Soil study and interpretation procedures in Tourkovounia hills of Attica, Greece

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***Abstract*—** This work is a soil study which its purpose is to analyze and study the physicochemical properties of soil in the region of Tourkovounia hills of Attica, based on the samples that collected. Fifteen soil samples were collected from different parts of the analyzed area and several laboratory tests were carried out on them. The purpose of this study and laboratory tests is a deeper understanding of the soil nature and formation in the region of Tourkovounia hills of Attica, as well as the possibility of exporting valuable conclusions for the whole region.

***Keywords*—**Attica region, Bouyoukos method, carbonate salts, electrical conductivity, organic substance, soil classification.

I. Introduction

RECONNAISSANCE surveys have played a major role in soil investigations all around world [1, 2]. They continue to be undertaken to map regional soil resources and to locate areas with developmental potential. Although such surveys normally have to contend with large areas, long distances, poor access, and limited vehicle servicing facilities and frequently they are in areas of forested terrain with poor ground visibility, their use is also valuable and significant in other areas as well [3, 4].

During the last 60 years several similar studies and surveys have been performed in an effort the region of Attica to be classified and to provide to the soil scientists a better understanding and modeling of the complex distribution of soil over space [5, 6]. The current work contributes in this field performing new laboratory tests in the region of Attica and more specific in the region of Tourkovounia hills. For this purpose 15 different sites were selected and 15 different samples have been taken. Based on the conducted laboratory tests and the produced results the composition of the soil in the region of Attica can be better understood and valuable conclusions on the whole region can be extracted.

II. Description of the Analyzed Region

Attica has an average annual air temperature 17.5 °C. The minimum value of the average temperature is 9.3 °C, while the maximum value is 27.6 °C. The average soil temperature is 2 °C higher than the value of air temperature. The average annual rainfall in Attica is 393 mm, while the annual heights ranging between 370 and 1100 mm. Attica area has average annual value 2699 hours of sunshine and is considered one of the sunniest regions of Greece. The number of days that the sun is not blocked by clouds reaching on average of 114 days per year. On the other hand the number of days that the sun is blocked by clouds reaching on average of 19 days per year. The monthly average values of absolute humidity in mmHg are ranging from a minimum 6.16 to a maximum 11.02. The average values per month of relative humidity ranging from a maximum of 74.5 % to a minimum of 46 %. Evaporation in Attica is generally high. During the summer is very high, with a maximum value of 250 mm in July, while the minimum value observed in January to about 64 mm. The total evaporation is 1600 mm. The potential evaporation shows maximum of 173.4 mm and minimum of 15.3 mm. The average atmospheric pressure is 62.65 mb.

Sampling took place in Tourkovounia hills of Attica in 15 selected sites (Fig. 1). After sampling, all the soil samples were cleaned by using a backhoe in order to remove any weeds and high content of organic substance from the surface. A total of 15 samples were tested (Fig. 2). The first five samples were taken from positions of soil background slate, the second five samples were taken from soil sites with limestone base and the last 5 samples were taken from the Athens Park. It must be mentioned that the geographical longitude, latitude and altitude of each site was recorded.

III. The Methodologies Used in the Study

The mechanical analysis of soil samples which determine the particle size composition was the Bouyoukos method [7]. According to Bouyoukos method, soil samples of known dry weight are dispersed in a water column and the density of suspension is measured at predetermined intervals. The coarse materials settle faster than the fine soil materials (Stokes law), thus the time intervals that the sand has settle down were selected and when the sand and silt has settled down (clay remains in suspension) the percentage of sand, silt and clay were calculated. This method uses a densitometer (Bouyoukos hydrometer) to measure the density of the suspended soil-water mixture. The density depends on the concentration of the suspended soil particles in the measurement depth. The sedimentation rate of soil materials and therefore the

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measurement time is determined by Stokes equation given in (1).

Fig. 1: The region of study: Tourkovounia hills of Attica (sample 6, limestone base background, geographical latitude l479162, geographical longitude 4206406, altitude 295.3).

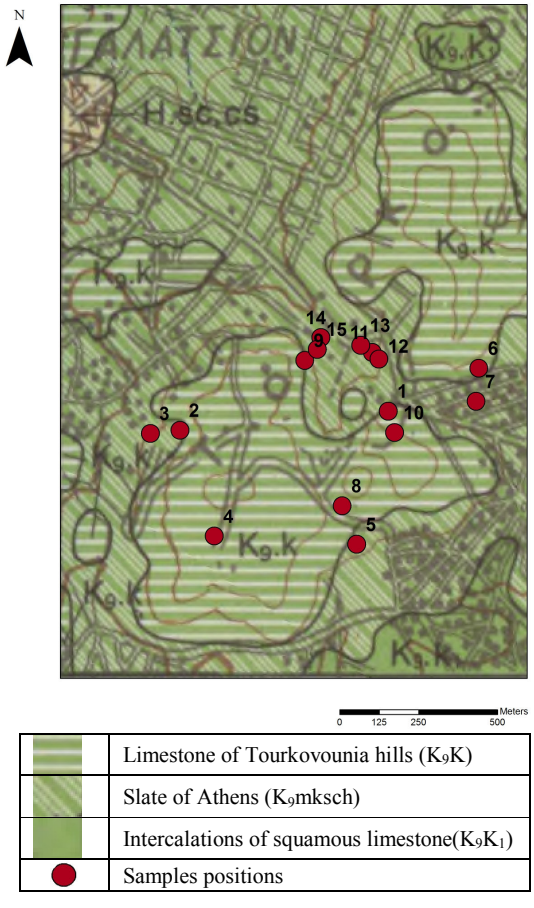

Fig. 2: Positions of the 15 soil samples in the region of study.

$$V = 2r^2(D-d)g/9n \quad (1)$$

where:

V the speed that the soil particles fall (cm/sec),
D the density of the soil particles (2.65 gr/cm^3),
d the water density (0.998 gr/cm^3),
g the gravity acceleration (980 cm/sec^2),
r the radius of soil particles (cm) and
n the absolute viscosity of fluid (poises).

As dispersive mean Calgon, a commercial product of polymetaphosphate sodium $(NaPO_3)x + NaHCO_3$ was used, in order to release all the grains. For this purpose mechanical shakers have been also used. Finally the reduction of measurements at the temperature of 20 ^oC has been performed and the mechanical fractions of soil were calculated.

The pH determination of soil samples was performed in a suspension of 1:1 soil-water with an electric pHmeter [8], after having been left for an hour in order to be in balance [9]. The instrument was adjusted using a buffer solution of known pH value.

The determination of organic substance of soil samples was performed with the Walkley-Black method which is based on the oxidation of organic substance with an oxidant and measuring the degree of reduction [10, 11]. The oxidant that was used was potassium dichromate ($K_2Cr_2O_7$ 1N). Initially the coal organic substance of each soil sample was oxidised with $K_2Cr_2O_7$ 1N and then the excess of $K_2Cr_2O_7$ 1N with divalent iron sulphate 0.5 N was titrated. The total organic substance percentage [12] and the total organic carbon were calculated using (2) and (3).

$$\text{Total organic substance (\%)} = (T-T')\cdot N\cdot 0.67/B \quad (2)$$

$$\text{Total organic carbon (\%)} = (T-T')\cdot N\cdot 0.39/B \quad (3)$$

where:
T' is the ml solution of ferrous sulphate iron consumed in the titration of soil sample,
T is the ml solution without soil,
N is the normality of solution of ferrous sulphate iron and
B is the weight of soil samples that used.

It must be mentioned that the weight of all the soil samples used were 0.5 gr and the ml solution of ferrous sulphate iron consumed in the titration of the sample without soil (T) was 20.6 ml.

In order to measure the electrical conductivity, a soil paste with 100 gr soil (grain size 2 mm), which was placed in a suitable cylindrical container, has been prepared. Then distilled water has been added with a measuring cylinder and it was mixed with a spatula. The paste placed in a suitable container and then the instrument that measures the electrical conductivity has been used.

The determination of carbonate salts has used the Bernard method [13]. This method identifies the types of soil carbon, particularly Ca^{2+} and Mg^{2+} and is expressed in gr $CaCO_3$/100 gr of soil. The technique of this method is based on the measuring of the emitted CO_2 by adding HCl to the soil sample at a ratio of 1:1 (soil: HCl) and the reaction of the latter with various forms of soil carbon. All the carbonates in the sample are expressed in percent (%) in gr CaCO3 and are calculated using (4).

$$CaCO_3\ (\%) = K*V/G \quad (4)$$

where:
V is the volume of CO_2 emitted in ml,
G is the weight of soil sample in gr and
K is the conversion factor of 1 cm^3 CO_2 converted in gr $CaCO_3$ and the value is 0.44 at 0 ^oC temperature and 760 mm Hg pressure, 0.42 at 15 ^oC temperature and 760 mm Hg pressure, 0.41 at 20 ^oC temperature and 760 mm Hg pressure and 0.40 at 30 ^oC temperature and 760 mm Hg pressure.

It must be mentioned that the conversion factor *K* that used in this laboratory test was 0.41 and the weight of soil samples was 0.5 gr.

IV. Test Results

Fifteen soil samples were collected from 15 different sites of Tourkovounia hills region of Attica. The samples initially left to dry and then they have been crushing and sieving. After the samples' sieving with the 2 mm sieve, a fraction of fine earth was gained. Then a certain amount was removed in order to perform the laboratory tests. From particle composition's point of view, the soil samples 1, 5, 7, 9, 11, 12, 13, 14 and 15 were classified as loam. The soil samples 3 and 4 were classified as clay loam. The soil samples 2 and 8 were classified as silty clay loam. The soil sample 6 was classified as sandy clay loam and finally the soil sample 10 was classified as silty loam. Fig. 3 shows the triangle of classes of particle size composition of the 15 soil samples (Fig. 3).

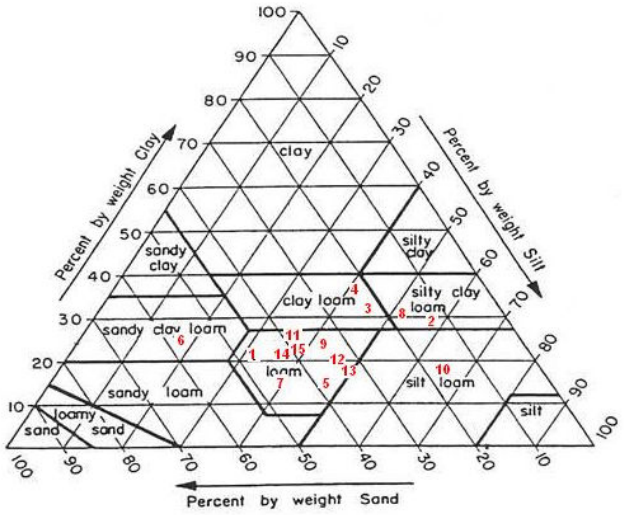

Fig. 3: Triangle of classes of particle size composition of the 15 soil samples.

For all soil samples pH was almost the same with mean value of 8.33, maximum value 8.51 and minimum value 8.14 (Fig. 4). This results the medium alkalinity of the soil samples. The total organic substance shows fluctuations with mean value of 0.934 %, while the minimum value was 0.469 % and the maximum value was 2.814 % (Fig. 5). The concentration of carbonate salts in gr $CaCO_3$ (%) has mean value of 38.518 %, while the minimum value was 20.008 % and maximum value was 53.300 % (Fig. 6). These fluctuations don't show any spatial distribution and should be a result of good or poor soil leaching. The values of electrical conductivity were too low in all samples therefore no salinity problems have been noticed. Table 1 presents the results of all laboratory tests that have been conducted for the 15 soil samples.

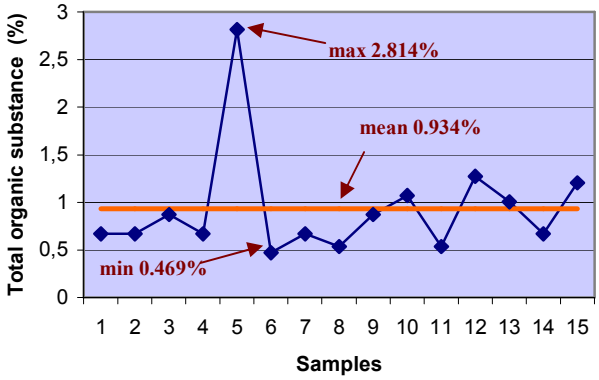

Fig. 4: Total organic substance of the 15 soil samples.

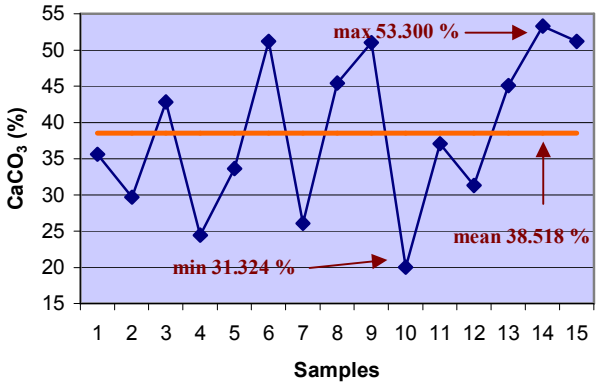

Fig. 5: Concentration of carbonate salts of the 15 soil samples.

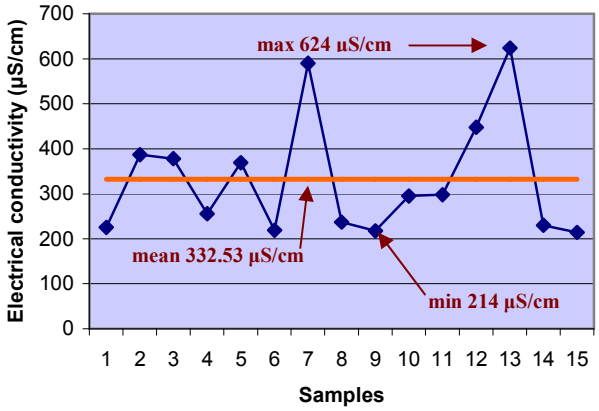

Fig. 6: Electrical conductivity of the 15 soil samples.

Table 1: Laboratory results of the 15 soil samples.

Sample number	Sand (%)	Clay (%)	Silt (%)	pH Value	Organic substance (%)	$CaCO_3$ (%)	Electrical conductivity (μS/cm)	Background	Altitude
1	46	22	32	8.32	0.670	35.588	225	Slate	278.4
2	16	28	56	8.35	0.670	29.684	387	Slate	242.8
3	22	30	48	8.25	0.871	42.804	378	Slate	232.1
4	20	36	44	8.38	0.670	24.436	256	Slate	237.4
5	46	16	38	8.19	2.814	33.620	369	Slate	252.3
6	58	26	16	8.21	0.469	51.168	219	Limestone	295.3
7	44	16	40	8.23	0.670	26.076	590	Limestone	297.3
8	16	30	54	8.50	0.536	45.428	237	Limestone	284.3
9	32	22	46	8.44	0.871	51.004	218	Limestone	305.4
10	18	18	64	8.40	1.072	20.008	295	Limestone	278.4
11	38	28	34	8.43	0.536	37.064	298	Athens Park	291.3
12	36	20	44	8.22	1.273	31.324	448	Athens Park	283.3
13	34	20	46	8.14	1.005	45.100	624	Athens Park	292.3
14	42	20	38	8.41	0.670	53.300	230	Athens Park	300.5
15	46	22	32	8.51	1.206	51.168	214	Athens Park	298.4

I. Conclusions

In this paper are presented the laboratory tests that have been conducted in the region of Tourkovounia hills of Attica. Fifteen different sites have been selected and fifteen samples have been collected in order to perform laboratory tests (particle composition, organic substance, concentration of carbonate salts, electrical conductivity) and to analyze the physicochemical properties of the soil.

Based on the tests the composition of the soil in the region of Tourkovounia hills of Attica can be better understood and valuable conclusions useful to the scientists for the whole region can be extracted.

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