Particle Size Analysis of Soil Obtainable in Maiduguri, Nigeria

D. W. Medugu¹, M. Maina², Y.B. Dibal³

¹Department of Pure and Applied Physics, Adamawa State University, Mubi, Adamawa State, Nigeria
²Department of Science Laboratory Technology, Ramat Polytechnic, Maiduguri, Borno State, Nigeria
³Department of Physics, University of Maiduguri, Maiduguri, Borno State, Nigeria

Abstracts: Soil is a substantial resource and displays adaptable physical, chemical, mineralogical, hydrological and geochemical properties. Particle size is a fundamental analysis procedure for soils, and pedological and paleopedological analysis. In view of this particle size distribution of soil samples were conducted and analysed for 10 locations in Maiduguri, Nigeria by sieving technique. Their sand, silt, and clay contents were determined. The distribution of particle size influences the moisture retention and transmission properties of soils. The overall result showed that the soil in Maiduguri is predominantly sand having low moisture retention and high permeability. This study at higher precision will be helpful for the textural management concerns all operations, practices and treatments used to protect soil and enhance its performance.

Keywords: Particle size, Soil samples, Moisture retention, Textural management

1.0 Introduction
Particle size is a fundamental analysis procedure for soils, and pedological and paleopedological analysis (Konen et al., 2003; Lindbo et al., 2008). Particle size distribution is one of the most important soil characteristics, which influences many soil properties (Ryzak and Bieganowski, 2011). Its distributions also provide fundamental information for rock characterization and geological process description in earth sciences, including sedimentology, stratigraphy, structural geology, pedology, and volcanology (Storti and Balsamo, 2010). The need for classification of soil particles according to their sizes granularity divided into intervals that are called grain size category. There are several classification systems based on differently defined thresholds granularity intervals. The basic division of fine soil particles and the skeleton (particles less than 2 mm) is the same in most systems (Skalová, 2003). The clay (0-2 μm), silt (2-50μm) and sand (50-2000 μm), are three texture fraction which are commonly used to characterize the soil particle distribution of fine soil (< 2 mm) by classifying it into a soil texture class according to a soil texture triangle (Vandecasteele, and De Vos, 2001).

Soil texture is one of the important properties of soil maps and is defined as relative proportions of clay, sand and silt contents. Soil texture has an extremely significant influence on the physical and mechanical behaviours of the soil and on all the properties related to water content and the movement of water (Marc and Jacques, 2011). Soil texture directly affects the porosity of soil, which in turn, determines its water-retention, flow characteristics, rate of water intake, nutrient-holding capacity and long-term soil fertility (Zhengyong et al, 2008). It also determines the soil erodibility and thus, affects the risk of soil erosion. The interaction of soil clay with nutrient ions, water and organic substances determines the soil fertility, which in turn largely controlled by the quality and nature of minerals (Thompson and Troen, 1973). Land use capability and soil management practices are also determined by the texture.

The most fundamental method of soil characterization is the measurement of particle size distribution (PSD). The PSD of a coarse-grained soil is usually found by sieving. Hence the objective of this study was to determine the PSD of the soil samples by sieving technique, also, to find out whether the sieving method is suitable for use on soils collected from Maiduguri and its environs in the North Eastern part of Nigeria.

2.0 Materials and Methods
Soil samples were collected from 10 locations in Maiduguri, Borno State, Nigeria lying on the geographical coordinates of 11° 51’ N, 13° 9’ E. The locations are namely; Bolori Ward, Shehuri North, Limanti Ward Gwange Ward, Gamburu Ward, Bulabulin Ward, Polo Ground, National Stadium and
Teachers Village. From each sampling site, moist soil samples of about 500 g were collected at 0.5 m depth and bulked to form a composite air-dried, gently crushed to break the clods and passed through a 2-mm sieve to separate the fine-earth materials from coarse fragments with the aid of sieve shaker machine. The sieves were removed from the sieve machine and the contents retained, passed and percentages passed (mass) by each sieve were weighed and recorded using electronic balance. The process was repeated for the remaining samples of the remaining locations at different depths -1.0 m, 1.5 m and 2.0 m. A wet sieving method was used for Polo Ground, National Stadium and Teachers Village because of their high clay and silt contents.

3.0 Results and Discussion
3.1 Particle Size Analysis of Soil
Tables 1 – 10, are the sieve analysis test results for the locations where the samples were collected. The Tables show weight retained (g), cumulative weight retained (g), percentage weight retained and percentage of the weight that passed from each sieve number. For the sake of completeness, Particle size distribution characteristics of these locations are presented in Figures 1 – 10.

The distribution of particle size influences the moisture retention and transmission properties of soils. From the result obtained, the soil at 7 locations are sand with the highest passentage content value of 99.28% obtained in Bulabulin ward followed by 99.06% obtained in Ramat Polytechnic area while the least passentage content value of 95.74% is obtained in Bolori ward. The soils have low moisture retention and high permeability. The soil at the National Stadium and Teachers Village have the silt and clay passentage content value of 41.66% and 41.92 % of respectively. Hence the soil is classified as loam. The soils in this area have high moisture retention and low permeability. The soil at Polo Ground is clay soil since it has 75.74% content value of clay and silt. This may be due to inadequate drainage. The clay fraction contains larger alumin oxide-silicates and has higher content of humus. Therefore, the properties of soils are affected by clay content rather than silt and sand particle. The clay content is also characterized by a higher charge density per unit surface. The overall result showed that the soil in Maiduguri is predominantly sand.

The process of particle size analysis of soil textural characteristic helped for continuous textural information generation at precise level. The superimposing of soil samples over soil types clearly visualized the relationship between soil types and texture.

Table 1: Particle Size Analysis of the soils from Ramat Polytechnic

| S/N | Sieve size (mm) | Weight Retained (g) | Cumulative Weight Retained (g) | %Weight Retained(g) | % Weight Passing |
|-----|----------------|---------------------|-------------------------------|----------------------|------------------|
| 1   | 4.750          | 7.2                 | 7.2                           | 1.44                 | 98.56            |
| 2   | 3.750          | 8.3                 | 15.5                          | 1.66                 | 96.90            |
| 3   | 2.360          | 21.0                | 36.5                          | 4.20                 | 92.70            |
| 4   | 1.180          | 38.2                | 74.7                          | 7.64                 | 85.06            |
| 5   | 0.600          | 70.3                | 145.0                         | 14.04                | 71.02            |
| 6   | 0.425          | 56.0                | 201.0                         | 11.20                | 59.82            |
| 7   | 0.300          | 40.6                | 241.6                         | 8.12                 | 51.70            |
| 8   | 0.150          | 230.0               | 471.6                         | 46.0                 | 5.70             |
| 9   | 0.075          | 23.7                | 495.3                         | 4.74                 | 0.96             |
| Pan | 4.1            |                      | 499.4                         | 0.82                 | 0.14             |

Weight of dry sample before sieving = 500g
Percentage of sand content = 99.06%
Percentage of clay and silt content = 94%
The soil is sand soil.
Table 2: Particle Size Analysis of the soils from Bolori

| S/N | Sieve size (mm) | Weight Retained (g) | Cumulative Weight Retained (g) | % Weight Retained | % Weight Passing |
|-----|----------------|---------------------|--------------------------------|-------------------|-----------------|
| 1   | 4.750          | 0.0                 | 0.0                            | 0.0               | 100             |
| 2   | 3.750          | 0.6                 | 0.6                            | 0.12              | 99.88           |
| 3   | 2.360          | 1.4                 | 2.0                            | 0.28              | 99.60           |
| 4   | 1.180          | 32.0                | 34.0                           | 6.40              | 93.2            |
| 5   | 0.600          | 114.5               | 148.5                          | 22.90             | 70.3            |
| 6   | 0.425          | 77.1                | 225.6                          | 15.42             | 54.88           |
| 7   | 0.300          | 58.1                | 283.7                          | 11.62             | 43.26           |
| 8   | 0.150          | 150.8               | 434.5                          | 30.16             | 13.10           |
| 9   | 0.075          | 44.2                | 478.7                          | 8.84              | 4.26            |
| 10  | Pan            | 20.6                | 499.3                          | 4.12              | 0.34            |

Total 499.3

Weight of dry sample before sieving = 500g
Percentage of sand = 95.74%
Percentage of silt and clay = 4.26%
The soil is sand soil.

Table 3: Particle Size Analysis of the soils from Limanti Ward

| S/N | Sieve size (mm) | Weight Retained (g) | Cumulative Weight Retained (g) | % Weight Retained | % Weight Passing |
|-----|----------------|---------------------|--------------------------------|-------------------|-----------------|
| 1   | 4.750          | 2.4                 | 2.4                            | 0.48              | 99.52           |
| 2   | 3.750          | 2.5                 | 4.9                            | 0.50              | 99.02           |
| 3   | 2.360          | 5.3                 | 10.2                           | 1.06              | 97.96           |
| 4   | 1.180          | 32.8                | 43.0                           | 6.40              | 91.56           |
| 5   | 0.600          | 123.2               | 166.2                          | 24.64             | 66.92           |
| 6   | 0.425          | 92.0                | 258.2                          | 18.40             | 48.52           |
| 7   | 0.300          | 68.4                | 326.6                          | 13.68             | 34.84           |
| 8   | 0.150          | 126.4               | 453.0                          | 24.48             | 10.36           |
| 9   | 0.075          | 36.4                | 489.4                          | 7.28              | 3.08            |
| 10  | Pan            | 10.5                | 499.9                          | 2.10              | 0.98            |

Total 499.9

Weight of dry sample before sieving = 500g
Percentage of sand = 97.88%
Percentage of silt and clay = 2.12%
The soil is sand soil.

Table 4: Particle Size Analysis of the soils from Gamboru

| S/N | Sieve size (mm) | Weight Retained (g) | Cumulative Weight Retained (g) | % Weight Retained | % Weight Passing |
|-----|----------------|---------------------|--------------------------------|-------------------|-----------------|
| 1   | 4.750          | 9.1                 | 9.1                            | 1.82              | 98.18           |
| 2   | 3.750          | 10.2                | 19.3                           | 2.04              | 96.14           |
| 3   | 2.360          | 27.9                | 47.2                           | 5.58              | 90.56           |
| 4   | 1.180          | 87.5                | 134.7                          | 17.50             | 73.06           |
| 5   | 0.600          | 127.6               | 262.3                          | 25.52             | 47.81           |
| 6   | 0.425          | 79.7                | 342.0                          | 15.94             | 31.87           |
| 7   | 0.300          | 54.9                | 396.9                          | 10.98             | 20.89           |
| 8   | 0.150          | 95.3                | 492.2                          | 19.06             | 1.83            |
| 9   | 0.075          | 3.2                 | 495.4                          | 0.64              | 1.19            |
| 10  | Pan            | 1.8                 | 497.2                          | 0.36              | 0.83            |

Total 497.2

Weight of dry sample before sieving = 500g
Percentage of sand = 99.08%
Percentage of silt and clay = 0.92%
The soil is sand soil.
### Table 5: Particle Size Analysis of the soils from Shehuri North

| S/NO | Sieve size (mm) | Material retained (g) | Cumulative Weight Retained (g) | % Weight Retained | % Weight Passing |
|------|-----------------|-----------------------|-------------------------------|-------------------|------------------|
| 1    | 4.750           | 7.8                   | 7.8                           | 1.56              | 98.44            |
| 2    | 3.750           | 8.1                   | 15.9                          | 1.62              | 96.82            |
| 3    | 2.360           | 22.1                  | 38.0                          | 4.42              | 92.4             |
| 4    | 1.180           | 69.6                  | 107.6                         | 13.92             | 86.08            |
| 5    | 0.600           | 104.3                 | 211.9                         | 20.86             | 79.14            |
| 6    | 0.425           | 73.0                  | 284.9                         | 14.60             | 85.40            |
| 7    | 0.300           | 59.9                  | 344.8                         | 11.90             | 88.10            |
| 8    | 0.150           | 123.6                 | 468.4                         | 24.72             | 75.28            |
| 9    | 0.075           | 25.0                  | 493.4                         | 5.00              | 95.00            |
| 10   | Pan             | 6.1                   | 499.5                         | 1.22              | 98.78            |

Total: 499.5

Weight of dry sample before sieving = 500g
Percentage of sand = 98.68%
Percentage of silt and clay = 1.32%
The soil is sand soil.

### Table 6: Particle Size Analysis of the soils from Gwange

| S/NO | Sieve size (mm) | Weight Retained (g) | Cumulative Weight Retained (g) | % Weight Retained | % Weight Passing |
|------|-----------------|---------------------|-------------------------------|-------------------|------------------|
| 1    | 4.750           | 12.4                | 12.4                          | 2.48              | 97.52            |
| 2    | 3.750           | 18.0                | 30.4                          | 3.60              | 93.92            |
| 3    | 2.360           | 45.8                | 76.2                          | 9.16              | 90.84            |
| 4    | 1.180           | 118.9               | 195.1                         | 23.78             | 76.22            |
| 5    | 0.600           | 118.4               | 313.5                         | 23.68             | 76.32            |
| 6    | 0.425           | 57.1                | 370.6                         | 11.42             | 88.58            |
| 7    | 0.300           | 40.9                | 408.0                         | 7.48              | 92.52            |
| 8    | 0.150           | 74.7                | 482.7                         | 14.94             | 85.06            |
| 9    | 0.075           | 13.6                | 496.3                         | 2.72              | 97.28            |
| 10   | Pan             | 3.2                 | 499.5                         | 0.64              | 99.36            |

Total: 499.5

Weight of dry sample before sieving = 500g
Percentage of sand = 99.26%
Percentage of silt and clay = 0.74%
The soil is sand soil.

### Table 7: Particle Size Analysis of the soils from Bulabulin

| S/NO | Sieve size (mm) | Weight Retained (g) | Cumulative Weight Retained (g) | % Weight Retained | % Weight Passing |
|------|-----------------|---------------------|-------------------------------|-------------------|------------------|
| 1    | 4.750           | 12.9                | 12.9                          | 2.58              | 97.42            |
| 2    | 3.750           | 16.4                | 29.3                          | 3.28              | 96.72            |
| 3    | 2.360           | 34.1                | 63.4                          | 6.82              | 93.18            |
| 4    | 1.180           | 113.1               | 176.5                         | 22.62             | 77.38            |
| 5    | 0.600           | 145.9               | 322.4                         | 29.18             | 70.82            |
| 6    | 0.425           | 59.2                | 481.6                         | 11.84             | 88.16            |
| 7    | 0.300           | 35.9                | 417.5                         | 7.18              | 92.82            |
| 8    | 0.150           | 67.1                | 484.6                         | 13.42             | 86.58            |
| 9    | 0.075           | 11.8                | 496.4                         | 2.36              | 97.64            |
| 10   | Pan             | 3.0                 | 499.4                         | 0.6               | 99.40            |

Total: 499.4

Weight of dry sample before sieving = 500g
Percentage of sand = 99.28%
Percentage of silt and clay = 0.72%
The soil is sand soil.
Particle Size Analysis of the soils from Polo Ground

| S/N | Sieve size (mm) | Weight Retained (g) | Cumulative Weight Retained (g) | % Weight Retained | % Weight passing |
|-----|-----------------|---------------------|--------------------------------|-------------------|-----------------|
| 1   | 4.750           | 22.00               | 22.00                          | 4.40              | 95.60           |
| 2   | 3.750           | 13.00               | 35.00                          | 2.60              | 97.40           |
| 3   | 2.360           | 15.02               | 50.02                          | 3.00              | 97.00           |
| 4   | 1.180           | 9.00                | 59.02                          | 1.80              | 98.20           |
| 5   | 0.600           | 8.40                | 67.42                          | 1.68              | 98.32           |
| 6   | 0.425           | 21.60               | 89.02                          | 4.32              | 95.68           |
| 7   | 0.300           | 6.20                | 95.22                          | 1.24              | 98.76           |
| 8   | 0.150           | 18.00               | 113.22                         | 3.60              | 96.40           |
| 9   | 0.075           | 8.1                 | 121.32                         | 1.62              | 98.38           |
| 10  | Pan             | 0.00                | Total 121.32                   |                   |                 |

Weight of dry sample before sieving = 500g
Percentage of sand = 24.26%
Percentage of clay and silt content = 75.74%
The soil is clay soil.

Particle Size Analysis of the soils from National Stadium

| S/N | Sieve size (mm) | Weight Retained (g) | Cumulative Weight Retained (g) | % Weight Retained | % Weight passing |
|-----|-----------------|---------------------|--------------------------------|-------------------|-----------------|
| 1   | 4.750           | 23.80               | 23.80                          | 4.76              | 95.24           |
| 2   | 3.750           | 27.90               | 51.7                           | 5.58              | 94.42           |
| 3   | 2.360           | 33.60               | 85.3                           | 6.72              | 93.28           |
| 4   | 1.180           | 41.20               | 126.5                          | 8.24              | 91.76           |
| 5   | 0.600           | 32.80               | 159.3                          | 6.56              | 93.44           |
| 6   | 0.425           | 40.50               | 199.8                          | 8.10              | 91.90           |
| 7   | 0.300           | 31.60               | 231.4                          | 6.32              | 93.68           |
| 8   | 0.150           | 33.70               | 265.1                          | 6.74              | 93.26           |
| 9   | 0.075           | 26.6                | 291.7                          | 5.32              | 94.68           |
| 10  | Pan             | 0.00                | Total 291.7                    |                   |                 |

Weight of dry sample before sieving = 500g
Percentage of sand content = 58.34%
Percentage of clay and silt = 41.66%
The soil is loam soil.

Particle Size Analysis of the soils from Teachers Village

| S/N | Sieve size (mm) | Weight Retained (g) | Cumulative Weight Retained (g) | % Weight Retained | % Weight passing |
|-----|-----------------|---------------------|--------------------------------|-------------------|-----------------|
| 1   | 4.750           | 25.4                | 25.4                           | 5.08              | 94.92           |
| 2   | 3.750           | 30.2                | 55.6                           | 6.04              | 93.96           |
| 3   | 2.360           | 35.2                | 90.8                           | 7.00              | 93.00           |
| 4   | 1.180           | 40.9                | 131.7                          | 8.18              | 91.82           |
| 5   | 0.600           | 30.4                | 162.1                          | 6.08              | 93.92           |
| 6   | 0.425           | 38.5                | 2000.6                         | 7.70              | 92.30           |
| 7   | 0.300           | 31.5                | 232.1                          | 6.30              | 93.70           |
| 8   | 0.150           | 35.0                | 267.1                          | 7.00              | 93.00           |
| 9   | 0.075           | 23.5                | 290.6                          | 4.70              | 95.30           |
| 10  | Pan             | 0.00                | Total 290.6                    |                   |                 |

Weight of dry sample before sieving = 500g
Percentage of sand content = 58.08%
Percentage of silt and clay = 41.92%
The soil is loam soil.
Fig. 1: Particle size distribution characteristics of various soils used in Ramat Polytechnic.

Fig. 2: Particle size distribution characteristics of various soils used in Bolori ward.

Fig. 3: Particle size distribution characteristics of various soils used in Limanti ward.
Fig. 4: Particle size distribution characteristics of various soils used in Gamboru ward.

Fig. 5: Particle size distribution characteristics of various soils used in Shehuri North.

Fig. 6: Particle size distribution characteristics of various soils used in Gwange ward.
Fig. 7: Particle size distribution characteristics of various soils used in Bulabulin.

Fig. 8: Particle size distribution characteristics of various soils used in Polo Ground.

Fig. 9: Particle size distribution characteristics of various soils used in National Stadium.
4.0 Conclusion
The particle size distribution of soil samples were conducted for 10 locations in Maiduguri, Borno State, Nigeria by sieving technique. It is observed that this method is a fast, repeatable and accurate method of soil particle size determination. Three textural groups of soils viz. clay, loam and sand were identified in the areas. Out of these, majority of the samples represent sand which are located in 7 locations namely: Ramat Polytechnic, Bolori, Limanti, Gamboru, Shehruri North, Gwange and Bulabulin indicating that the soil in Maiduguri is predominantly sand. The soils have low moisture retention and high permeability. The study of soil textural characteristics at higher precision will be helpful for the textural management concerns all operations, practices and treatments used to protect soil and enhance its performance.

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