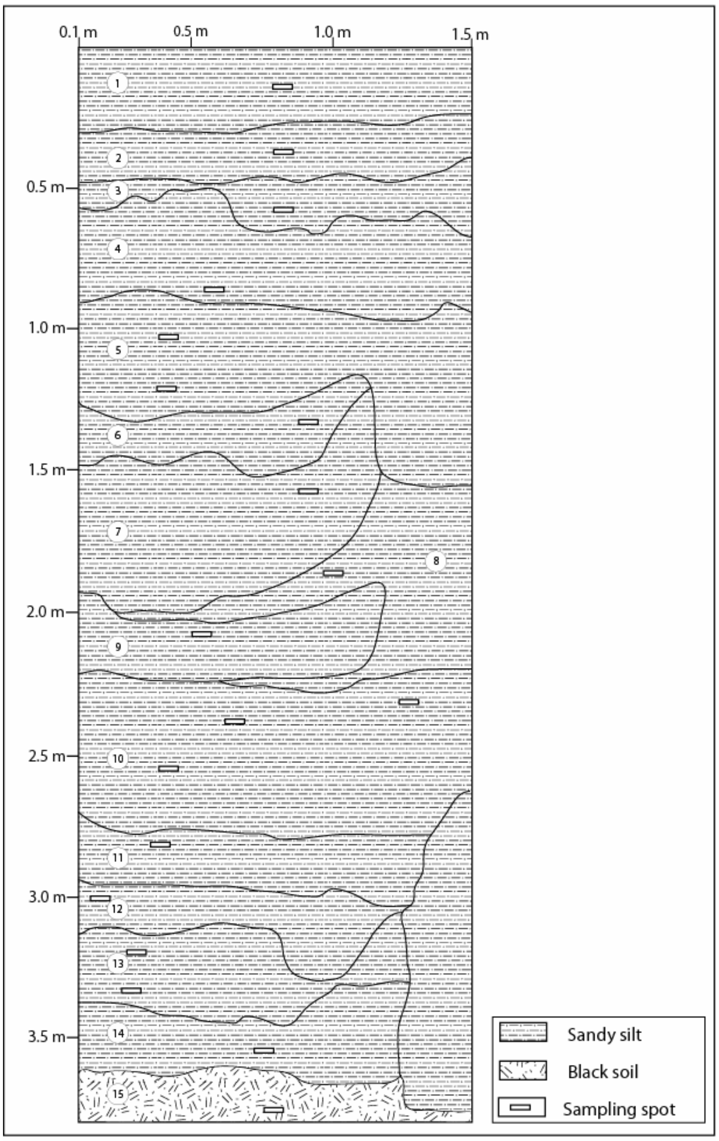

Fig. 4: Stratigraphic section facing south from Paturda

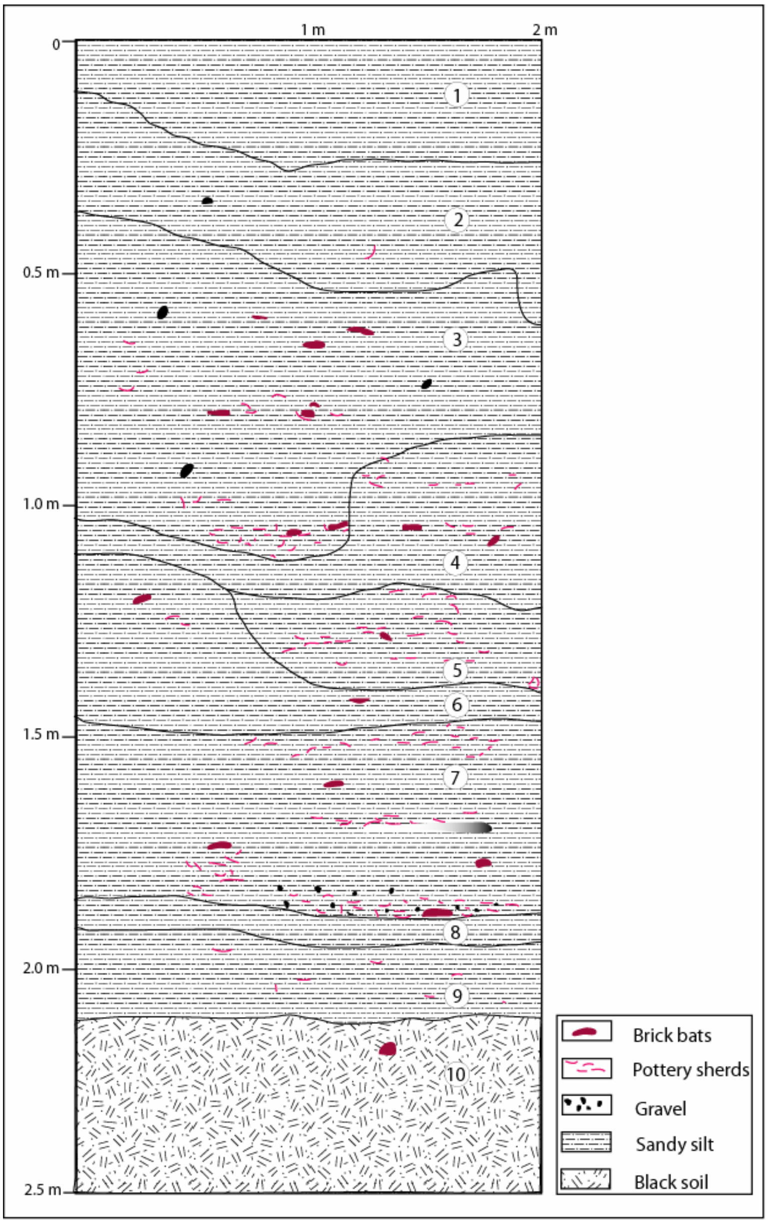

Fig. 5: Stratigraphic section facing south in trench B on Mound I from Bhon

3. Results and Discussions

The textural analysis results thus obtained are incorporated in Tables 2 and 3 for the sites, Paturda and Bhon, respectively. The soil samples from Paturda stratigraphy (Fig. 4) show a soil texture, silt loam (Table 2, Fig. 6). The graphical presentation of particle size distribution from Paturda is presented in Fig. 6, showing all soil samples containing silt fraction below 80%, in the range 52.48% to 78.40%; sand fraction 17.61% to 45.58% and clay fraction from 1.735 to 10.16%. All these soil samples contain soil particles as per the USDA soil particle class Table 1, showing silt loam texture. Whereas the modern soil sample from same site, sample number 20, shows silt texture with the silt fraction 90.03%, sand 8.98% and clay 0.99%.

Table 2: Particle size analysis of samples collected from the Paturda profile

Sample No.	Layer No.	Depth in cm	Description	% Sand	% Silt	% Clay	Texture
1	15	363-372	Dark brown clayeysilt	22.98	66.86	10.16	Silt loam
2	14	347-367	Compact, light graydeposit	27.30	70.19	02.51	Silt loam
3	13	327-338	Compact floor	25.97	69.06	04.97	Silt loam
4	13	310-320	Burnt, red ashydeposit	40.92	54.70	04.38	Silt loam
5	12	300-307	Relatively loosedeposit	23.45	73.74	02.81	Silt loam
6	11	285-290	Compact, moreclayey floor	17.61	78.41	03.98	Silt loam
7	10	258-265	Relatively loosedeposit	33.04	62.90	04.06	Silt loam
8	10	240-250	Loose ashy deposit	25.46	70.01	04.53	Silt loam
9	10	230-240	Compact floor	29.10	65.34	05.56	Silt loam
10	9	206-214	Little loose ashy, decomposed grass	32.76	64.80	02.44	Silt loam
11	8	190-200	Sample from pit	36.28	61.99	01.73	Silt loam
12	7	150-160	Compact, clayey silt	32.84	63.92	03.24	Silt loam
13	6	130-140	Loose ashy deposit	40.62	56.39	02.99	Silt loam
14	5	118-125	Compact floor	45.58	52.48	01.94	Silt loam
15	5	95-102	Loose ashy deposit	37.51	59.97	02.52	Silt loam
16	4	75-85	Loose deposit	33.63	61.58	04.79	Silt loam
17	3	50-55	Very loose deposit,roots present	31.75	63.28	04.97	Silt loam
18	2	30-35	Very loose deposit	36.13	59.83	04.04	Silt loam
19	1	15-20	Disturbed, loose deposit	30.38	66.25	03.38	Silt loam
20	-	10-20	Modern soil sample ~70 m west ofmound	08.98	90.03	00.99	Silt
21	-	253-256	Dig –46 floor soil sample	23.43	71.38	05.19	Silt loam

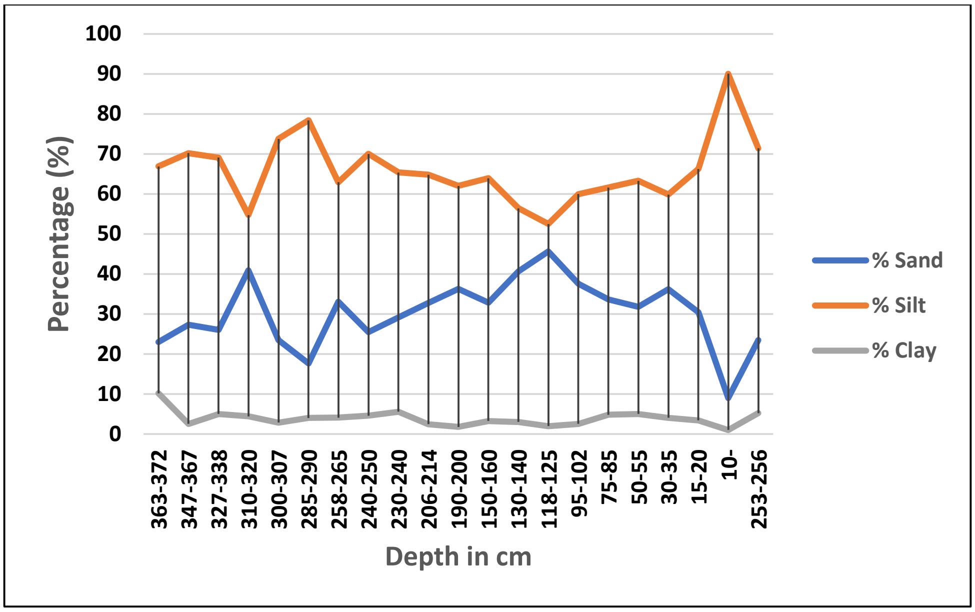

Fig. 6: Distribution of Sand, Silt, and Clay in the samples from Paturda profile

Pipette analysis results of the soil samples from Bhon stratigraphy (Fig. 5, Table 3) show different trends for the texture of the soil deposits. Samples numbers 1,2,5,6,7,9,10 (Table 3,Fig.7) show silt fraction content above 80%; sand fraction ranges from 9.52% to 16.86%, and clay fraction ranges from 1.24% to 3.09%, which is within the range of silt soil texture as per USDA textural class (Table 1). The remaining soil samples' sand fraction in the range 16.71% to 38.52%; silt fraction in the range 56.65% to 79.69%, and clay fraction in the range 2.39% to 4.82%. the texture of these remaining soil samples is silt loam.

Table 3: Particle size Analysis of soil samples from Trench B,Mound-I, at Bhon

Sr. No.	Layer No.	Depth in cm	Description	% Sand	% Silt	% Clay	Texture
1	10	245	Virgin soil	13.09	85.54	1.37	Silt
2	10	225	Compact grayish deposit	9.52	89.24	1.24	Silt
3	9	195-190	Compact clayey silt deposit	31.95	64.82	3.26	Silt loam
4	7	180-185	Ashy deposit	25.84	71.66	2.51	Silt loam
5	7	170-165	Ashy deposit	12.66	85.21	2.22	Silt
6	6	145-140	Compact heterogeneous Deposit	11.26	87.41	1.33	Silt
7	5	135-130	Ashy deposit	16.63	80.27	3.09	Silt
8	4	120-115	Floor deposit, dominated by Clay	16.71	79.69	3.60	Silt loam

9	4	105-100	Floor deposit, dominated by Clay	16.86	81.20	1.94	Silt
10	3	100-85	Compact depositwith lots of pottery and pebbles	18.62	80.34	1.04	Silt
11	3	80-75	Compact depositwith lots of pottery and pebbles	24.07	73.42	2.51	Silt loam
12	2	60-50	Relatively compact deposit	26.89	70.73	2.39	Silt loam
13	2	40-35	Relatively compact deposit	35.03	61.30	3.67	Silt loam
14	1	15-01	Upper portion of trench disturbed and loose	38.53	56.65	4.82	Silt loam

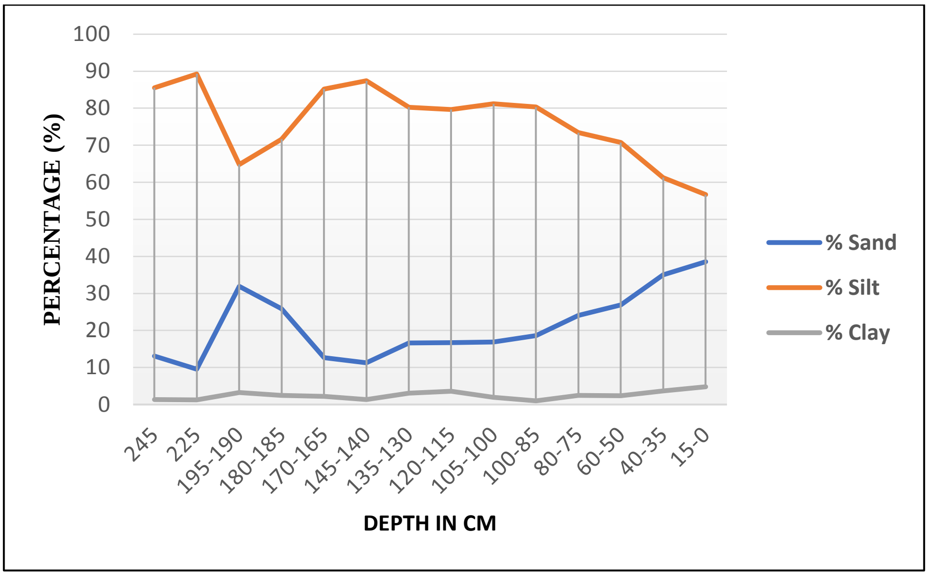

Fig. 7: Distribution of Sand, Silt and Clay in the samples from the Trench B, Mound-I, at Bhon

Conclusions:

The objective of the present study was to find the texture of the soil deposits from sites Paturda and Bhon, to study the formation processes of the two ancient sites. The international pipette method was used to determine the particle fractions of soil, clay, silt and sand, by sedimentation of these soil deposits. This method is widely used in archaeology to extract information about the past climate conditions, agricultural practices and human and natural activities responsible for the formation of these deposits. Accuracy and precision of this method are good, only it is time-consuming and requires good practical accuracy.

The textural analysis of soil deposits from sites Paturda and Bhon situated on the river bank of the river Purna, Buldhana District, Maharashtra. shows the different trend in texture class of soil, Paturda soil samples are silt loam textural class, except modern soil samples with silt texture. Whereas Bhon soil samples show different trend within the stratigraphy from the trench B on Mound I. showing some intense human activities related to burning, causing ash formation showing the silt soil texture of the soil deposits. Other samples from same stratigraphy are of silt loam soil texture.

Both sites are about 10 km apart from each other and of different periods. Paturda is Early Medieval period site and Bhon is Early Historic Site. Time span between these two sites is about 1000 years, and the climate variation of these sites was drastic. During the Early Historic time climate was humid at Bhon and during the Early Medieval period at Paturda climate was semi-arid. This climatic change also plays an important role in the site formation processes and texture of deposits of these two sites. The above particle size analysis results indicate that the origin of all the deposits was the alluvium deposited during the time periods of these sites by the river Purna and its tributary river Wan. The archaeological and non-archaeological deposits are the results of flood activities of the river Purna and different human and natural activities that played a vital role in the formation of the habitational deposit of these two archaeological sites.

Acknowledgement:

Author would like to thank Deccan College Post Graduate Research Institute, Pune for providing the infrastructural facilities. Prof. Dr. B. C. Deotare and Prof. Dr. Shiela Mishra are gratefully acknowledged for their support during this work.

Author's Contributions

Soil sample collection during excavation, soil sample preparation, analysis, investigation, resources, and writing the manuscript.

Conflict of Interest

The author declares no conflict of interest.

References

1. J. Linderholm, P. Geladi, N. Gorretta, R. Bendoula, and A. Gobrecht, Near infrared and hyperspectral studies of archaeological stratigraphy and statistical considerations, Geoarchaeology, 34 (3), 311-321, 2019.
2. Y. J. Choi, J. Lampel, S Fielder, D. Jordan and T. Wagner, A new method for the identification of archaeological soils by their spectral signatures in the vis-NIR region J. Archa. Sci. Reports, 33, 2020. http://dx.doi.org/10.1016/j.jasrep.2020.102553

3. D. N. Svensson, I. Messing and J. Barron, An investigation in laser diffraction analysis to obtain compatible results with sieve and pipette method, Soil & Tillage Research, 223, 2022. https://doi.org/10.1016/j.still.2022.105450
4. C. Polakowski, M. Ry˙zak and A. Bieganowski, Particle Size Distribution of Various Soil Materials Measured by Laser Diffraction—The Problem of Reproducibility, Minerals,11,465, 2021. http://dx.doi.org/10.3390/min11050465
5. S. Sylaiou, Z. Tsifodimou, I. Tavantzis, K. Evangelidis, A. Skondras, A. Stamou, and E. Stylianidis, Redefining Archaeological Research: Digital Tools, Challenges, and Integration in Advancing Methods, Applied Sci, 15, 2025. https://doi.org/10.3390/app15052495
6. V. S. Kathale, Ph. D. Thesis Formation Processes of Historical Sites from Purna Basin, Vidarbha, Maharashtra: A Geochemical Study, DCPGR, Pune 2009.
7. B.C. Deotare, Late Holocene Climatic Change: Archaeological Evidence from the Purna Basin, Maharashtra, J. Geological Society of India. 68, 517-526, 2006.
8. B. Deotare, G. Shete, R. Sawant V. Kathale, S. Naik, Discovery of Structural Stupa at Bhon District Buldana, Maharashtra, Purātattva 37, 176-85, 2006.
9. B. C. Deotare, S. Deo, P. P. Joglekar, S. Ghate qnd S. N. Rajaguru, Archaeology of Early Historic South Asia, Pragati Publication New Delhi, 81-95, 2008.
10. C S. Piper, *Soil and Plant Analysis*. Hans Publisher Bombay1966.
11. P. R. Day, Particle Fractionation and Particle-Size Analysis, In: C. A. Black, Ed., Methods of Soil Analysis, American Society of Agronomy Inc., Madison, 1965, pp. 545-567, 1965.
12. P. D B. J. Palihakkara and U. W. A. Vitharana, A time-efficient and accurate texture analysing method for tropical soils, J. of Agri. And Value Addition 2(2), 1-9, 2019.
13. T. A. Kettler, J. W. Doran and T. L. Gilbert, Simplified Method for Soil Particle-Size Determination to Accompany Soil-Quality Analyses, Published from USDA-ARS/UNL Faculty 305, 2001. http://dx.doi.org/10.2136/sssaj2001.653849x
14. USDA soil textural classification
15. https://www.fao.org/fishery/static/FAO_Training/FAO_Training/General/x6706e/x6706e06.htm