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INTERACTION BETWEEN SOILS AND CLIMATE CHANGE

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Abstract: Small changes in the soil carbon pool can increase or decrease atmospheric CO2. Soils can be either pet sink or net source of CO2 depending on their management and climate.

One of the ways to mitigate the rise in atmospheric CO2 is sequestration of carbon by soils. Climate change have a multitude effect on soils, but also the soil carbon sequestration decreases climate change. Soil carbon exists in all three phases of soil, as organic or/and inorganic carbon. Several papers have showed that CO2 saturation concentration in atmosphere for photosynthesis was approximately 0.1% and low light intensity affects photosynthetic rate. The organic matter content of soils ranges from less than 1% in desert soil to close to 100% in organic soils. A typical agricultural soil may contain between 1 and 5 % organic matter in the top 15 cm. Soils that are low in carbon, like Arenosol, Calcisol, Ferralsol, Gipsisol, Lixisol, Regosol, can become net carbon sinks thus reducing the increase in atmospheric CO2. For the climate change problem, a great importance presents the soil groups which contain the greatest quantity of carbon, as Cryosol (4.1-1.0%OC and 1800 mill.ha). Warming of these soils could switch these arctic soils from a carbon sink to a carbon (CO2, CH4) source. The total area of soil cover on the Earth's surface is about 15 billion ha and stored 4000 PgC, more than in the atmosphere and biota. Paleosols allows to establish the magnitude and periods of climate chenage.

Keywords: soil carbon, organic matter, soil groups, climate change

1. INTRODUCTION

It is recognized that carbon is an essential building block of life. Carbon is a non-metallic element (C). In the atmosphere the content of CO_2 varies approximately of 0.03%. Carbon occurs in soils in both organic and inorganic forms, the greatest part of it being found in the organic matter and in the carbonate minerals. Some soils also contain highly condensed forms of nearby elemental C, such as charcoal, coal, graphite or cinder. Carbon is a major constituent of organic plant material [1]

There is a continuously interchange of various gases between the atmosphere and the soils cover and the various reactions that either consume or produce gases in the soil.

The two major gases are O_2 and CO_2, where O_2 moves from the atmosphere to soil and is consumed, and CO_2 is produces in soil, by respiration of microorganisms and plant roots or biological reactions, and moves from the soil to the atmosphere.

The storage of atmospheric C in soils and in living biomass has a significant role in reducing the CO_2 content in the atmosphere and has a consequences in diminishing the green house effect [2]

Earth's first inhabitants were phototrophs, converting CO_2, water and sunlight into glucose and oxygen.

Any of the gases emitted from the Earth's surface into the atmosphere, including CO_2, CH_4, N_2O, NO, NO_2 and chloroform carbons, originate mainly from industrial emissions [3]

World soils and their use in agriculture contribute to some 1/3 of the total gases following deforestation and inappropriate soil management.

Some agricultural practices, mainly those increasing the input of organic matter to soils and decreasing soil organic matter decomposition promote a lasting carbon sequestration, ultimately as stable soil humus.

Although C is in evidence, no other cycle has been so altered by humanity as that of nitrogen (N_2O is 300 times greater effect than that of CO_2) and little attention has been given to the impacts on global warming and human health [4]

Small changes in the soil carbon pool can increase or decrease atmospheric CO_2. Soils can be either pet sink or net source of CO_2 depending on their management and climate.

One of the ways to mitigate the rise in atmospheric CO_2 is sequestration of carbon by soils [2]

In accordance with WRB-SR 2014 ,,soil is any material within 2 m of the Earth's surface that is in contact with the atmosphere, excluding living organisms, areas with continuous ice, not covered by other material, and water bodies deeper than 2m'' [5]

Soil has always been a basic resource for sustaining human populations. Soils served as the planting medium and also provided material for building earthen architectural structures and for making pottery.

From the list of Reference Soil Group it can be seen that there are 32 Soil Groups with a total area of 15,0205 billion ha. Climate change have a multitude effects on soils, but also the soil carbon sequestration decrease climate change.

2. MATERIAL AND METHOD

The main objective of this thesis is to present the soil organic carbon content for the representative Soil

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Groups comprise in the World Reference Base for Soil Resources (W.R.B-SR 2014) and for soil types which cover the landscape in the region Banat, situated in the SW of Romania. For the Romanian soil cover the analytical data have been resulted as a consequence of a long period of own soil survey. This means to realize morphological, physical and chemical analyses in the field and laboratory. [6][7]

In order to illustrate the climate change unfolded in the European mountainous Glaciation, a Paleosol was presented.

3. RESULTS AND DISSCURSION

The primary sources of soil organic matter with organic carbon are dead plant, originate from forest, steppe, savannah or taiga (table 1)

Table 1. Plant residues in natural ecosystems

Vegetation types	Annual quantities of litter to/ha/ann
Arctic tundra	1.0
Taiga	3.5-5.5
Oaken forest	6.2
Steppe	11.7
Arid steppe	4.2
Semidesert	1.2
Arid savannah	7.2
Subtropical forests	21.0
Tropical forests	25.0

The greatest quantity of dead plant remains in the tropical and subtropical forests. The dead plant consists of lignocelluloses, with 15-60 % cellulose, 10-30% hemicelluloses, 5-30% lignin, and 2-15% protein. Soils may contain several tones per hectare.

Soil content in organic matter is strongly impacted by human activities and land use changes or intensive agricultural practices with little return of biomass to soil (table 2)

Table 2. Crop residues after harvest

Crop	Dry substance, t/ha
Wheat, rye, oats	1.2-1.5
Spring barley	0.9
Autumn barley	1.7
Bean	2.0
Sweet pea	0.5
Lupines luteus	1.5
Clover	4.0-5.6
Potatoes, sugar beet, rape	0.6-1.0

For the land in crop it is recommended to cultivate evergreen, such as clover, lucerne or sainfoin (4.0-5.6 to/ha)

Soil carbon exists in all three phases of soil, as organic or/and inorganic carbon, including solid phase (mineral matter with inorganic carbon, and organic matter with organic carbon), liquid phase (which represent 15-35% from the total volume of soil) and gaseous phase (with CO_2 and CH_4)

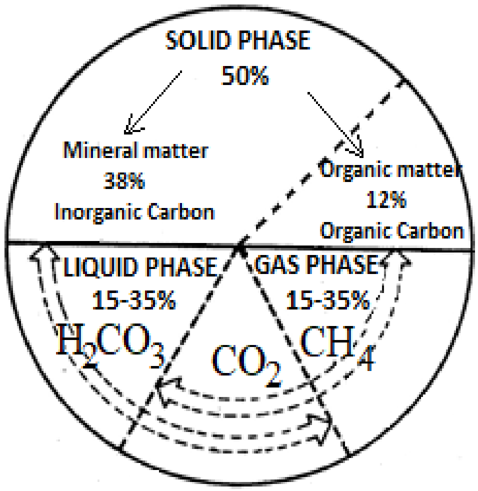

Figure 1. Forms of carbon contained in three soil phases

The soil, the plants and the atmosphere are all components of a physically unified and dynamic system in which various flow processes occur interdependently. In this system flow takes place from higher to lower potential energy.

Several papers have showed that CO_2 saturation concentration in atmosphere for photosynthesis was approximately 0.1% and low light intensity affects photosynthetic rate. Plants need also to draw quantities of water from the soil in excess of their actual metabolic requirements. Transpiration is caused by the vapor pressure gradient existing between the leaves and the atmosphere. Decomposition of plant debris is controlled by interrelated factors primarily moisture content, temperature, acidity, microbial activity composition of the deposit, and time. The earth can be divided in two organic soil-forming zones, temperate zone and tropical zone. In temperate zone the median rate of organic soil formation is about 0.6 mm year $^{-1}$, and in tropical zone 2.2 mm year^{-1}.

In the high latitudes of Asia, Europe, and North America soils are covered by glaciers and formed following retreat of glaciers.

The organic matter content of soils ranges from less than 1% in desert soil to close to 100% in organic soils. A typical agricultural soil may contain between 1 and 5 % organic matter in the top 15 cm. Most soil chemists partition the soil organic matter into the following three fractions: (1) labile (carbohydrates, lipids, proteinaceous materials), (2) intermediate (humic and fulvic acids) and (3) stabile (humin).

It is assumed that humus contains as an average, 58 % organic C, and that the ratio C:N:S:P is of the order 100:10:1:1. The molecular formula of humic acid is $C_{308}H_{328}C_{90}N_5$.

Soil inorganic carbon (figure 2) is part of the global C cycle and is originating in soil from carbonaceous parent rock and though the process of soil – forming.

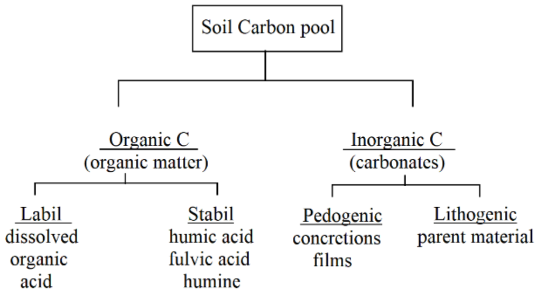

Figure 2. Soil carbon pool

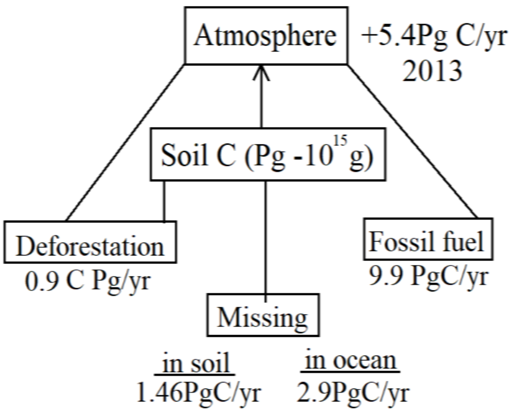

Figure 3. (Carbon cycle, data on Lal R.)

Soils can be defined as four dimensional (space and time) which performs functions including: biomass production, the storing, filtering and transformation material, a reservoir of soil biodiversity, storing and cycling elements like C, N, P etc, water.

Table 3. Organic C in the first two horizons of the world soils, WRB, 2014

Soil	OC(1.2)	Soil	OC(1.2)
Acrisol	6.5, 1.6	Leptosol	0.8, 0.1
Alisol	1.2, 0.6	Lixisol	0.2, 0.2
Andosol	14.5, 5.8	Luvisol	1.1, 0.7
Anthrosol	2.2, 1.3	Nitisol	2.0, 1.2
Arenosol	0.1, 0.1	Phaeozem	1.9, 0.9
Calcisol	0.8, 0.4	Planosol	0.8, 1.8
Cambisol	4.4, 1.9	Plinthosol	1.1, 1.0
Chernozem	2.4, 1.1	Podzol	21.6, 22
Cryosol	4.1, 1.0	Regosol	0.4, 0.4
Ferralsol	1.5, 0.4	Retisol	7.2, 1.8
Fluvisol	3.3, 3.3	Solonceak	1.6, 0.4
Gleysol	8.0, 3.0	Solonetz	1.4, 1.0
Gypsisol	1.2, 1.0	Stagnosol	1.1, 0.6
Histosol	50.4, 45.5	Umbrisol	1.6, 0.7
Kastanozem	2.4, 2.0	Vertisol	2.0, 1.9

Table 4. Organic C% in the first two horizons of the soils in SW of Romania (Banat)

Soil	OC (1,2)	Soil	OC (1,2)
Litosol	1.45, 1.37	Planosol	0.84, 0.51
Regosol	4.30, 2.07	Alosol	3.20, 1.26
Aluvisol	1.65, 1.19	Podzol	7.97, 2.91
Chernoziom	2.12, 1.49	Vertisols	1.98, 1.91
Phaeoziom	1.87, 1.80	Stagnosol	1.14, 0.59
Rendzina	2.81, 2.34	Gleysol	1.66, 1.49
Umbrisol	15.35,5.70	Histosol	50.42,50.76
Eutric		Solonetz	1.77, 1.64
Cambisol		Anthrosol	
Dystric	2.42, 1.94	erodic	1.20, 0.68
Cambisol		Technosol	0.25, 0.24
Luvosol	2.16, 1.61		
	0.44, 0.30		

Soil carbon is the most important component in soils as it affects soil properties. Soils that are low in carbon, like Arenosol, Calcisol, Ferralsol, Gipsisol, Lixisol, Regosol, can become net carbon sinks thus reducing the increase in atmospheric CO_2.

For the climate change problem, a great importance presents the soil groups which contain the greatest quantity of carbon, and occupy considerable areas as Histosol (50.4-45.5% OC and 375 mill.ha), Podzol (21.6-2.2% O.C. and 485 mill. ha), and Cryosol (4.1-1.0%OC and 1800 mill.ha)

The three quoted soils are either in the continuous permafrost (isotherm -6^0C) or in the discontinuous permafrost (isotherm -6^0C to 0^0C). The most widespread areas with permafrost are Canadian and Siberian zones, between the North Pole and about latitude 50^0 north. The thickness of continuous permafrost can be 100m or even more than 1000m (in the case of relict permafrost [9]

Occurring in the Arctic and subarctic regions of Canada, Alaska, Russia, China, Antarctica and at high elevation in mountainous areas, Cryosols are associated with Podzols, Histosols and Gleysols. Cryosols have a perennially frozen subsoil and their genesis and properties are the result of cryogenic processes, which include the freeze-thaw cycle, cryoturbation and ice segregation often to a thickness of several meters.

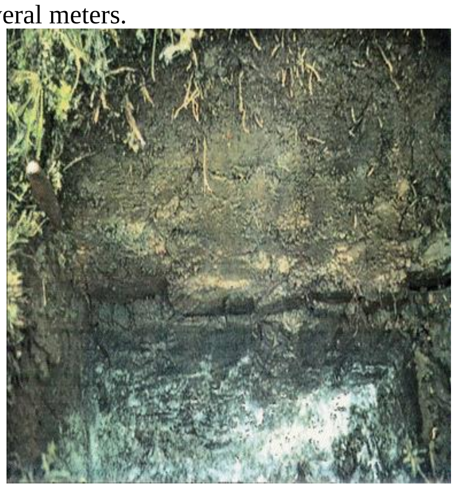

Figure 4. Ice layers at shallow depth in Cryosol Yukon Territory, Canada (WRB-SR, 1998)

Disturbance of the surface soil lead to alterations of the permafrost depth and to rapid and drastic environmental changes with possible damage and chemical pollution. Warming of these soils could switch these arctic soils from a carbon sink to a carbon (CO_2, CH_4) source. Since Arctic soils contain about 30% of the world's soil carbon, immense quantities of carbon gases could be released to the atmosphere causing a great climate change.

Histosols occur extensively in boreal, subarctic and arctic regions, to poorly drained basins, swamps, with shallow ground-water and cool highland areas. In Romania and Banat region they occur and developed in predominantly masspeat (Sphagnum) as in Mount Semenic, or in low land as in the Danube Delta (265000ha)

Figure 5. Dystric Histosol in Semenic Mountains

Table 5 Analytical data, Dystric Histosol [10]

Horizon	Tț	Tf	Ts	Ts	Tb	TGr
Depth, cm	0-32	-53	-64	-74	-153	-160
C,%	50.42	50.76	51.18	53.20	57.22	55.07
N_{tot}, %	0.71	1.02	1.12	0.74	0.77	-
C/N	71.01	49.76	45.70	71.89	74.31	-
pH_{H2O}	3.60	3.71	3.76	3.75	4.10	4.20
SB,me/100g	1380	13.80	14.70	14.60	15.40	16.10
T, me/100g	73.80	72.60	73.00	72.90	70.80	71.30
V, %	18.43	19.01	20.14	20.03	21.75	22.58

Histosols, unlike other soils, are formed only from organic matter or peat, the undecomposed remains of plants. The colors are usually dark and the material is saturated with water, and extreme acidity (pH 3.60-4.20). The content of organic carbon varies between 50.42 to 57.22 %.

The majority of the scientists consider that the soil carbon pool is the largest reservoir among the terrestrial C pools (table 6)

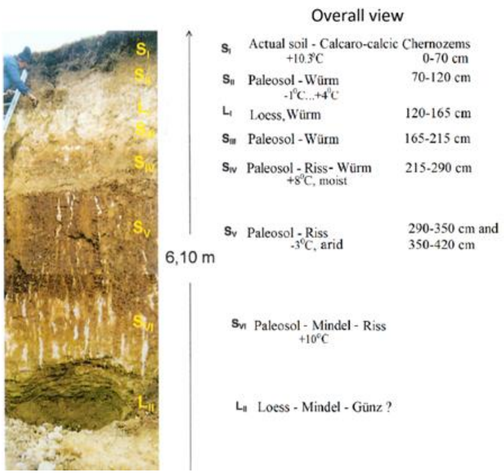

Figure 6. Paleosol Vinga

4. CONCLUSIONS

An important characteristic of the soil cover is that it varies from place to place, in some cases these change are rapid over short distances, in other places the changes are gradual over greater distances. There is a set of properties which differentiate the soils among each other. So is for example the soil organic carbon content which varies from 0.5 to 60%.

Small changes in the soil carbon pool can increase or decrease atmospheric CO_2. One of the ways to mitigate the rise in atmospheric CO_2 is sequestration of carbon by soils.

The total area of soil cover on the Earth's surface is about 15 billion ha and stored 4000 PgC, more than in the atmosphere and biota.

For the climate change the greatest importance presents Cryosols, Histosols and Podzols, situated between North Pole and about latitude 50^0 north of about 2 billion ha, which contain about 30 % of the world's soil carbon, and is preserved for thousands of years. The climate warming will be quickly releas the carbon stored now in a frozen state.

A good agricultural and silvocultural methods, mainly those increasing the input of organic matter to soil or decreasing soil organic matter decomposition promote carbon sequestration as stable soil humus.

Paleosols allows to establish the magnitude and periods of climate chenage.

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