Soils of the Republic of Macedonia: Present Situation and Future Prospects

Tatjana Mitkova
Josif Mitrikeski

Faculty of Agriculture, bul. 'Aleksandar Makedonski', 1000, Skopje, Republic of Macedonia

Introduction

The Former Yugoslav Republic of Macedonia is situated in the Balkan Peninsula, in the southern part of the temperate zone, and on the borders of the subtropical zone, between $40^0 50^'$ and $42^0 20^'$ N latitude and $20^0 27^'$ and $23^0 05^'$ E latitude. The northern part of country borders the Republic of Serbia and Montenegro, in the south with Greece, in the east with Republic of Bulgaria and in the west with Republic of Albania.

The Republic of Macedonia is small (25,713km^2, Table 1), but it shows great natural diversity, though mountains occupy nearly 80% and basins 20% of the country (see also Figure 1).

Table 1: Landforms

Type	Area (km$^{2)}$	%
Water	488	1.9
Plains	4,900	19.1
Mountain	20,325	79.0
Total	25,713	100.0

According to Filipovski (1995), the Republic of Macedonia can be divided into four geotectonic entities: the Western Macedonian Zone, Pelagonian Massif, Vardar Zone and Serbian-Macedonian Massif. The relief is very heterogeneous, with numerous relief forms, with different expositions and inclinations, and with great differences of altitude (from 40 to 2,764m above sea level). The division into mountains and basins of lower relief category (undulating-hilly, sloping and flat relief) is of great significance for the regionalisation.

In the Republic of Macedonia, there are numerous geological formations of heterogeneous petrographic-mineralogical composition. The mountains are composed of non-calcareous hard rocks, including quartzite, and various silicate rocks: acidic, neutral, basic and ultrabasic rocks; as well as calcareous rocks such as pure limestones, marbles and dolomites.

Basins are composed of loose and lightly cemented sediments, and a small quantity of young volcanic rocks. Undulating-hilly terrains in the basins are composed of sea and lake sediments (Mesozoic, Paleogenic, Neogenic, diluvial (superficial) deposits) The sloping terrain consists of colluvial and some fluvioglacial deposits.

The relief modifies the influence of zonal climates. The country is under two zonal climates (Mediterranean and temperate-eastern continental) and one local (mountain) climate. These three climates combine with the relief and altitude to create eight vertical climatic belts (Filipovski *et al.* 1996):

- Sub-Mediterranean (50-100m above sea level);
- Continental-sub-Mediterranean (to 600m, 897,000ha or 34.9% of the territory);
- Warm-continental (600-900m, 740,000ha or 27.45% of the territory);
- Cold-continental (900-1,100m, 342,000ha or 13.3%);
- Piedmont-continental-mountain (1,100-1,300m, 250,000ha or 9.7%);
- Mountain-continental (1,300-1,650m;
- 269,000ha or 10.4%);
- Sub alpine-mountain (1,650-2,250m;
- 97,000ha or 3.8%);
- Alpine-mountain (over 2,250m, 17,000ha or 0.5%).

The vertical climate belts are at the same time climate-vegetation zones with different soil types and evolution sequences. They are, in fact, climate-vegetation-soil belts.

In the Republic of Macedonia, there is a great number of plant associations as a result of the heterogeneity of natural conditions. The occurrence of 7 vegetation zones with different climate-zonal forest associations and one zone of grass association has a great role in the process of regionalisation.

Hydrographic conditions show an influence on soil genesis, properties and geography through surface flows (river systems and erosion), floods and waterlogged lands, groundwaters and irrigation. The soils formed directly under the influence of erosion and strongly eroded soils cover 27.1% of the territory of the Republic of Macedonia, and together with those that are indirectly formed under its influence, cover 41.2%.

Table 2: Agricultural area, 2002

Type		ha
Cultivated	Total	598,000
	Meadows	56,000
	Vineyards	28,000
	Orchards	16,000
	Arable (incl gardens)	498,000
Pastures		636,000
Ponds, reed-beds, fishponds		2,000
Agriculture	Total	1,236,000

Source: Statistical Yearbook of the Republic of Macedonia, 2002

Table 2 shows the categories of agricultural land amounting to 48% of the country. Table 3 shows areas under various categories of arable cultivation. In Table 4, land cadastral and capability classes are listed.

Hydrographic conditions have caused the formation of 199,800ha of hydromorphic soils including alluvial soils. This amounts to 7.8% of the whole territory of the Republic of Macedonia. The ground waters contain very little salt, most often less than 1,000mg/l. Only in some basins, where there are halomorphic soils, are the waters more saline. Under these influences, 3,200ha of halomorphic soils have been formed, and salinisation and alkalinisation appear in an additional 8,000ha. Under the influence of salinised paleogenic sediments, the most salinised ground waters in the Balkans are found in Ovche Pole.

Table 3: Arable land, 2002

Category	ha
Fallow & uncultivated land	146,000
Sown area	350,000
Cereals	221,000
Industrial crops	34,000
Vegetable crops	60,000
Fodder crops	35,000
Nurseries	2,000
Arable (incl. gardens)	498,000

Source: Statistical Yearbook of the Republic of Macedonia, 2002

As there are no direct measurements of the age of the soils, i.e. of the time influence over which pedogenesis took place, conclusions are derived on the basis of morphology and level of evolution.

Man is a very important factor in changing the soils in the Republic of Macedonia, because The country was settled a very long time ago and it is a country of ancient civilisations. Many soils were anthropogenised to different levels.

Soil classification

The soil cover of the Republic of Macedonia is very heterogeneous, with great changes over small distances. Almost all relief forms, geological formations, climatic influences, plant associations and soils that appear in Europe (with the exception of podzols) are represented. More than thirty soil types are found in Macedonia (Table 4).

Using the classification of Skoric *et al*. (1985) and according to the monograph 'The Soils of the Republic of Macedonia' – (several volumes 1995, 1996, 1997, 1999), the following soil types have been established: lithosols, regosols, arenosols, colluvial soils, rendzinas on hard limestones and dolomites, rendzinas, rankers, vertisols, chernozems, chromic cambisols, red soils (terra rossa), brown soils on limestones and dolomites, brown forest soils, illimerised soils, brown podzolic soils, alluvial soils, fluviatile-meadow soils, hydromorphic black soils, gleyic soils, peat soils (histosols), pseudogleys, solonchaks and solonetz.(Table 5).

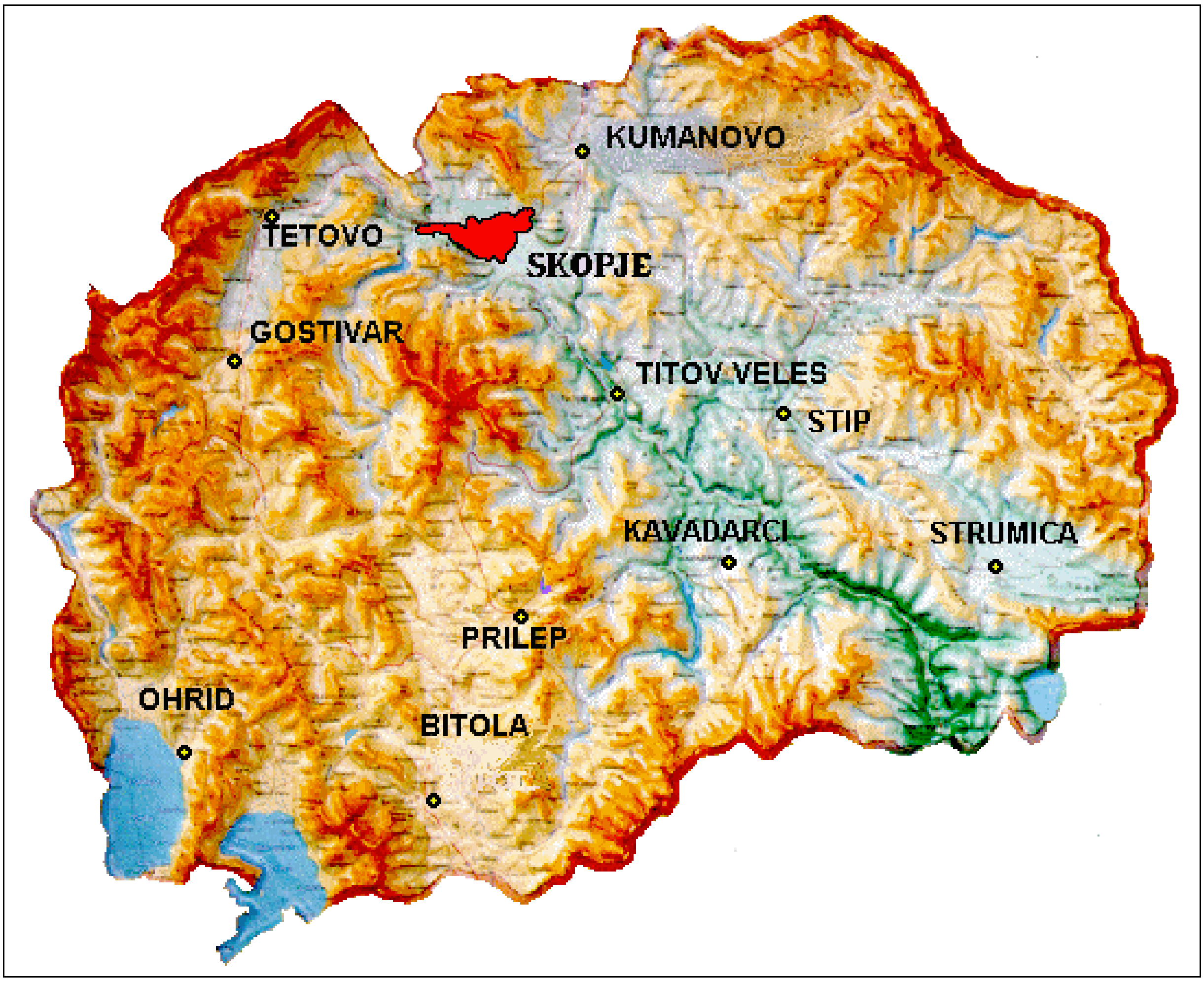

Figure 1. Geographical map of the Republic of Macedonia

Table 4: Cadastral classes (hectares)

(ha)	Cadastral classes								Total
	I	II	III	IV	V	VI	VII	VIII	
Fields	10,969	24,780	47,068	67,507	73,097	72,733	62,379	59,429	417,962
Vegetable -gardens	596	1,142	1,189	831	758	529	9	0	5,054
Orchards	938	2,617	3,765	3,549	2,269	610	73	0	13,281
Vineyards	552	2,863	5,801	5,519	2,818	982	727	12	18,774
Meadows	559	3,101	7,574	10,657	8,483	6,950	3,779	1,691	42,830
Pastures	818	1,848	7,815	21,923	20,689	18,627	12,072	7,019	90,800
Forests	825	3,438	11,095	30,290	25,405	17,725	6,202	2,606	97,586
Swamps	83	208	186	34	1	0	1	1	514
Total	15,375	39,997	84,493	140,310	133,520	118,156	84,742	70,758	687,352
%	2.24	5.82	12.29	20.41	19.43	17.19	12.33	10.29	100.00

Table 5. Soil types and complexes, ha (%)

Soil types and complexes	ha	%
I. Mountain soils		
Lithosols	13,053	0.51
Lithosols and eroded eutric and distric cambisols	299,068	11.63
Lithosols and cinnamonic forest soils	54,200	2.11
Lithosols, regosols and rankers	12,006	0.48
Rankers	232,897	9.06
Rendzinas on hard limestones and dolomites	221,441	8.61
Brown forest soils (dystric and eutric cambisols)	729,618	28.38
Brown soils on hard limestones and dolomites	92,944	3.62
Total	**1,655,227**	**64.40**
II. Soils of lake terraces and of undulated hilly relief		
Regosols	92,705	3.60
Regosols, rendzinas and cinnamonic forest soils	218,583	8.50
Regosols and luvisols	6,346	0.25
Vertisols	61,900	2.41
Rendzinas	2,100	0.08
Chernozems	32,800	1.28
Cinnamonic forest soils	113,359	4.41
Cinnamonic forest soils and luvisols	4,068	0.16
Luvisols	21,617	0.84
Total	**553,478**	**21.53**
III. Soils of colluvial fans		
Colluvial soils	159,593	6.19
Total	**159,593**	**6.19**
IV. Soils of the plains		
Alluvial soils	130,207	5.06
Fluviate-meadow and gley soils	39,395	1.53
Peat and peat-gley soils	28,100	1.09
Pseudogleys	2,100	0.08
Halomorphic soils	3,200	0.12
Total	**203,002**	**7.88**
Total for the Republic of Macedonia	**2,571,300**	**100.00**

In preparing this study, we used many research papers including: Mitkova *et al*. (1995, 1996, 1998, 2000, 2003), Mitrikeski (1995); Mitrikeski *et al*. (2001, 2002, 2003); Filipovski *et al*. 1985).

Lithosols

Lithosols are spread throughout the hilly-mountain zone and those over acid compact rocks dominate. They most frequently contain more than 50% coarse fragments, very small clay content (under 5%) and are normally very shallow, with low water capacity. These lithosols are well aerated and warm for the given climatic conditions and contain 1.7% humus on average in the A horizon. The pH in the water averages 6 over acid rocks and 6.25 over basic rocks. The cation exchange capacity is very low (8eqmmol in 100g soil). The soils are not used for agriculture.

Regosols occur in basins, mainly on undulating terrain, over paleogenic, neogenic and diluvial sediments. Depending on the substratum over which they are formed, these soils are very heterogeneous in mechanical composition. The regosols formed over residuum from acid rocks contain on average: 27% coarse fragments, 3% clay, 13% silt and 17% clay + silt. Sandy soils prevail, covering 83% of the area.

Silicate carbonate regosols over tertiary sediments contain on average: 8-9% coarse fragments, 17% clay, silt 28% and 45% clay + silt. The physical properties of carbonate regosols are: porosity 50%, water capacity 38%, air capacity 11%, wilting point 15% and available water 23%. The chemical properties also show heterogeneity. The regosols formed over residuum from acid rocks are without carbonate and contain around 2% humus. pH in water is on average 6.2, cation exchange capacity is 11.5, S = 4.5eqmmol in 100g soil and V = 38.7%. Silicate carbonate regosols over tertiary sediments contain more than 2% humus and 16% $CaCO_3$ on average. Their reaction in water is averages pH 7.7. Some of the regosols are under xerophilic hilly pastures. The rest are used intensively for agricultural purposes.

There are very small areas of *arenosols,* formed on sand from the Vardar River that has been transmitted and deposited with the help of strong winds in the Vardar valley.

Colluvial soils

Colluvial (diluvial) *soils* are intensively used in the agriculture. They have very heterogeneous texture. On average, these soils contain: 10% coarse fragments, 10% clay, 20% silt and thus sand dominates (70%). The average value for porosity is 44%, for water capacity 34%, for air capacity 10%, for wilting point 11% and for available water 23%. They are also heterogeneous in their chemical properties.

Lithosols contain on average 2% humus. The reaction of the surface soils in this group is as follows: neutral (44.7%), acid (42.7%), with a small number alkaline (12.6%). Dystric colluvial soils have a low cation exchange capacity (less clay, with more illite and kaolinite), which is on average 17eqmmol in 100g of soil, and the base saturation is 78%.

Rendzinas

Rendzinas on hard limestones and dolomites are found on all the mountains of appropriate substratum: calcitic limestone, calcitic marble, dolomites, dolomitic marble and calcitic-dolomitic marble. The soils are relatively rich in clay owing to the high content of clay in the silicate residuum. The average clay content amounts to 11% in the organogenic soils, 18% in the organomineral soils and 26% in the brown rendzinas. The humus content is highest in the organogenic rendzinas (19%), whereas the other subtypes contain on average 10% of humus.

The highest pH values have been recorded for the organogenic soils (an average of 7), followed by the organomineral (6.9); the brown rendzinas are the most acid (pH 5.8). The soils are characterised by high cation exchange capacity (an average of 51eqmmol/100g soil). The base saturation percentage is high (on average,98%). The ratio of humic: fulvic acids is 0.80. There is a high content of humic acids bonded with Ca.

Rendzinas are most frequently found in the valleys in the central part of Macedonia, which is also the driest part, up to 800m above sea level. The texture of these soils is heterogeneous and is conditioned by the substratum. On average, they contain some coarse fragments (7%) with particle-size fractions as follows: coarse sand 13%, fine sand 39%, silt 26% and clay 22% on average. Their micro aggregates and macro aggregates are stable.

The average porosity values amount to 49%, the water capacity 38% and the air capacity 11%. These soils contain an average of 2.6% humus in the A horizon. In calcareous rendzinas, the A horizon contains an average of 11% $CaCO_3$ and the C horizon 25% $CaCO_3$. The average pH of the A horizon is 7.8. The cation exchange capacity amounts to an average of 25.0eqmmol/100g of soil, and the base saturation percentage in non-calcareous rendzinas amounts to 96%.

Rankers

Rankers are characterised by their heterogeneous texture. They are rich in coarse fragments (average 21%). They contain small amounts of clay (an average of 7%). The different particle size fractions are as follows: coarse sand (43%) followed by silt, while clay is least common. The stability of the micro aggregates is above 90%, and the stability of the macro aggregates is 70-80%. The most stable are the macro aggregates of 1-5mm diameter.

The porosity of the rankers varies between 46 and 60%, the water capacity from 37 to 44%, and the air capacity from 11 to 16%. The chemical properties are heterogeneous. The average quantity of humus is 8.5%. The average C:N ratio is 11. The pH of the rankers varies from 3.5 to 7.7 (average 5.4). The average cation exchange capacity is 27eqmmol/100g of soil. The humus in the rankers is rich in insoluble remains and mobile fractions of humic and fulvic acids. The ratio of humic to fulvic acids in dystric rankers is 0.7 to 0.9, and in the eutric rankers it is above 1.

Vertisols

Vertisols are identified as intrazonal, lithogenic topogenic soils. They are found together with other types of soil; depending on the parent material, with regosols, rendzinas, chernozems and cinnamonic forest soils, and on basic compact rock with lithosols and vertic rankers. The texture of vertisols is characterised by the following features: low coarse fraction (4% on average); the clay fraction dominates (clay + silt = 60%); clay is the dominant soil separate (40%) in the fine earth; there is little coarse sand in the vertisols (9%), more silt (21%) and fine sand

(30%); clay textures prevail and there is no texture differentiation.

Coarser macro aggregates dominate (above 3mm and especially above 5mm). The air capacity is low (2.7 to 6.5%, with an average of 4.2%). Aeration is low in wet conditions. Vertisols are characterised by high plasticity: the upper limit is 79%, the lower 38%, and the plasticity number is 41%. The A horizon contains an average of 3.5% humus and an average of 5.3% $CaCO_3$ (calcareous vertisols). The mean pH value for all Vertisols is 7.2.

The exchange capacity is high and amounts on average to 38eqmmol/100g soil. Mean values of exchangeable alkaline cations are: Ca=56%, Mg=27%, H + Al=15%, K=1.0%, and Na=0.7%. Exchangeable Mg cations dominate in the Vertisols on serpentinite and gabbro. These soils are characterised by a high percentage of humic acids, among which few are free. They contain little fulvic acids. The ratio between the humic and fulvic acids is high (1.75, and varies from 1.1 to 2.6). These soils contain a high percentage of insoluble organic remains.

Chromic cambisols

Chromic cambisols (cinnamonic forest soils) are found in the regions influenced by a Mediterranean climate, under xerophilous and thermophilous oak vegetation. They occupy undulating hilly (fluviodenudational) relief up to 900m and lake terraces in the valleys, on tertiary sediments, particularly neogenic lake sediments and certain more recent ones. They can be found on Mesozoic and Paleogenic (Eocene) sediments and less frequently on compact basic rocks and pyroclastic sediments.

The solum of these soils is 50-100cm deep. The texture of the soils has the following composition: relatively low content of coarse separates (average 10%); in the A horizon the sand content (coarse + fine sand) dominates over the clay content (silt +clay) and amounts to 60% on average. The profile shows clear textural differentiation: the (B) horizon contains 1.7 times more clay than the A horizon. The micro- aggregates are very stable. There are clear differences between the physical properties of the A and (B) horizons. For example, the average values in the A and (B) horizons are as follows: for the bulk density 1.4 and 1.5 respectively; porosity 49% and 45%, water capacity 39%, and air capacity 10% and 5.5%. The humus content in the A horizon is very variable and is about 6-7% under forests, 4% under pastures, and in the cultivated soils averages 2.6%.

The average pH value in H_2O is 6.4 in the A horizon and 6.6 in (B) horizon. The cation exchange capacity (T) is on average 22eqmmol/100g soil. This value is higher in the (B) horizon. The sum of the exchangeable bases (S) is relatively high (an average of 18.0eqmmol/100g soil) and the same is true of the base saturation percentage (V), 83%.

The humus composition has the following characteristics: a high content of humic acids (30%), with those bonded with calcium prevailing, a reduction in the quantity of humic and an increased quantity of fulvic acids in the (B) horizon, so that the relation between them in the A horizon amounts to 1.27, and in (B) to 0.84. According to its composition, the humus can be classed as mull.

Red soils

Red soils (terra rossa) covers very small areas. It is found in those parts of the Republic of Macedonia influenced by a Mediterranean climate. The soils form on the mountain karst relief, most often up to 600m above sea level. The solum of the red soil is 30 to 70cm thick. They contain less than 10% skeletal material. The clay fraction dominates in the fine earth (average 38%). There is very little coarse sand (average 5.5%) and most of the sand is fine sand (27%), and silt (30%).

These soils are characterised by textural differentiation. In the (B) horizon there is 1.32 times more clay than in horizon A. The (B) horizon meets the FAO-UNESCO criteria for an *argic* horizon. The micro- aggregates and macro aggregates are stable. The humus content in the forest areas is on average 5.5% but can be as low as 2.5%, and in the (B) horizon it averages 3.6%. The average pH value in the A and B horizons is 6.9,. Neutral soils dominate absolutely.

The cation exchange capacity is high (on average in horizon A it is 35.5eqmmol/100g soil. The sum of exchangeable bases (S) is high (30eqmmol/100g soil) and the base saturation percentage (V) is also high 88%. The humic : fulvic acid ratio is 0.85 in the A horizon and 0.47 in the (B) horizon.

Cambisols

Brown soils on limestones and dolomites (calco-cambisols) are found only in the limestone and dolomite mountains in the Central mountain zone, at an altitude of 600 – 1,600m. The average depth of the solum is 56cm. The texture has the following characteristics on average: 12% skeletal material; physical clay (clay + silt) prevails (60%). The textural differentiation is clear. The (B) horizon contains 1.37 times more clay than the A horizon.

The average humus content in the A horizon is 7%. The solum is not calcareous. The pH in water is close to neutral (average 6.5). The cation exchange capacity is high (for the A horizon, on average, 39eqmmol/100g soil). The sum of exchangeable bases (S) is high (33eqmmol/100g soil in the A horizon) and the base saturation percentage (V) is also high, at around 84%. The humus composition has the following characteristics: there is a low percentage of insoluble residue (32-33%) and a fairly high percentage of humic (29%) and especially fulvic acids (38%). The ratio of these acids is fairly narrow (0.77 in the A and 0.67 in (B)).

Brown forest soils are the most widespread soil type in the Republic of Macedonia. They account for approximately 1/3 of the mountain territory of the Republic. As climatic-zonal soils, they are found on all forms of mountain relief, all aspects and inclinations at altitudes between 800 and 1,800m. They form on compact quartz rocks, as well as on a number of compact acid, neutral basic and ultra basic silicate eruptive and metamorphic rocks and, over small areas, on carbonate-free silicate sediments.

As far as the climate is concerned, these soils can be found in four vertical climatic zones: cold-continental, piedmont-continental-mountain, mountain-continental, and sub alpic. These soils are found under a number of associations in the oak, beech and subalpic regions. The texture of the soils is heterogeneous: sandy loams, loams, and clay loams prevail.The skeletal content is quite high (average 25%) in the A and (B) horizons. The clay content averages 9% in the A and 12% in (B) and textural differentiation is low. On average, the (B) horizon contains 1.28 times more clay than the A horizon; argilogenesis is low and there is 1.24 times more clay in the (B) horizon than in the C. The sand content (coarse + fine sand) accounts for 2/3 of all the particle-size fractions. Coarse aggregates dominate in these soils (46% of the aggregates are larger than 3mm).

The macro aggregates show high stability (82.5% in the A horizon and 77.7% in the (B) horizon. The soils are characterised by high porosity (54% in the A, 41% in the (B) horizon on average). They have moderate water retention capacity (37% in A, 33% in (B)). The aeration is very high (17%) in the A and 13% in the (B). The chemical properties vary within broad limits, depending on the parent material, altitude, climatic-vegetation zones.

The organic horizon contains approximately 19% humus. The mineral soils are also rich in humus: 6.6% on average in the Ahorizon. The soils are non-calcareous, with pH averaging 5.6 in the A horizon and 5.5 in the (B). Acid and moderately acid soils thus dominate. The cation exchange capacity in the A horizon is an average of 25 and in the (B) horizon an average of 20eqmmol/100g soil. The sum of exchangeable bases (S) is low: 13.5 in the A horizon, 9.9eqmmol/100g soil in the (B) horizon (B, so that V is around 50%, but it varies depending on the subtypes

The humus has a distinctly different composition in different horizons. The insoluble residue is the most dominant followed by the fulvic acids, while the humic acids come third (the ratio is 1:0.48:0.41); the ratio between the quantity of the humic acids and the fulvic acids is below 1 (in the A horizon 0.87 and in the (B) horizon 0.51).

Luvisols

Eluvial-illuvial soils (luvisols) have the following characteristics: the skeletal content is fairly low (9%). The sand fraction dominates and accounts for 2/3 of the particle-size fraction; physical clay dominates in the Bt horizon, where it accounts for 54%; the clay content in the A horizon averages 15%, and in the Bt 36%. The microaggregates show high stability. The stability of the macro- aggregates is greatly reduced in the cultivated soils (45%), especially of those under 1mm.

The porosity in the Ap is 45%, and lower in the Bt (37%), with high percentage of capillary pores. The water retention capacity in the A horizon is 31%, and in the Bt 35%. The chemical properties show heterogeneity and differentiation with profile depth. The average humus content in the A horizon A is 2.7%. The average pH values in H_2O indicate moderate acidity (5.8 in the A and 5.7 in the Bt). The cation exchange capacity in the A horizon averages 16 and in Bt 24eqmmol/100g soil. The sum of exchangeable bases shows similar differentiation (6.8 in the A and 15.5eqmmol/100g soil in the Bt). The C:N ratio of the humus is 11.2 in the A horizon, and 7.0 in Bt.

The areas of *brown podzolic soils* are small and not sufficiently studied as yet. This is the soil type accounting for the smallest area amongst the

mountain soils. In the Republic of Macedonia, they appear in the vertical zone between 1,500 and 2,200m. The texture has the following characteristics: a considerable quantity of coarse fragments: in A/E 27%, in B_1 32%, in B_2 43% and in the C, 52%. The sand content on average is 32% in the A/E, 32% in B_1, 25% in B_2, and 21% in the C.
The clay content is low, with an insignificant textural differentiation. In the organic horizon, there is an average of 23% humus, 9% in A/E, 6% in B_1, and 3.4% in B_2. The C:N ratio is 14 to 15 in all horizons. The horizons have a highly acid reaction, the pH in water averaging 4.5 in the A/E, 4.7 in B_1, 4.9 in B_2 and in the C, 5.0. The cation exchange capacity is 37eqmmol/100g soil on average in A/E horizons. A very important characteristic of these soils is the extremely low content of exchangeable bases: only 3.2 in the A/E horizon, 1.6 in the B_1 horizon, 1.0 in B_2 and 1.1eqmmol/100g soil in the C horizon. The base saturation is, therefore, very low: 9% in the A/E horizon, 6% in B_1, 5% in B_2 and 8% in the C horizon.

Fluvisols

Fluvisols (alluvial soils) cover approximately two-thirds of the flood plain surface and are among the best-known soils in these parts. They are characterized by their highly heterogeneous texture. The dominance of loamy soils (86%) indicates their favourable texture. The average texture is a follows: fine sand 51%, silt 30%, clay 10%, and coarse sand 9%. There are few coarse fragments (4%). In the surface horizon, these soils contain an average of 2% humus.

Of the entire area of alluvial soils, non-carbonate soils make up 62%, and carbonate soils 38%. The average CEC of the soils is 19 in the top layer, while the S is 16eqmmol/100g of soil; consequently, the average V is 82%. Salt content is low (below 0.2%), with predominance of Ca and Mg bicarbonates.

Fluviate-meadow soils (humofluvisols) cover a significantly smaller area than alluvial soils. Most of the profiles are loamy (85%), and only 15% of are clayey soils. The average particle-size content is: fine sand 42%, silt 30%, clay 16%, and coarse sand 12%. In the A horizon , the humus average is 2.4%, and the C:N ratio approximately 10. The average CEC of the A horizon is 19,and S is 16eqmmol/100g of soils, so that V is 83%. The salt content is low.

Hydromorphic soils

Hydromorphic black soils: Fifty seven per cent of these soil are clay soils and 21% are clay loam soils. The content of individual soil separates is on average as follows: fine sand 32.4%, clay 29%, silt 28%, and coarse sand only 11%. Micro aggregates are stable, macro aggregates are unstable. The C:N ratio varies from 6 to 13. The average CEC of the soils is 44 and S is 38eqmmol/100g of soils, so that V is 94-98%. The humus composition is characterised by the following properties: high prevalence of humic and fulvic acids, high content of insoluble residue, domination of an inert (stable) component of humus, and a high degree of polymerisation.

Swampy gley soils: The texture of these soils is also heterogeneous. Among them, loamy classes predominate (76%), followed by clay classes (24%). They contain very few coarse fragments (2.5%). Soil separates appear on average as follows: silt 36%, fine sand 36%, clay 21%, and coarse sand 6.5%. These soils are rich in humus (an average of 6% in the A horizon. The average pH in carbonate gley soils is 7.7, while in non-carbonate soils it is much lower, 6.2. The average CEC is high, 30, in the A horizon, and S is 20eqmmol/100g of soils, so the V in non-carbonate gley soils 69%. The salt content is very low.

Histosols

Peat soils (histosols) cover approximately 700ha. The total volume of peat is 8,000,000 cubic metres. The peat soils in the Republic of Macedonia are mainly lowland (90%) and eutrophic,. There are no climatogenic (ombrogenic) soils. The soils are characteried by low real density, rather low bulk density, high total porosity, high water holding capacity, high wilting coefficient, low capillary rise of water, pronounced swelling and shrinkage, low carrying capacity and hardness, high compressibility, high specific heat and strong thermal conductivity in a most environments. Also, these soils are characterised by high organic matter contents with a low degree of decomposition, high total content of nitrogen, high C:N ratio, high CEC, high buffering, absence of toxic Mn and Al ions in the presence of an acid reaction, and low quantities of nutrients per peat volume.

Pseudogleys

Pseudogleys. The total surface of these soils is small (several thousand ha) and has not been precisely established. The texture is highly differentiated. The average ratio of clay content between the lower and upper horizons is 2.7, varying between 2.1 and 4.5. Chemical properties also reveal similar differentiation.

Halomorphic soils

Halomorphic soils have specific properties by which they differ from non-halomorphic soils. They exhibit significant changes over small distances. A number of halomorphic soils are vertically heterogeneous with some of their properties changing significantly with depth. The salt can emerge as spots on the fertile non-halomorphic soils and can spread through anthropogenic salinisation and alkalisation. Halomorphic soils contain larger quantities of salts and exchangeable sodium ions than other types of soil and they can have strong alkaline reaction. They are characterised by low or no productive capacity, but can be reclaimed.

These types of soil are not extensive, covering only approximately 11,000ha in the Republic of Macedonia. More than 90% of halomorphic soils are formed in alluvium, and only very rarely from colluvial deposits. Saline Eocene deposits have an indirect influence on the genesis of these soils. In terrain with such deposits, halomorphic soils are formed when the ground water is close to the surface (meso-depressions, slopes). The dry matter in the water extracts of these deposits amounts to 0.813% on average with Na_2SO_4 predominating, and with the presence of boron (1.8mg/l). As it passes through these deposits, the ground water becomes richer in salts, particularly in Na_2SO_4 and boron. The parent material because of its properties (salt content and composition, $CaCO_3$ and $CaSO_4$ contents, clay content and composition), influences the properties of the solum.

The influence of the parent material is combined with topographic-hydrographic conditions. The ground- waters in the solonchak soil types contain considerably more salts (38.2g/l on average, with a maximum of 107g/l. This quantity of salts is not to be found elsewhere on the Balkan Peninsula. Salts in solonetz groundwaters amount to only 0.90g/l. The neutral salts (sulphates and chlorides) prevail in solonchaks, with the sulphates dominating.

Soil Monitoring

Unfortunately, the Republic of Macedonia has still not established soil monitoring programmes. This is the result of insufficient financial support for this complex and expensive work.

Future Prospects

- Elaborating and digitising of pedological maps at the scale 1:50,000;
- Mapping of locations where soil degradation is occurring;
- Establishing of a soil monitoring system;
- Introduction of a Soil Information System;
- Introduction of a law to regulate maximum permissible limits of harmful substances in soils;
- Defining of resources that cause soil pollution;
- Introduction of law for soil fertility control;
- Preventing activities of negative soil degradation by implementing measures for positive anthropogenisation of soils;
- Defining of regions for healthy food production.

References

Filipovski G., Rizovski, R. and Ristevski, P. (1996). The characteristic of the climate–vegetation–soil zones (regions) in the Republic of Macedonia. Macedonian Academy of Sciences and Arts, Skopje.

Filipovski, G., Mitrikeski, M. and Petkovski, D. (1985). Conditions of formation, genesis, evolution, classification, properties, and spread out of the soils in Malesh and Pianets, Vol. VI, Macedonian Academy of Sciences and Arts, Skopje.

Filpovski, G. (1995, 1996, 1997, 1999, 2001). Soils of the Republic of Macedonia, vol. I, II, III IV and V, Macedonian Academy of Sciences and Arts, Skopje.

Mitkova, T. and Mitrikeski, J. (2003). Humus composition of chernozems in Ovce Pole Region, Journal of Ecological Science, Vol. II, N^0 3-4, p.60-63, Sofia, Bulgaria.

Mitkova, T. and Mitrikeski, J. (1995). Contains of atsorptive ions of cinnamonic forest soils constitute at the area of Kumanovo. Agricultural Review, Vol. 42, 19-26, Skopje.

Mitkova, T., Mitrikeski, J. and Trajkoski, O. (1996). Contains of exchangeable ions of cinnamonic forest soils in the area of Prilep. Agricultural Review, Vol. 43, 15-19, Skopje.

Mitkova, T. and Mitrikeski, J. (1998). Contains of atsorptive cations of chernozems in area of Tikves. Yearbook of the Faculty of Agriculture, Vol. 43, 7-18, Skopje.

Mitkova, T. and Mitrikeski, J. (2000). Conditions of formation, genesis, evolution and classification of the chernozems in the Republic of Macedonia. Symposium Soils and their exploitation. Proceedings, 45-57, Macedonian Academy of Sciences and Arts, Skopje.

Mitrikeski, J. (1995). Humus composition in distric brown forest soil spread in R. Macedonia. Yearbook of the Agriculture, Vol. XL, 7-23, Skopje.

Mitrikeski, J. and Mitkova, T. (2001). Contents of exchangeable cations of distric brown forest soils on the mountain Bistra. Proceedings, X Conference, JDPZ, 12, CD, Vrnjacka Banja.

Mitrikeski, J. and Mitkova, T. (2002). Assessment of the quality of the contaminated soils in Republic of Macedonia. International Workshop: Assessment of the Quality of Contaminated Soils and Sites in Central and Eastern European Countries and New Independent States, PROCEEDINGS p.171-173, Sofia, Bulgaria.

Mitrikeski, J. and Mitkova, T. (2003). Humus composition of brown forest soils in the Republic of Macedonia, Bulgarian Journal of Ecological Science, Vol. II, N^0 3-4, p.64-70, Sofia, Bulgaria.

Skoric, A *et al.* (1985). Soil classification in the Yugoslavia. Book. LXXVIII, ANUBH, Sarajevo.

Statistical Yearbook of the Republic of Macedonia. (2002)