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The Cumulative Particle Size Distribution Curves for Three Different Textural Soils in Albania

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Abstract

In spite of the undisputable importance of the cumulative particle size distribution curves in textural assessment of soils, there is not any effort, up to now, to build them in the research process of Albania. Even more, there is not any effort to use or apply these curves in the general practice of soil management. The only way to deal with the texture of Albanian soils up to now has been by using the textural triangles, which many times have brought confusion in the process. That is why, the objective of this study is to initiate the process of introducing the cumulative particle size distribution curves in research process of scientists in Albania and on this base, developing some more accurate methods to replace gradually the textural triangles in the textural assessment process of soils. In this context, this article will be followed by other ones, in order to cover adequately the entire process of replacement the textural triangles by cumulative particle size distribution curves. The method applied is based on the combining of three very much known classifications on particle sizes: ISSS, USDA and Katschinski ones, with their specific particle sizes limit ranges. The soils picked to carry out the study are respectively representatives of three major groups, divided as such based on textural status: light soil, medium soil and heavy soil. The curves were determined by applying the regression analysis. The determined functions showed the distribution of particles of various sizes over a range starting from less than 1 µm to 2000 µm. It resulted that the best fit, for each of the three soils considered, is a semi logarithmic function, which is in accordance with the results of many research works done in this area.

Keywords: Soil texture, particle size distribution, textural triangle, regression analysis, particle size limit ranges.

1. Introduction

It is within a general agreement that the arbitrary limits of soil textural classes, based on a relative combination of soil particles as clay, silt and sand, can be avoided if the textural triangle would be replaced by the cumulative particle size distribution curves. This very essential idea has been originally stressed by [5], in his later publications as well as [6], [7], [8]; and by many other scientists following him, as [2], [9]. In some other works, including the present one, can even be found that for the same textural soil class taken from a given textural triangle, several cumulative particle size distribution can be found. It means that being arbitrary, the soil textural triangle, whatever system it belongs to, is not an accurate mean to determine the textural status of a given soil [4]. To this arbitrary, undefined situation, the confusion caused by the existing of different systems of soil particles classification, as it is fully known, will have to be added. The cumulative particle-size distribution curves, which represent the relative distribution of soil particles mass of various sizes over a given range of sizes, avoid the arbitrary status of both: particles classification based on size and soil texture classification by textural triangles, whatever system it might belong. However, it is also well known that having all of these advantages, the cumulative particle-size distribution curves have also one important disadvantage or limitation: these curves are realistic for "the well graded" soils only. The cumulative particle size distribution curves are also great means by which the very important hydraulic

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properties of soils, like soil water retention curves and hydraulic conductivity [2], [3] can be predicted.

2. Materials and Methods

In this study, three different soils from the textural point of view are chosen: pedon 19, classified as a representative of sandy clay loam class; pedon 21, classified as clay soil, and pedon 28, classified as fine sandy loam soil, as it is described in [11]. The naming of soil is done based on the USDA textural triangle system. The soils to be analyzed were picked in order to represent as realistically as it is possible the three respective soil characterization: heavy, medium, and light ones. Even more important than that, the limit sizes of the particles were collected from the most known textural systems: ISSS, USDA, Katschinski. It is shown in the following Table 1. The concept introduced by the inequation, sign >, means “the particles size less than the actual size”. For example, the “> 0.001” means all the particles with the size less than 0.001mm; as “> 0.002” means all the particles with the size less than 0.002 mm, including those with the size less than 0.001mm as well.

Table 1. Method applied to determine the cumulative distribution of particles with various size limits (where VF is very fine, F is fine, M is medium, C is coarse, VC is very coarse)

Particle size mm	The classification it belongs to	The particles Involved
0,001	Katschinski	clay fine
0,002	USDA&ISSS	clay
0,01	Katschinski	clay +fine silt
0,05	USDA&Katschinski	clay + fine silt + coarse silt
0,1	USDA	clay + fine silt + coarse silt + VF sand
0,25	USDA&Katschinski	clay + fine silt + coarse silt + (VF + F) sand
0,5	USDA&Katschinski	clay + fine silt + coarse silt + (VF + F+ M) sand
1	USDA&Katschinski	clay + fine silt + coarse silt + (VF + F + M + C) sand
2	USDA&ISSS	clay + fine silt + coarse silt + (VF + F + M + C+ VC) sand

The above table was filled with the measured values presented in the following one:

Table 2. The measured values of clay, silt and sand in the three soils under investigation

Mean	Percent < 2mm			% of Clay	Silt (%)		Sand (%)				
Pedon	Clay	Silt	Sand	Fine clay	Fine	Coarse	VF	F	M	C	VC
Pedon19	34.47	35.44	30.09	18.47	20.30	15.14	10.33	11.91	4.51	2.07	1.26
Pedon 21	60.67	31.00	8.33	31.88	22.93	8.07	2.73	2.55	1.38	1.02	0.65
Pedon 28	20.81	65.90	13.29	4.43	47.04	18.86	6.89	5.46	0.47	0.31	0.18

After the Table 1 was set, then it became possible the regression analysis to be done. By this analysis, the distribution of particles with various sizes was quantified and the shape of curves and regression coefficients were determined.

3. Results and discussions

Before the regression analysis was done, the measurements range were determined and presented in the following tables for each soil under the consideration. The number of determinations represents the number of soil profile layers, as all other indicators (mean, standard deviation, minimum and maximum) do so:

Table 3. The measured particle-size distribution belonging to Pedon 21, classified as clay soil

Particle size fraction	Mean	Standard deviation	Minimum	Maximum	Number of determinations
µm	%	%	%	%	
<1	31.88	13.00	31.88	31.88	6
<2	60.67	24.70	60.67	60.67	6
<10	83.60	26.68	22.93	60.67	6
<50	91.67	27.12	8.07	60.67	6
<100	94.40	26.15	2.73	60.67	6
<250	96.95	24.52	2.55	60.67	6
<500	98.33	23.13	1.38	60.67	6
<1000	99.35	21.90	1.02	60.67	6
<2000	100.00	20.8	0.7	60.7	6

Table 4. The measured particle-size distribution belonging to Pedon 19, classified as sandy clay loam soil

Particle size fraction	Mean	Standard deviation	Minimum	Maximum	Number of determinations
µm	%	%	%	%	
<1	18.47	6.98	18.47	18.47	7
<2	34.47	13.02	34.47	34.47	7
<10	54.77	10.02	20.30	34.47	7
<50	69.91	10.01	15.14	34.47	7
<100	80.24	10.43	10.33	34.47	7
<250	92.16	9.74	10.33	34.47	7
<500	96.67	10.40	4.51	34.47	7
<1000	98.74	10.88	2.07	34.47	7
<2000	100.0	11.0	1.3	34.5	7

Table 5. The measured particle-size distribution belonging to Pedon 28, classified as fine sandy loam

Particle size fraction	Mean	Standard deviation	Minimum	Maximum	Number of determinations
µm	%	%	%	%	
<1	4.43	1.67	4.43	4.43	7
<2	20.81	7.86	20.81	20.81	7
<10	67.86	18.55	20.81	20.81	7
<50	86.71	15.74	18.86	18.86	7
<100	93.60	16.92	6.89	6.89	7
<250	99.06	16.71	5.46	5.46	7
<500	99.53	16.90	0.47	0.47	7
<1000	99.84	16.61	0.31	0.31	7
<2000	100.0	16.2	0.2	0.2	7

The results of regression analysis produced semi logarithmic functions, which provided the maximum coefficients of regression. These functions are presented in the following figures:

Determin	Mean
x	y
>0.001	31.88
>0.002	60.67
>0.01	83.60
>0.05	91.67
>0.1	94.40
>0.25	96.95
>0.5	98.33
>1	99.35
>2	100.0

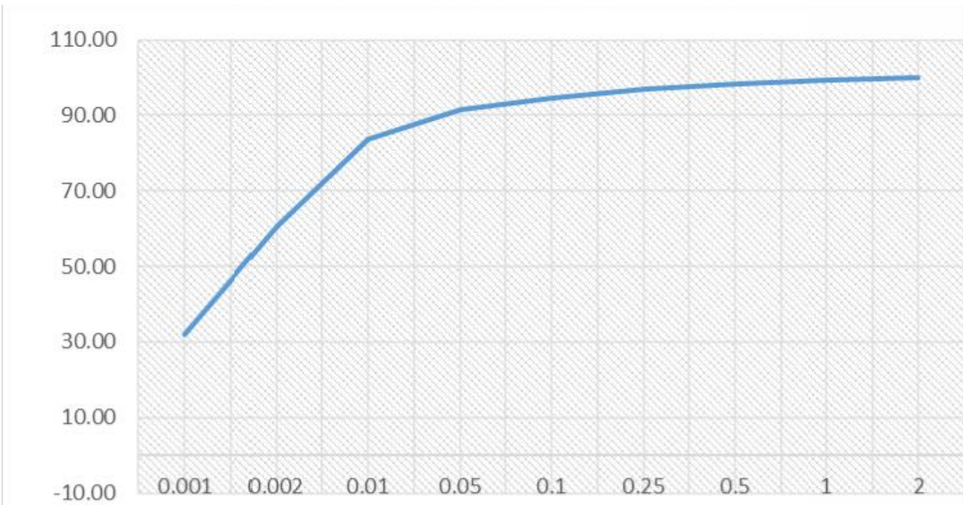


Figure 1. The cumulative particle-size distribution function belonging to Pedon 21, classified as clay soil

Determin	Mean
x	y
>0.001	18.47
>0.002	34.47
>0.01	54.77
>0.05	69.91
>0.1	80.24
>0.25	92.16
>0.5	96.67
>1	98.74
>2	100.0

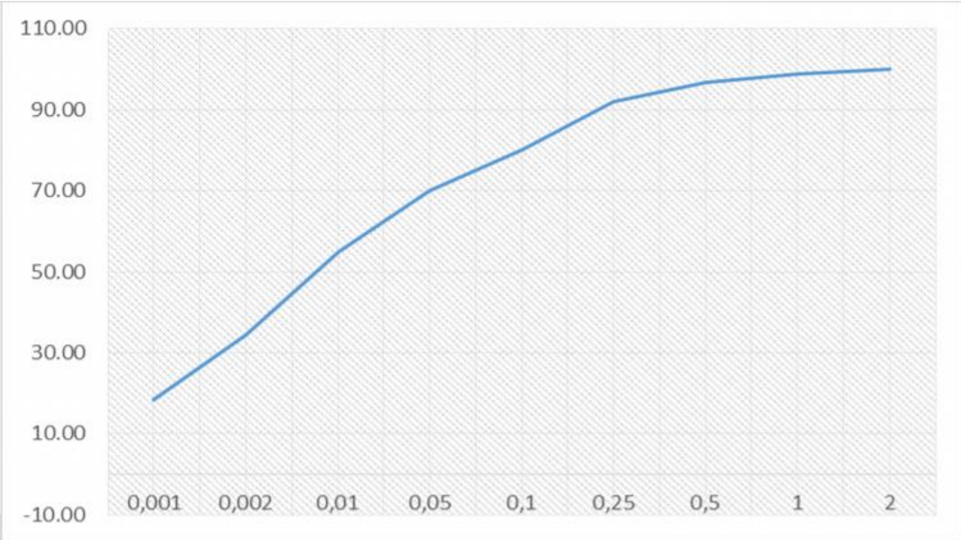


Figure 2. The cumulative particle-size distribution function belonging to Pedon 19, classified as sandy clay loam soil

Particle size fraction	Mean
μm	%
<1	4.43
<2	20.81
<10	67.86
<50	86.71
<100	93.60
<250	99.06
<500	99.53
<1000	99.84
<2000	100.0

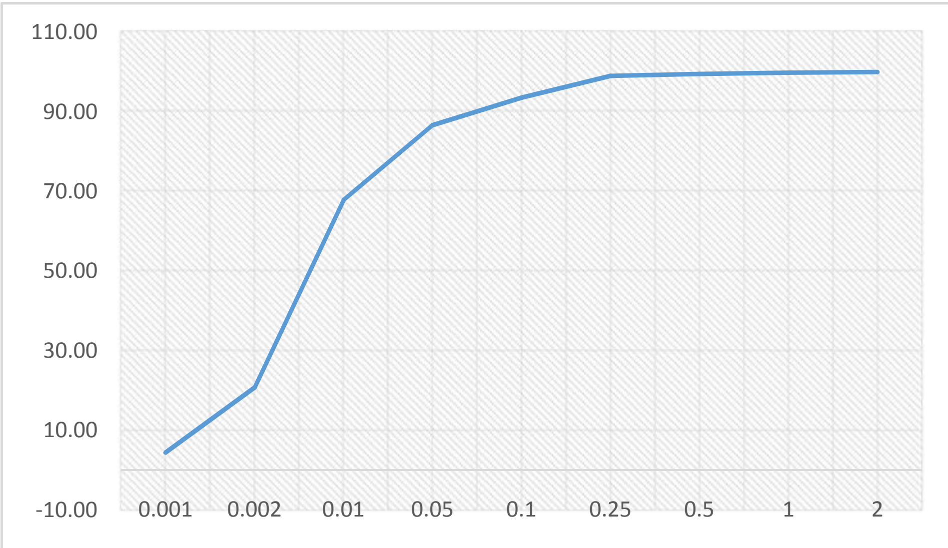


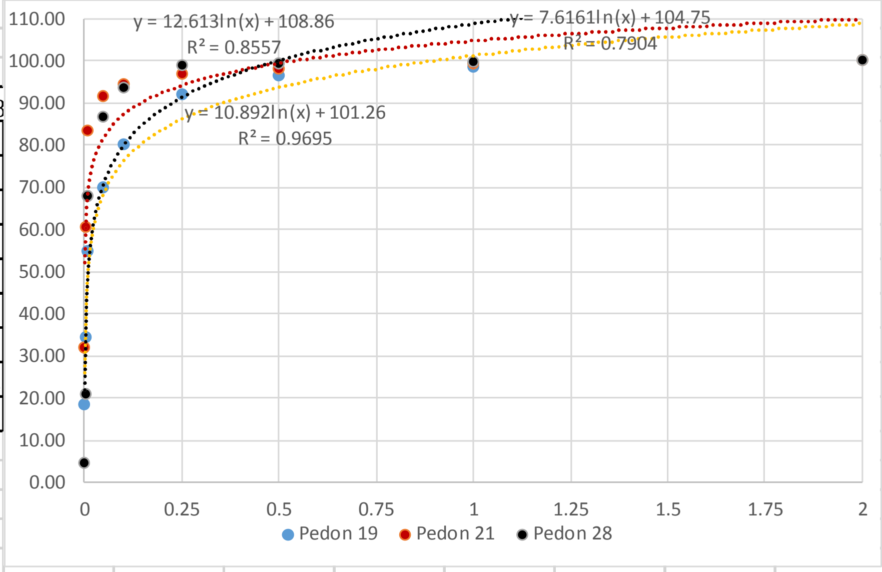
Figure 3. The cumulative particle-size function belonging to Pedon 28, classified as fine sandy loam

It can be easily noticed, that the three curves are cumulative, and because of that, they have a rising wing, starting from almost zero point and after, they go closer and closer almost asymptotically to a parallel line with the x axis corresponding with a value of 100% in y axis. It is for sure that if a given size particle on x-axis corresponds with a given relative amount shown on the y-axis, then you are to be sure that the soil under the consideration is going to be as it is marked under the graph. For example, if the relative amount of the particles less than 0.01mm is going to be at about 84%, then the soil should be classified as clay soil and it can be classified neither as sandy clay loam nor as fine sandy loam.

In order to have the advantage of comparison among the three cumulative particle-size distributions, placing the three of them in the same graph is necessary. This is shown in the following graphs.

a.

Determir	Pedon 19	Pedon 21	Pedon 28
0.001	18.47	31.88	4.43
0.002	34.47	60.67	20.81
0.01	54.77	83.60	67.86
0.05	69.91	91.67	86.71
0.1	80.24	94.40	93.60
0.25	92.16	96.95	99.06
0.5	96.67	98.33	99.53
1	98.74	99.35	99.84
2	100.0	100.0	100.0



b.

Determin	Pedon 19	Pedon 21	Pedon 28
0,001	18.47	31.88	4.43
0,002	34.47	60.67	20.81
0,01	54.77	83.60	67.86
0,05	69.91	91.67	86.71
0,1	80.24	94.40	93.60
0,25	92.16	96.95	99.06
0,5	96.67	98.33	99.53
1	98.74	99.35	99.84
2	100.0	100.0	100.0

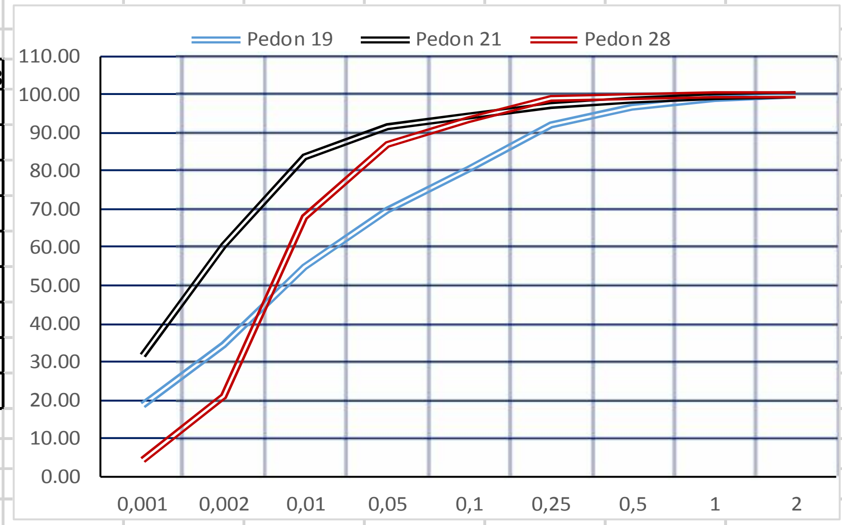


Figure 4. The cumulative particle-size functions belonging to Pedon 21, 19, and 28 classified respectively as clay, sandy clay loam and fine sandy loam; a. statistically elaborated and b. not treated statistically

As it can be seen, the cumulative particle-size curve belonging to clay soil is over placed to the rest of the curves, which clearly indicates that for the same particle size limit, let say 0.01mm, a soil will be called as clay (heavy soil) if the relative percentage is more than 80%; it would be called sandy clay loam (medium soil) if the relative percentage is a little bit less than 70%; it would be called sandy loam (light soil) if the relative percentage is a little bit more than 50%. This is the advantage of the cumulative curves in comparison to the textural triangles: the arbitrary limits or zones in the textural triangles are avoided and replaced by a natural distribution of particles over a wide range of sizes.

4. Conclusions

a. The cumulative particle-size distribution curves showed that, being as built by participation of particles of various sizes coming from the three main known classifications: ISSS, USDA, Katschinski, reflect realistically the textural status of a given soil. The high and significant coefficients of regressions confirmed it.

b. The best statistical fit found for the cumulative particle-size distribution curves was the semi logarithmic function in each of the three soils considered in this research.

c. The heavier the soil, the more over placed is the "cumulative particle size distribution curve" in the relative percentage – soil particle size system of coordinates.

d. The experimentally determined cumulative curves are going to be a very good base to study the hydraulic properties of those soils the curves belong to.

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