RESEARCH ARTICLE **(Open Access)**

Erodibility factor in soils of Albania

PRANVERA MZIU[1], OLIVER LEKAJ[1], BESNIK GJONGECAJ[2*]

[1]M.Sc., PhD student.,Department of Agro-environment and Ecology, Agricultural University of Tirana, Kodër Kamëz, Tirana, Albania.

[2]Prof. Dr., Department of Agro-environment and Ecology, Agricultural University of Tirana, Kodër Kamëz, Tirana, Albania.

[*]Corresponding author E-mail **bgjongecaj@ubt.edu.al**

Abstract

At the centre of this study is the determination of the erodibility factor, which is known as K factor in the Wischmeier universal equation of soil loss. It could be determined experimentally, in local conditions, or by deriving from the factors determining it. Before any determination or any quantifying, it should bear in mind that the erodibility factor is a physical quantity, which depends on the soil physical properties. So, it is an inherent property of soil itself. Experimentally, it can be derived from the Wischmeier universal equation of soil loss by measuring all other factors of the equation, turning it into an equation with one unknown: soil erodibility. In a large scale, soil erodibility would be determined by measuring four factors closely related with the soil physical status: soil texture, soil structure, soil permeability, and soil organic matter. In the presented study, soil erodibility factor was determined in the second way and for the entire country of Albania. About twenty nine experimental plots were used to measure the above mentioned factors determining K factor. The equation used was that of Wischmeier and a mathematical model was created just for doing the right calculations. The K factor was found to be between 0.0137 to 0.441, which means that there is a large variation in Albanian soils according to their behavior towards the erodibility, or finally, towards erosion. Based on the results found, a map is produced, in which, it is clearly indicated the way the soils with various capacity to resist to erosion are spread throughout Albania. The zones characterized by high potential of erosion correspond with the zones where the majority of silt rich soils occur, as the zones with low potential erosion correspond with the zones where the majority of light and heavy soils occur.

Keywords: soil erodibility factor, soil inherent (intrinsic) property, silt rich soils, high potential erosion, soil physical properties.

1. Introduction

There is a general agreement in this area of research that the erodibility factor is strictly depended on the soil itself, its most important physical properties [2, 3]. Even when the soil organic matter is considered as a factor determining the soil erodibility, it really means that it is not the organic matter itself under consideration, but instead, its role to attach soil particles with each other and produce soil structure, or, which is the same thing, a better resistance to erosive power of water. What is not within this general agreement, so what divides the scientists in this area of research, is the nature of the relationship between the soil factors and soil erodibility; or even more than that, the number of soil factors should be considered in the regression analysis for determining the type of equation [2] and the determination coefficient of the regression equation. In spite of all of these efforts, the Wischmeier equation, [6, 7] seems clearly to be the most realistic one, because it considers all the possible soil factors affecting the soil erodibility, which, in Wischmeier soil loss equation, is represented by K. Therefore, as in specific equations the soil texture is considered to be the only factor affecting the magnitude of K factor; or in some other equations the soil structure is already added to the soil texture to quantify the K factor; in the Wischmeier equation four soil factors are considered: soil texture, soil structure, soil permeability and soil organic matter. All of this increases the applicative value of Wischmeier equation;

gives to it a more universal value. That is why, among many others, the Wischmeier equation was picked in this research work to calculate the erodibility of soils, factor K, in Albania.

2. Materials and Methods

To apply the Wischmeier equation for determining the K factor in soils of Albania [6, 7] the measurements of soil texture, soil structure, soil permeability, and soil organic matter for each location are used.

The Wischmeier equation applied in this article is:

$$\mathbf{K = 2.1 \cdot 10^{-6}(12 - OM)f_p^{1.14} + 3.25 \cdot 10^{-2}(S - 2) + 2.5 \cdot 10^{-2}(P - 3)}; \quad (1)$$

where:

K is the erodibility factor as it is determined in the universal soil loss equation.

OM is the organic matter expressed in percentage.

To go from the soil carbon content in percentage, which is actually measured for each location under investigation, to soil organic matter content in percentage, the following empirical relation was used:

Organic matter (%) = Total organic carbon (%) x 1.72 (2)

knowing that, more or less, in normal conditions, the organic matter contains about 58% carbon, C.

f_p is the particle factor, or otherwise expressed as a product of:

f_p = (%silt + %very fine sand) · (% of other particles except clay) (3)

S is soil structure code, which is taken as it is shown in the following table (Table. 1):

P is soil permeability code, which is taken as it is indicated in the following table (Table.2):

Table 1. Soil structure code as it determined from the type of soil structure.

Type of soil structure	*S, soil structure code(index)*
very fine granular soil	1
fine granular soil	2
medium or coarse granular soil	3
blocky, platy, or massive soil	4

Table 2. Soil permeability code as it determined from the type of soil structure.

Typ of infiltration	*P, soil permeability code (index)*
very slow infiltration	1
slow infiltration	2
slow to moderate infiltration	3
moderate infiltration	4
moderate to rapid infiltration	5
rapid infiltration	6

In order to arrange a better-organized presentation of data throughout Albania, each location where the measurements are done will represented by a code. This last one is nothing but the pedon, where the soil profile is studied.

The relation between the name of the place and the code is presented in the table 3:

Having these experimental locations in the context of Albania, the following map was produced:

To do the numerous calculations in the process of equation (1) application for each site chosen, a computer program is modulated, as it is seen, preliminarily, in the table 4 :

Table. 3 Soil sites named by the place and the corresponsive codes, (pedon number)

Nr.	*Pedon*	*Site*
1	006	Korce (EXP Station AUK)
2	001	Hoxhara (Fieri)
3	002	Jonufer (Vlore)
4	003	Çuke (Sarande)
5	004	Radanj (Erseke)
6	005	Dovoran (Korce)
7	007	Maliq (Korce)
8	008	Fushe Kruje
9	009	Vidhas (Elbasan)
10	010	IKB (Lushnje)
11	011	IOM (Shkoder)
12	012	Dukagjin (Kukes)
13	013	Pilafe (Peshkopi)
14	014	Kolaj (Burrel)
15	015	IFDC AUT (Tirane)
16	016	Terbuf (Lushnje)
17	017	Bathore (Tirane)
18	018	Tren (Korce)
19	019	Dishnice (Korce)
20	020	Bucimas (Pogradec)
21	021	Cervence (Pogradec)
22	022	Lin fshat (Pogradec)
23	023	Lapardha (Berat)
24	024	Roskovec (Fier)
25	025	Novosel (Vlore)
26	026	Synej (Kavaje)
27	027	Lac (Kurbin)
28	028	Melgush (Shkoder)
29	029	Oglike (Shkoder)
30	030	Markatomaj (Lezhe)

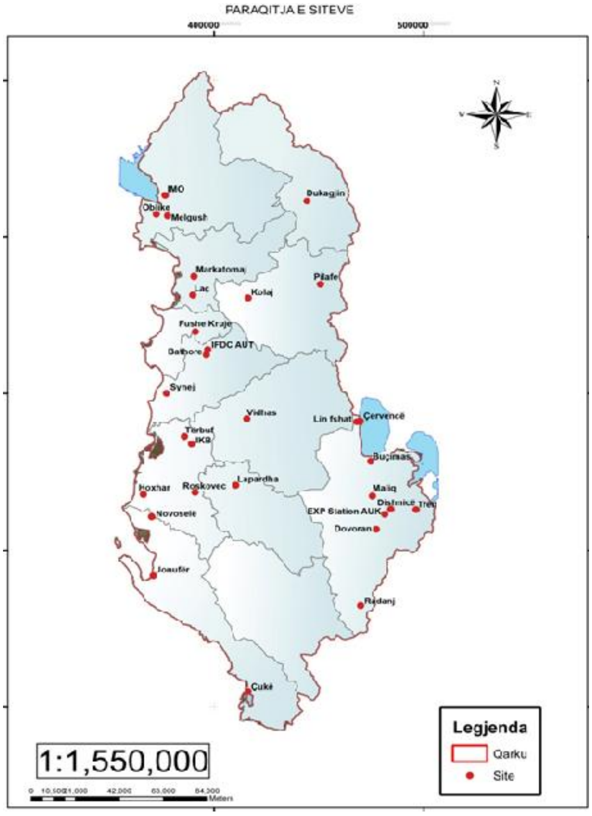

Figure. 1 The map of Albania showing the locations where the soil parameters are measured.

Table 4. Part of the computer program to apply the equation (1) shown.

informacion_permbledhes

FID	Shape *	ID	x	y	Emri_
0	Point	1	4407964.299	416685.659	Çukë (Sarandë)
1	Point	2	4538051.605	386112.09	Tërbuf (Lushnje)
2	Point	3	4619989.797	390437.512	Markatomaj (Lezhë
3	Point	5	4546005.098	469561.68	Lin fshat (Pogradec)
4	Point	6	4507903.426	475588.003	Maliq (Korçë)
5	Point	7	4451686.404	469979.279	Radanj (Ersekë)
6	Point	8	4658311.511	444163.565	Dukagjin (Kukës)
7	Point	9	4508387.325	366265.855	Hoxhar (Fier)
8	Point	10	4608913.971	416221.727	Kolaj (Burrel)
9	Point	11	4534137.569	389542.865	IKB (Lushnje)
10	Point	12	4546020.008	468947.923	Çervencë (Pogradec)
11	Point	13	4610409.756	390353.505	Laç (Kurbin)
12	Point	14	4615821.474	450591.012	Pilafe (Peshkopi)
13	Point	15	4581437.357	397158.787	Bathore (Tirane)
14	Point	16	4467184.389	371206.256	Jonufer (Vlore)
15	Point	17	4501157.641	484448.681	Dishnice (Korce)
16	Point	18	4490473.326	477348.424	Dovoran (Korce)
17	Point	19	4591728.579	391386.544	Fushe Kruje
18	Point	20	4580274.506	396507.924	IFDC AUT (Tirane)
19	Point	21	4560420.226	377189.738	Synej (Kavaje)
20	Point	22	4498194.387	481769.289	Korce (EXP Station AUK)
21	Point	23	4661057.001	376711.433	IMO (Shkoder)
22	Point	24	4525482.039	474845.531	Buçimas (Pogradec)
23	Point	25	4509686.251	390922.141	Rosovec (Fier)
24	Point	26	4651801.835	372500.345	Oblike (Shkoder)
25	Point	27	4497336.195	370041.528	Novosel (Vlore)
26	Point	28	4513138.542	410642.728	Lapardha (Berat)
27	Point	29	4546936.612	415617.299	Vidhas (Elbasan)
28	Point	30	4500497.754	496519.848	Tren (Korce)
29	Point	31	4650903.051	377991.135	Melgush (Shkoder)

3. Results and Discussions.

The results used to apply the formulae (1) related with the f_p factor can be found in the following table:

Table 5. Calculation of f_p factor for each site under investigation.

Pedon	*Silt %*	*Clay %*	f_p
006	52	36,35	3310
001	37,7	61,8	1440
002	35,95	22,85	2774
003	30,8	67,5	1001
004	22,9	48,65	1176
005	52	27,1	3791
007	29,9	66,15	1012
008	57,25	40,95	3381
009	66,6	22,15	5185
010	43,25	54,75	1957
011	46,45	13,25	4030
012	28,4	33,1	1900
013	36,75	51,1	1797
014	35,7	50,3	1774
015	50,15	25,45	3739
016	39,25	52,55	1862
017	59,5	35,2	3856
018	61,55	15,95	5173
019	35,8	25,45	2669
020	46,2	15,05	3925
021	34,65	55,95	1526
022	31,95	54,05	1468
023	56,7	24	4309
024	61,6	31,08	4245
025	58,35	11,85	5144
026	58,1	35,1	3771
027	42,7	55,75	1889
028	69,2	18,4	5647
029	56,3	21,15	4439
030	37,35	59,05	1529

As it is seen from the formulae (1), the relationship between erodibility K and the particle factor, f_p, is proportional, which means that any increase in the particle factor will be reflected as an increase in soil erodibility. The influence of proportionality is stronger, because the particle factor is shown up as a factor to the power 1.14, so greater than one, f_p 1.14 . When the particle factor, f_p1.14 , gets greater? The answer can be found from the analysis of formulae (3). The particle factor, f_p, gets greater when the difference {(%silt + %very fine sand) - (% of other particles except clay)} gets greater [2]. It happens either when the relative presence of silt increases or when the presence of other particles except clay decreases; which means that the most erodible particle of soil is silt particle, [2].

This comment is in full accordance of the findings in table 5 and of Wischmeier equation. The greater the relative amount of silt, the greater the particle factor is, and consequently, the greater the erodibility factor, K, becomes.

The structure and the permeability indexes, S and P respectively, are also proportional with the erodibility factor, K, as it is seen from the Wischmeier equation (1).

The increase of each of them, leads to an increase of the erodibility factor [4].

The results found for the soil structure and soil permeability representations in the Wischmeier equation are shown in the following table:

Table. 6 Soil structure and soil permeability status in various pedons.

Pedon	*Type of soil structure*	*S, soil structure code (index)*	*Type of infiltration*	*P, soil permeability code (index)*
006	medium or coarse granular soil	2,75	rapid infiltration	5
001	fine granular soil	2,75	moderately slow infiltration	3
002	medium or coarse granular soil	2,75	moderately rapid infiltration	4
003	blocky, platy, or massive soil	3,5	moderate infiltration	4
004	blocky, platy, or massive soil	3,5	moderately slow infiltration	2
005	blocky, platy, or massive soil	3,5	slow infiltration	2
007	fine granular soil	2	slow infiltration	2
008	fine granular soil	3,25	moderately slow infiltration	3
009	medium or coarse granular soil	2,75	moderately rapid infiltration	4
010	fine granular soil	2,25	moderately slow infiltration	3
011	medium or coarse granular soil	3,25	moderate infiltration	3
012	medium or coarse granular soil	2,75	moderately slow infiltration	2
013	medium or coarse granular soil	3	moderately rapid infiltration	5
014	medium or coarse granular soil	3	slow infiltration	2
015	medium or coarse granular soil	3	moderate infiltration	3
016	fine granular soil	2,25	slow infiltration	2
017	medium or coarse granular soil	3	slow to modrate infiltration	2
018	medium or coarse granular soil	2,75	moderately rapid	4
019	blocky, platy, or massive soil	3,5	moderate infiltration	2
020	medium or coarse granular soil	3	moderate infiltration	3
021	medium or coarse granular soil	3	moderately slow infiltration	3
022	medium or coarse granular soil	3,25	moderate infiltration	3

023	medium or coarse granular soil	3,25	rapid infiltration	5
024	medium or coarse granular soil	3,25	moderately rapid infiltration	4
025	medium or coarse granular soil	2,5	moderately slow infiltration	2
026	blocky, platy, or massive soil	4	moderately slow infiltration	2
027	blocky, platy, or massive soil	4	moderately slow infiltration	2
028	medium or coarse granular soil	3	moderate infiltration	3
029	blocky, platy, or massive soil	4	moderate infiltration	3
030	blocky, platy, or massive soil	3.70	moderate infiltration	4

Table 7. Soil organic matter as it is related with various pedons in Albania.

Pedon	***C*** *%*	***OM*** *%*
006	1,02	1,75
001	0,92	1,58
002	1,77	3,04
003	2,78	4,78
004	1	1,72
005	1,07	1,84
007	1.2	2,06
008	1,65	2,84
009	0,94	1,62
010	1,28	2,2
011	1,12	1,93
012	1,84	3,16
013	1,1	1,89
014	1,03	1,77
015	1,73	2,98
016	5,29	9,1
017	1,37	2,36
018	0,67	1,15
019	0,5	0,86
020	0,64	1,1
021	0,66	1,14
022	1,19	2,05
023	0,78	1,34
024	0,56	0,96
025	0,53	0,91
026	1,13	1,94
027	1,57	2,7
028	1	1,72
029	0,82	1,41
030	2,52	4,33

Organic matter – soil erodibility relationship is disproportional, as it is shown in the Wischmeier equation. Any increase of soil organic matter leads to a decrease of the soil erodibility factor, (K. Physically), it is well understood. An increase of the organic matter content will strengthen the adsorbing forces among soil particles and consequently, it will increase the soil particles resistance towards the power of running water.

The results found after the soil carbon content is converted into organic matter content [5], which are related with the distribution of organic matter throughout Albania, are shown in the Table 7:

The next attempt to have a broad picture on the relationships among the soil erodibility and all the factors affecting it, such as soil texture, soil structure, soil permeability, and soil organic matter, is to include all of them in the Table 8:

Table. 8 Soil erodibility and the magnitude of all factors affecting it in the soils of Albania.

Site	*Pedon*	*C* %	*Silt* %	*Clay* %	*OM* %	*S*	*P*	*K*
Korce (EXP Station AUK)	006	1,02	52,00	36,35	1,75	2,75	5,0	0,29585305
Hoxhara (Fier)	001	0,92	37,70	61,80	1,58	2,75	3,0	0,11158541
Jonufer (Vlore)	002	1,77	35,95	22,85	3,04	2,75	4,0	0,20763592
Cuke (Sarande)	003	2,78	30,80	67,50	4,78	3,50	4.0	0,11366674
Radanj (Erseke)	004	1,00	22,90	48,65	1,72	3,50	2,0	0,09205319
Dovoran (Korce)	005	1,07	52,00	27,10	1,84	3,50	2.0	0,28010931
Maliq (Korce)	007	1.2	29,90	66,15	2,06	2,00	2,0	0,03064074
Fushe Kruje	008	1,65	57,25	40,95	2,84	3,25	3,0	0,24351672
Vidhas (Elbasan)	009	0,94	66,60	22,15	1,62	2,75	4,0	0,42378372
IKB (Lushnje)	010	1,28	43,25	54,75	2,20	2,25	3,0	0,12448503
IOM (Shkoder)	011	1,12	46,45	13,25	1,93	3,25	3,0	0,31314283
Dukagjin (Kukes)	012	1,84	28,40	33,10	3,16	2,75	2,0	0,10081386
Pilafe (Peshkopi)	013	1,10	36,75	51,10	1,89	3,00	5,0	0,19141558
Kolaj (Burrel)	014	1,03	35,70	50,30	1,77	3,00	2,0	0,11612131
IFDC AUT (Tirane)	015	1,73	50,15	25,45	2,98	3,00	3,0	0,25664901
Terbuf (Lushnje)	016	5,29	39,25	52,55	9,10	2,25	2,0	0,01568493
Bathore (Tirane)	017	1,37	59,50	35,20	2,36	3,00	3.0	0,25558661
Tren (Korce)	018	0,67	61,55	15,95	1,15	2,75	4,0	0,43953787
Dishnice (Korce)	019	0,50	35,80	25,45	0,86	3,50	2,0	0,21216759
Bucimas (Pogradec)	020	0,64	46,20	15,05	1,10	3,00	3,0	0,31862251
Cervence (Pogradec)	021	0,66	34,65	55,95	1,14	3,00	3,0	0,12968541
Lin fshat (Pogradec)	022	1,19	31,95	54,05	2,05	3,25	4.0	0,12579454
Lapardha (Berat)	023	0,78	56,70	24,00	1,34	3,25	5,0	0,40188513
Roskovec (Fier)	024	0,56	61,60	31,08	0,96	3,25	4,0	0,38250738
Novosel (Vlore)	025	0,53	58,35	11,85	0,91	2,50	2,0	0,38746253
Synej (Kavaje)	026	1,13	58,10	35,10	1,94	4,00	2,0	0,2922212
Lac (Kurbin)	027	1,57	42,70	55,75	2,70	4,00	2,0	0,14609929
Melgush (Shkoder)	028	1,00	69,20	18,40	1,72	3,00	3,0	0,44106404
Oglike (Shkoder)	029	0,82	56,30	21,15	1,41	4,00	3,0	0,38491334
Markatomaj (Lezhe)	030	2,52	37,35	59,05	4,33	3.70	4.0	0,14897998

It is very much noticeable, that the erodibility factor gets the highest values where the combination of the factors affecting it like silt content increases, organic matter decreases and structure plus permeability get both together the values already shown. In order to make more visible the way the soils are exposed towards the erosion, based on the data found in the (Table. 8), the following map is built, which clearly indicates the zones of higher, medium, and lower risks to erosion throughout Albania. Before the map was produced, the soil erodibility calculated was classified in six grades, from the least to the most dangerous erodibility.

This classification done is presented in the following table:

Table 9. Soil Erodibility classification based on K value.

Erodibility K	*Values averages*	*Soil classification*
0,01366674 – 0.09205319	0.052859965	Not erodible
0.09205319- 0.20558661	0.1488199	Slightly erodible
0.20558661- 0.31314283	0.25936472	Medium erodible
0.31314283- 0.40188513	0.35751398	Considerably erodible
0.40188513- 0.42378372	0.412834425	Erodible
0,42378372	0,42378372	Severely erodible

Clearly, the data in the above table indicate a great variability of soils behavior towards erodibility.

In a small country like Albania, the variability extended from 0.0137 to 0.4238 is very much significant, because the maximum value of soil erodibility is at least 30 times greater than the minimum value of soil erodibility.

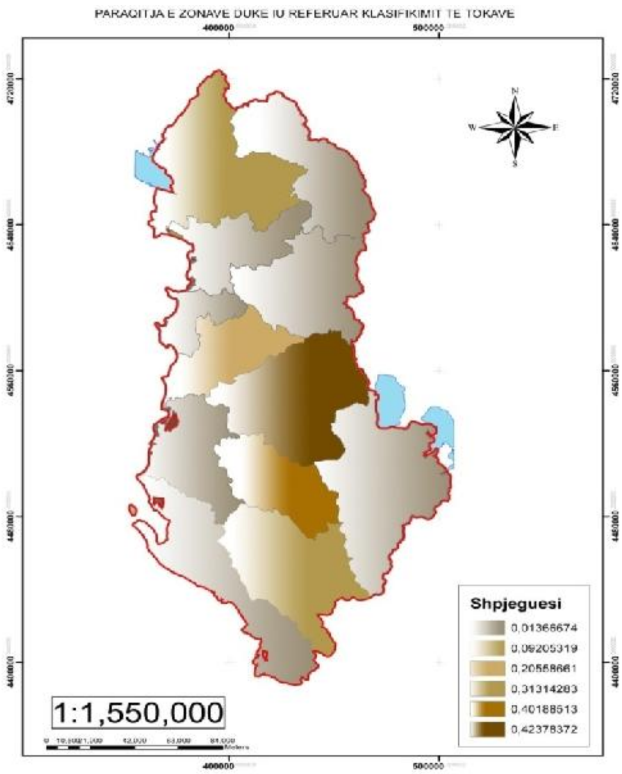

Figure 2. The erodibility map of soils of Albania

As it is found in (1) the K erodibility index in a much larger country like the United States varies between 0.7 for the most fragile soils, 0.3 for brown leached soils, and 0.02 for the most resistant soils, which means that the variability extends from 0.7 to 0.2, or, the maximum value of soil erodibility is 35 times greater than the minimum one.

4. Conclusions

1. The Wischmeier equation can be used successfully to determine the magnitude of soil erodibility.
2. The K factor was found to be between 0.0137 to 0.424, (the maximum value is at least 30 times greater than the minimum value), which means that there is a large variation in Albanian soils according to their behavior towards the erodibility, or finally, towards erosion.
3. Based on the results found a map is produced, in which is clearly indicated the way the soils with various capacity to resist to erosion are spread throughout Albania.
4. The zones characterized by high potential of erosion correspond with the zones where the majority of silt rich soils occur, as the zones with low potential erosion correspond with the zones where the majority of light and heavy soils occur.

5. References

1. Roose E: **Land husbandry : Components and strategy,** Food and Agriculture Organization of the United Nations, 70 FAO soils bulletin,1996.
2. John M, Laflen and Dennis C. Flanagan, **The development of US soil erosion prediction and modeling,** International Soil and Water Conservation Research: 2013,**1**(2):111.
3. Cool Mc K, Foster RG, Renard GK, Yoder CD and Weesies AG.: **The Revised**

Universal Soil Loss Equation, Department of Defense/Interagency Workshop on Technologies to Address Soil Erosion on Department of Defense Lands, San Antonio, TX,june 11-15,1995.

4. Rodríguez R, Belo DC, Armas M C, Mora L J and Guerra JA: **Soil erodibility variation in relation to environmental factors in volcanic soils of the Canary Islands, Spain**, International Soil Conservation Organization Conference– Brisbane,2004.
5. Tiessen HJ, Moir O.: **Total and organic carbon. In: Soil Sampling and Methods of Analysis,** M.E. Carter, Ed. Lewis Publishers, Ann Arbor, MI,187-211,1993.
6. Wischmeier WH, Johnson CB, Cross BV: **A soil erodibility nomograph for farmland and construction sites**; Soil Water Conser. 26:189–193,1971.
7. Wischmeier WH, Smith DD: **Predicting Rainfall Erosion Losses: A Guide to Conservation Planning. Agriculture Handbook** No. 537. USDA: Washington, DC.,1978.
8. Zdruli, P. 1997. Benchmark Soils of Albania.Soil and Site Characteristics, **2**, p. 202.