ERODIBILITY OF ULTRAMAFIC SOILS IN ALBANIA

P. MZIU[1], B. GJONGECAJ[2]

[1]Doctorate student, Department of Agro-environment and Ecology, Agricultural University of Tirana, Albania
[2]Prof. Dr., Department of Agro-environment and Ecology, Agricultural University of Tirana, Albania

Corresponding author: *pranveramziu@gmail.com*

Abstract. *Albania is known for having a considerable area of ultramafic soils, which are mainly located on the southeastern part of the country. The major part of this area is under intensive research aiming the recognition of status and its behavior above of all, and after, finding out the best ways and practices to improve the soil productivity. This is also, firstly, in fact, the broad aim of the research undertaken by our research team and presented in this article. Secondly, the more concrete aim is to determine, in real magnitudes, the capacity of these very specific soils to resist to erosion, which is a very widespread and dangerous phenomenon in the area where this type of soils occur naturally. That is why, the relationships existing between the erodibility index, K, and the textural factors, particularly clay and silt contents in ultramafic substrates (serpentines), is also at the centre of this study. The most typical ultramafic soils in Albania are considered to be the "ground" to determine these relationships. For each soil under consideration, the soil texture, organic matter, soil structure and soil permeability are determined experimentally. The above-mentioned measurements were used to calculate the erodibility factor for every single soil under consideration, by applying the Wischmeier equation. After, the erodibility factor, K, already determined, was considered, theoretically at least, as affected by the relative presence of clay and silt particles in soil. In order to determine this relationship quantitatively, which is believed to be a cause-effect relationship as well, the regression analysis was undertaken. The findings revealed interesting and specific relations between the erodibility factor and both: clay and silt contents, respectively. The very essential result was that the direction of dependency of soil erodibility on the clay content is the opposite of the direction of dependency of soil erodibility on the silt content. The increase of clay content in serpentines soils leads to a decrease of the soil erodibility; but the increase of silt content of the same type of soils leads to an increase of the soil erodibility.*

Keywords*: soil erodibility, ultramafic soils, Wischmeier equation, soil texture, organic matter, soil structure, soil permeability.*

INTRODUCTION

There is a general agreement in this area of research that the erodibility factor is strictly depended on the soil itself, namely, on soil most important physical properties LAFLEN, FLANAGAN (2013); MC COOL (1995). 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 separates 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 LAFLEN, FLANAGAN (2013); and the determination coefficient of the regression equation. In spite of all of these efforts, the Wischmeier equation, WISCHMEIER, JOHNSON, CROSS (1971); WISCHMEIER, SMITH, (1978); 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.

This entire situation 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 ultramafic soils of Albania.

MATERIAL AND METHODS

The soils into consideration are the ones which have been characterized as ultramafic or serpentine soils, namely, those soil types rich in magnesium, potassium, ZDRULI (1997); CHIARUCCI & BAKER (2007); LESOVAYA, GORYACHKIN, & POLEKHOVSKII, (2012). These types of soil are spread out all over Albania.

The presence of these chemical elements are given in the following tables:

Table 1

The content of calcium magnesium, potassium in ultramafic substrates in Radanj, Ersekë.

Pedon no: 004 Soil series : Radanj (Ersekë)	NH_4OH Ac Extractable (M.eq./100g soil)			
Depth cm	Ca	Mg	K	Na
0 - 17	34.9	15.5	0.5	0.3
17 - 38	30.3	16.0	0.2	0.2
38 - 66	24.7	20.9	0.1	0.2
66 - 100	22.1	20.9	0.2	0.2

Table 2

The content of calcium, magnesium, potassium in ultramafic substrates in Dovoran (Korca)

Pedon no: 005 Soil series : Dovoran (Korca)	NH_4OH Ac Extractable (M.eq./100g soil)			
Depth cm	Ca	Mg	K	Na
0 - 17	24.4	5.0	0.2	0.2
17 - 38	25.0	6.3	0.2	0.1
38 - 66	-	6.4	0.1	0.2
66 - 100	-	6.6	0.2	0.1

Table 3

The content of calcium, magnesium, potassium in ultramafic substrates in Korçe (Exp.Station of Agricultural of Korca).

Pedon no: 6 Soil series : Korce (exp.stacion of agricultural of korca)	NH_4OH Ac Extractable (M.eq./100g soil)		
Depth cm	Mg	K	Na
0 - 17	7.1	0.2	0.1
17 - 38	7.7	0.3	0.1
38 - 66	8.5	0.3	0.1
66 - 100	8.0	0.1	0.1

Table 4

The content of calcium, magnesium, potassium in ultramafic substrates in Maliq ,(Korça).

Pedon no: 7 Soil series : Maliq (Korça)	NH_4OH Ac Extractable (M.eq./100g soil)		
Depth cm	Mg	K	Na
0 - 17	9.6	0.6	0.3
17 - 38	9.5	0.7	0.4
38 - 66	9.1	0.1	0.7
66 - 100	7.8	0.4	0.8

Table 5

The content of calcium, magnesium, potassium in ultramafic substrates in Dukagjin (Kukës).

Pedon no: 012 Soil series : Dukagjin (Kukes).	NH_4OH Ac Extractable (M.eq./100g soil)			
Depth cm	Ca	Mg	K	Na
0 - 17	9.2	5.1	0.2	0.2
17 - 38	7.3	4.7	0.2	0.1
38 - 66	7.8	8.5	0.1	0.2
66 - 100	20.1	24.7	0.2	0.5

Table 6

The content of calcium, magnesium, potassium in ultramafic substrates in Dishnice,(Korçë).

Pedon no: 19 Soil series : Dishnice (Korça)	NH_4OH Ac Extractable (M.eq./100g soil)			
Depth cm	Ca	Mg	K	Na
0 - 17	11.6	6.3	0.4	0.1
17 - 38	11.6	7.9	0.4	0.1
38 - 66	13.2	12.5	0.5	0.1
66 - 100	17.8	20.3	0.6	0.1

Table 7

The content of calcium, magnesium, potassium in ultramafic substrates in Bucimas (Pogradec).

Pedon no: 20 Soil series : Bucimas (Pogradec)	NH_4OH Ac Extractable (M.eq./100g soil)			
Depth cm	Ca	Mg	K	Na
0 - 17	9.4	1.5	0.1	0.1
17 - 38	8.4	2.3	0.1	0.1
38 - 66	13.5	6.0	0.2	0.2
66 - 100	9.5	4.6	0.2	0.2

Table 8

The content of calcium, magnesium, potassium in ultramafic substrates in Cervence (Pogradec).

Pedon no: 021 Soil series:Çervence (Pogradec)	NH_4OH Ac Extractable (M.eq./100g soil)			
Depth cm	Ca	Mg	K	Na
0 - 17	23.6	6.6	0.8	0.2
17 - 38	15.4	5.7	0.4	0.2
38 - 66	18.2	6.7	0.4	0.2
66 - 100	22.7	11.6	0.5	0.2

Table 9

The content of calcium, magnesium, potassium in ultramafic substrates in Lin Fashat (Pogradec).

Pedon no:022 Soil series : Lin Fashat (Pogradec)	NH_4OH Ac Extractable (M.eq./100g soil)			
Depth cm	Ca	Mg	K	Na
0 - 17	28.8	13.0	0.7	0.1

17 - 38	29.9	13.6	0.6	0.2
38 - 66	28.4	15.1	0.5	0.1
66 - 100	26.9	18.9	0.6	0.2

The textural types of the ultramafic soils under investigation are given in the following table :

Table 10

The occurrence and textural types of the ultramafic soils under investigation are given in the following table.

Nr.	Site	Pedon	Textural types of the ultramafic soils		
			Clay %	Silt %	Sand %
1	Maliq (Korca)	007	65.7	30.4	3.9
2	Radanj (Erseke)	004	48.5	23.4	28.1
3	Dukagjin (Kukes)	012	31.9	29.7	38.4
4	Lin fshat (Pogradec)	022	53.7	32.5	13.8
5	Cervence (Pogradec)	021	55.4	34.3	10.3
6	Dishnice (Korca)	019	24.2	36.2	39.6
7	Dovoran (Korca)	005	26.6	51.6	21.8
8	Korce (EXP Station AUK)	006	35.6	49.4	15.0
9	Bucimas (Pogradec)	020	13.4	45.7	40.9

To better understand the occurrence of these soils in Albania, the following map is given:

To apply the Wischmeier equation for determining the K factor in ultramafic soils of Albania WISCHMEIER, JOHNSON & CROSS (1971), WISCHMEIER & SMITH (1978) , the measurements of soil texture, soil structure, soil permeability, and soil organic matter for each location are used ZDRULI, (1997).

The Wischmeier equation applied in this article is:

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

where:

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

OM is the organic matter expressed in percentage.

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

fp = (%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. 11):

;P is soil permeability code, which is taken as it is indicated in the following table (Table.12):

The following empirical relation was used to quantify the organic matter from total carbon content expressed in percentage:

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

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

Table 11

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

Nr.	Site	Pedon
1	Maliq (Korce)	007
2	Radanj (Erseke)	004
3	Dukagjin (Kukes)	012
4	Lin fshat (Pogradec)	022
5	Cervence (Pogradec)	021
6	Dishnice (Korce)	019
7	Dovoran (Korce)	005
8	Korce (EXP Station AUK)	006

Table 12

Soil

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

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

In order to arrange a better-organized presentation of data, 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 following table:

Table 13

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

9	Bucimas (Pogradec)	020

To better understand the occurrence of these soils in Albania, the following map is produced:

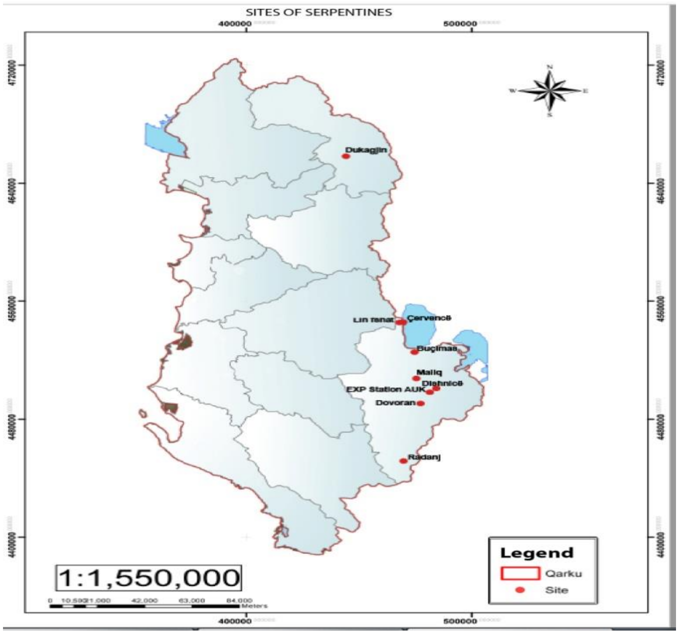

Figure.1 The map of Albania showing the locations where the soil parameters are measured.

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

Table 14

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

Sitet_sakta

FID	Shape *	ID	x	y	Emri_
0	Point	1	4546005.098	469561.68	Lin fshat (Pogradec)
1	Point	2	4658311.511	444163.565	Dukagjin (Kukës)
2	Point	3	4546020.008	468947.923	Çervencë (Pogradec)
3	Point	4	4501157.641	484448.681	Dishnice (Korce)
4	Point	5	4498194.387	481769.289	Korce (EXP Station AUK)
5	Point	6	4525482.039	474845.531	Buçimas (Pogradec)
6	Point	7	4507903.426	475588.003	Maliq (Korce)
7	Point	8	4451686.404	469979.279	Radanj (Erseke)
8	Point	9	4490473.326	477348.424	Dovoran (Korçe)

RESULTS AND DISCUSSION

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

Table 15

Results of calculations done to quantify f_p factor for each site under investigation.

Nr.	Pedon	silt %	clay %	f_p
1	7	29.90	66.15	1012
2	4	22.90	48.65	1176
3	12	28.40	33.10	1900
4	22	31.95	54.05	1468
5	21	34.65	55.95	1526
6	19	35.80	25.45	2669
7	5	52.00	27.10	3791
8	6	52.00	36.35	3310
9	20	46.20	15.05	3925

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

Table 16

Soil structure and soil permeability status in various pedons of ultramafic substrates.

Pedon	Type of soil structure	S, soil structure code (index)	Type of infiltration	P, soil permeability code (index)
007	fine granular soil	2	slow infiltration	2
004	blocky, platy, or massive soil	3,5	moderately slow infiltration	2
012	medium or coarse granular soil	2,75	moderately slow infiltration	2
022	medium or coarse granular soil	3,25	moderate infiltration	3
021	medium or coarse granular soil	3	moderately slow infiltration	3
019	blocky, platy, or massive soil	3,5	moderate infiltration	2
005	blocky, platy, or massive soil	3,5	slow infiltration	2
006	medium or coarse granular soil	2,75	rapid infiltration	5

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 TIESSEN, MOIR (1993), which are related with the distribution of organic matter throughout Albania, are shown in the following table:

Nr	Site	Pedon	C%	silt%	clay%	OM%	S struk	f pream	K
1	Maliq (Korce)	007	1.20	29.90	66.15	2.06	2.00	2	0.03064074
2	Radanj (Erseke)	004	1.00	22.90	48.65	1.72	3.50	2	0.09205319
3	Dukagjin (Kukes)	012	1.84	28.40	33.10	3.16	2.75	2	0.100813860
4	Lin fshat (Pogradec)	022	1.19	31.95	54.05	2.05	3.25	3	0.12579454
5	Cervence (Pogradec)	021	0.66	34.65	55.95	1.14	3.00	3	0.12968541
6	Dishnice (Korce)	019	0.50	35.80	25.45	0.86	3.50	2	0.21216759
7	Dovoran (Korce)	005	1.07	52.00	27.10	1.84	3.50	2	0.28010931
8	Korce (EXP Station AUK)	006	1.02	52.00	36.35	1.75	2.75	5	0.29585305
9	Bucimas (Pogradec)	020	0.64	46.20	15.05	1.10	3.00	3	0.318622510

Table 17

Soil organic matter as it is related with various pedons in ulramafic substrates of Albanian soils .

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 following table:

Table 18

Nr	Site	Pedon	C %	OM %
1	Maliq (Korce)	7	1.20	2.06
2	Radanj (Erseke)	4	1.00	1.72
3	Dukagjin (Kukes)	12	1.84	3.16
4	Lin fshat (Pogradec)	22	1.19	2.05
5	Cervence (Pogradec)	21	0.66	1.14
6	Dishnice (Korce)	19	0.50	0.86
7	Dovoran (Korce)	5	1.07	1.84
8	Korce (EXP Station AUK)	6	1.02	1.75
9	Bucimas (Pogradec)	20	0.64	1.10

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

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 all together the values already shown. In order to make more visible the way the ultramafic soils are exposed towards the erosion based on the data found in the (Table. 19), the following map is built, which clearly indicates the zones of higher, medium, and lower risks to erosion in ultramafic soils. Before the map was produced, the soil erodibility calculated was classified in four grades, from the least to the most dangerous erodibility. This classification done is presented in the following table:

Table 19

Soil erodibility classification based on K value.

Erodibility K	Values averages	Soil classification
0,01366674 – 0.09205319	0.03064074	Not erodible
0.09205319- 0.20558661	0.1488199	Slightly erodible
0.20558661- 0.31314283	0.28010931	Medium erodible
0.31314283- 0.40188513	0.318622510	Considerably erodible

Clearly, the data in the above table indicate a great variability of ultramafic soils behavior towards erodibility. In a small country like Albania, the variability extended from 0.03064074 to 0.318622510 is very much significant, because the maximum value of soil erodibility is at least 10 times greater than the minimum value of soil erodibility.

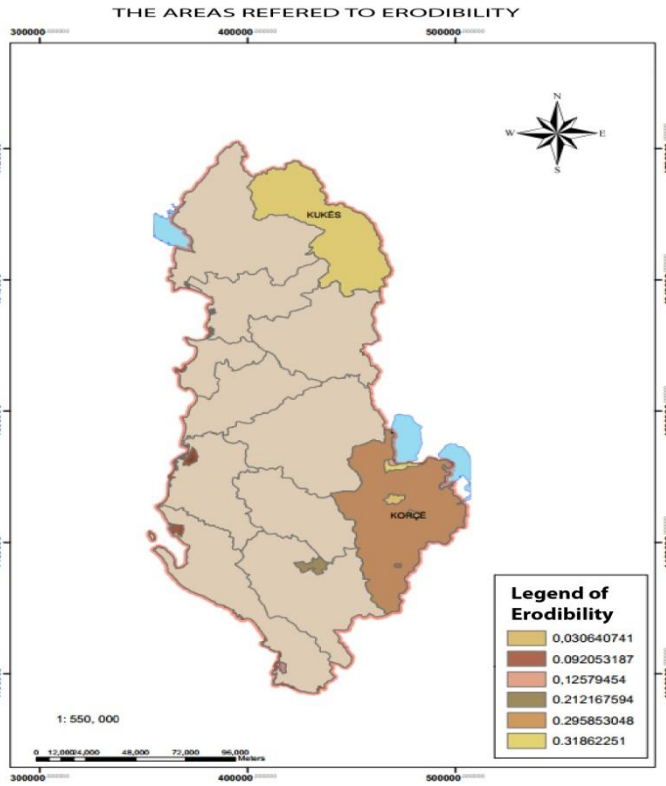

Figure 2. The erodibility map of ultramafic soils of Albania.

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 0.03064074 and 0.3186 (the maximum value is at least 10 times greater than the minimum value), which means that there is a large variation in Albanian ultramafic soils according to their behavior towards the erodibility, or finally, towards erosion.
3. Based on the results found a map is produced, in which it is clearly indicated THE WAY THE ULTRAMAFIC SOILS WITH VARIOUS CAPACITY TO RESIST TO EROSION ARE SPREAD THROUGHOUT A considerable area of 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.

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