INFLUENCE OF LAND USE ON MICROBIOLOGICAL ACTIVITY OF SANDY SOILS

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Major interrelated factors affecting microbiological diversity in soil include soil forming processes, physico-chemical properties of soil, soil particle size distribution, vegetation, and land use type. In the south-east Romanian Plain important land use changes occur in the last two decades. The aim of the study is to analyze the influence of the land use on the microbiological properties of sandy soils. We examined five sites, representing four different land-use types (cultivated land, vineyard, acacia forest, and pasture), in the south-east Romanian Plain. The soil profiles were described in the field and sampled (from each genetic horizon), after the removal of forest litter, for particle size distribution, pH, $CaCO_3$ content, organic matter content, V8.3% analyses, conforming to RISSA Methodology-1987. For microbiological analyzes three indices were determined: number of heterotrophic bacteria, number of microscopic fungi and soil respiration. Soil respiration, as a global indicator of soil microbial activity, has the highest values for pasture, while lowest values for bacterial and fungal microflora were recorded under vineyard use, reflecting soil life response to anthropic interventions.

Keywords: sandy soils, microbiological activity, land use.

INTRODUCTION

Microbial communities can provide a measure of soil quality because of their capacity to respond sensitively to changes and environmental stress (Cornea *et al.*, 2011). The modifications of microbiological parameters can precede detectable changes in soil or plant properties, which can be an early sign of improving soil quality or, by contrary, an early warning of soil deterioration (Winding *et al.*, 2005).

Major factors affecting microbiological diversity in soil include soil forming processes, physical and chemical properties of soil, soil particle size distribution, vegetation, and land use type. Many publications emphasize the influence of the land use on the structure of soil microbial communities (Nusslein and Tiedje, 1999; McCaig *et al.*, 2001; Webster *et al.*, 2002; Clegg *et al.*, 2003, cited by Grantina *et al.*, 2011).

In the south-east Romanian Plain important land use changes occur in the last two decades (Pravalie *et al.*, 2013), which led to serious problems such as erosion and structure degradation, groundwater contamination, insufficient water holding capacity, increasing susceptibility to pests, reduced soil fertility.

The paper presents the results concerning the quantitative estimations of densities in heterotrophic bacteria, fungi and their global physiological activities in five sites, representing four different land-use types (cultivated land, vineyard, acacia forest, and pasture) of sandy soils.

MATERIALS AND METHODS

Study Area

Study area is located in the southwestern part of the Romanian Plain (Băileşti Plain). The landscape is presented as a series of sand dunes which cover the terraces and meadow of Danube River. Parental materials of the soils consist of carbonated and uncarbonate sands deposited as dunes and interdunes. The climate is characterized by hot and dry summers with few precipitations, with mean annual temperatures exceeding 11°C and mean annual values of precipitation between 525 and 550 mm.

Natural vegetation is characterized by forest-steppe vegetation, with xerophyte oak as representative species, severly restricted due to extention of arable lands (The Geography of Romania, Volume V, 2005).

Figure 1. Localization of the study area

Large areas have been planted with acacia (*Robinia pseudoacacia*) in the first half of the twentieth century, and with vineyards starting with 1961, for the stabilization of the sandy soils, but some forest areas have been cleared during second half of the twentieth century in order to expand the agricultural areas (Nuță, 2005).

Soil Sampling and Laboratory Analysis

We examined five sites, representing four different land-use types. First two soil profiles, P1 and P2 are Eutric Arenosols, under pasture. P1 is formed on a sand dune deposit that cover the Danube terrace (location on the background picture of Figure 3) and P2 is formed on a sand dune deposit that cover the Danube meadow sediments (location on the background picture of Figure 4). P3 is an Aric Arenosol, under vineyard, formed on a stabilized sand dune deposit that was ploughed to a depth of 40 cm. P4 is an Arenic Chernozem, under arable (wheat stubble), formed on interdune and P5 is an Eutric Arenosol, under accacia forest, formed on a stabilized sand dune deposit (location of the P3 to P5 soil profiles on Figure 1).

The soil diagnostics were based on the concept of elementary pedogenetic processes, in agreement with the World Reference Base for Soil Resources (IUSS - FAO, 2014).

The soil profiles were morphologically described, and disturbed soil samples were collected from diagnostic horizons within the first 40 cm of the soil profiles. Physical and chemical determinations were made: particle size distribution, pH, calcium carbonate ($CaCO_3$) content, organic matter content analyses, base saturation degree ($V_{8.3}$ %), conforming to RISSA Soil Survey Methodology-1987.

Microbiological analyses of soil samples were performed by plating soil decimal dilutions on specific solid culture media, Topping for heterotrophic bacteria and Czapek for fungi (Papacostea, 1976). After incubation, the developed colonies were counted and the densities of microbial structures were reported to gram of dry soil. Global physiological activities of microbial communities were determined by the substrate induced respiration method (Ştefanic, 1991).

RESULTS AND DISCUSSION

Physical and Chemical Characterization

The soils analyzed inherited the *textural characteristics* from the parent material and have coarse texture, with up to 70 % sand content (coarse and fine sand, between 2-0.02 mm) (table 1).

The colloidal clay (< 0.002 mm) has the lowest values for P3 - vineyard (between 4.7 and 4.2%) and P5 - forest (between 5.9 and 4.4%), while P2 - pasture has the highest clay content (17.9% in At and decrease to 10.2% in Am2 horizon). Also, P2 profile has the lowest coarse sand content (0.2-2 mm), between 10.0 and 11.6%, while whithin P3 soil profile the coarse sand values exceed 60%.

The *calcium carbonate* has been leached from the soil profiles.

Table 1. Physical and chemical properties of studied soils

Horizon	Depth (cm)	Texture	Granulometrical fractions (% g/g)				Carbo-nates (%)	V8.3 (%)	pH	SOM (%)
			Clay <0.002 mm	Silt 0.002-0.02 mm	Fine sand 0.02-0.2 mm	Coarse sand 0.2-2.0 mm				
P1 – Eutric Arenosol, pasture, N: 43°50’55,07”, E: 23°0’8,24”, Alt: 32 m										
At	0-12	LS	8.5	4.3	54.3	32.9	-	70.0	5.72	2.52
Am	12-28	LS	7.8	4.8	51.1	36.3	-	69.2	5.93	0.96
AB	28-35	LS	10.7	3.9	53.1	32.3	-	83.5	6.64	0.78
P2 - Eutric Arenosol, pasture, N: 43°49’13,55”, E: 22°58’49,08”, Alt: 31 m										
At	0-12	SL	17.9	11.3	60.7	10.0	-	100	7.73	4.38
Am1	12-24	SL	14.7	11.3	62.3	11.7	-	100	7.74	2.34
Am2	24-37	LS	10.9	10.2	67.3	11.6	-	100	7.87	1.50
P3 - Aric Arenosol, vineyard, N: 43°51’21,55”, E: 23°1’21,27”, Alt: 36 m										
Ao1d	0-12	CS	4.5	0.9	33.1	61.6	-	100	7.94	0.30
Ao2d	25	CS	4.7	0.7	30.3	64.3	-	100	8.16	0.36
(A+C)d	25-40	CS	4.2	0.9	30.2	64.7	-	100	8.08	0.30
P4 - Arenic Chernozem, arable, N: 43°51´27,14”, E: 23°1´22,30”, Alt: 34 m										
Ap	0-15	SL	16.5	12.8	50.3	20.4	-	77.3	6.28	2.46
Am	15-26	SL	16.2	12.4	51.8	19.5	-	76.6	6.19	2.22
AB	26-43	SL	15.7	10.9	56.5	16.9	-	85.2	6.64	2.04
P5 – Eutric Arenosol, accacia forest, N: 43°51’44,75”, E: 23°1’10,13”, Alt: 42 m										
Ao	0-10	LS	5.9	1.5	45.5	47.1	-	71.4	6.29	1.44
AC	10-27	MS	4.9	1.3	46.2	47.7	-	85.3	6.7	0.54
C1	27-42	CS	4.4	0.2	32.4	63.0	-	100	7.56	0.36

LS – loamy sand, SL – sandy loam; CS – coarse sand; MS – medium sand

The *base saturation degree* ($V_{8.3}$ %) correlates with soil reaction, and has maximum value of 100% for P2 - pasture, due to annual Danube overflows), and for P3 - vineyard profile, due to chemical treatments applied (table 1).

P1 - pasture has the mezobasic values of the base saturation within the first two horizons (70.0% in At and 69.2% in Am) and eubasic values in AB horizon (83.5%), while P4 - arable and P5 - forest are eubasic within the soil profile.

Soil reaction (pH) is slightly acid for P1 - pasture (except the surface horizon which is moderate acid - 5.72), with 5.93 in Am and 6.64 in AB, and P4 - arable, with pH values between 6.28 in Ap and 6.64 in AB horizon.

P2 - pasture and P3 - vineyard have slightly alkaline reaction, with values varying between 7.73 and 7.87 for P1 and between 7.94 and 8.16 to P3.

P5 - forest has slightly acid reaction within the first two horizons (6.29 and 6.7 respectively) and slightly alkaline reaction in C1 horizon (7.56).

The soil organic matter content (SOM) varies from medium to low for the soil profiles under pasture and arable land use. The SOM values decrease from 2.52% in At to 0.78% in AB within the P1 - pasture, and from 4.38% in At to 1.50% in Am2 within the P2 - pasture, while the values determined for P4 - arable are more closed and vary between 2.46% in Ap to 2.04% in AB horizon.

The SOM content is very low for the P3 - vineyard, with values between 0.36% in Ao2d and 0.30% in Ao1d and (A+C)d.

P5 - forest has low values of SOM within Ao horizon (1.44%) and very low values within AC (0.54%) and C1 (0.36%) horizons.

Microbiological Characterization

Mostly low values of potential level of *soil respiration* have been determined in analyzed soil profiles, corresponding to a reduced activity of microflora.

Surface horizons of the five profiles (correspond to depths of about 0-40 cm profile) show values exceeding 30mg CO_2/100g soil, considered average values for analyzed parameter.

The highest level of soil respiration was determined for P2 - pasture (85.89 mg CO_2/100g soil in At, 54.90 mg CO_2/100g soil in Am and 44.27 mg CO_2/100g soil in AC), while the lower values were found for P3 - vineyard (29.13 mg CO_2/100g soil in Ao1d, 39.08 mg CO_2/100g soil in Ao2d and 36.95 mg CO_2/100g soil in (A+C)d).

Bacterial microflora is best developed in P2 - pasture (38.60 viable cells / g dry soil in At) and P5 - forest (33.66 viable cells / g dry soil in Ao) profiles and average developed in P1 - pasture, P3 - vineyard and P4 - arable profiles (between 19.83 and 14.80 viable cells / g dry soil in P1, 13.80 and 10.69 viable cells / g dry soil in P3 and between 15.70 and 12.38 viable cells / g dry soil in P4).

The analysis of the *fungal microflora* on soil profile highlights an average load for P2 - pasture (between 88.61 and 54.79 cfu / g dry soil), P1 - pasture (between 56.99 and 47.90 cfu / g dry soil), P4 - arable (between 58.63 and 52.67 cfu / g dry soil), and P5 - forest (between 60.42 and 47.87 cfu / g dry soil), while the lowest level of fungi in soil has been determined for P3 - vineyard (50.39 cfu / g dry soil in Ao_1d horizon).

The organic horizons of P5 - forest, Ol and Of+h, respectively, have an intense activity of microflora, with high number of bacteria (22.37 viable cells / g dry soil in Ol and 47.12 viable cells / g dry soil in Of+h) and an average number of fungi (61.72 cfu / g dry soil in Ol and 78.31 cfu / g dry soil in Of+h).

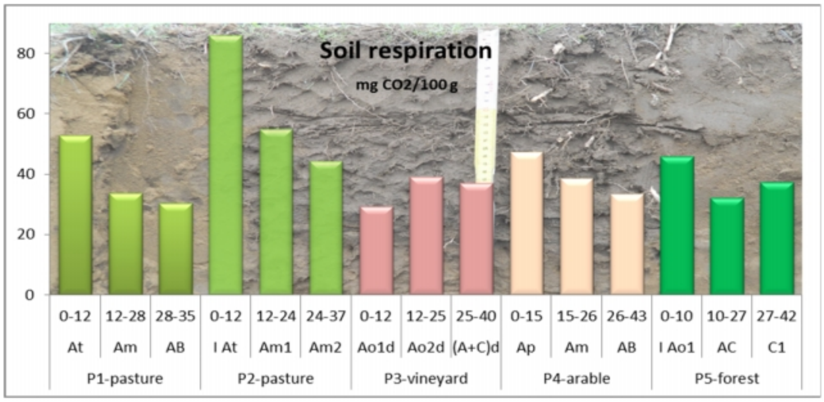

Figure 2. Soil respiration potential level within the first 40 cm of the soil profiles

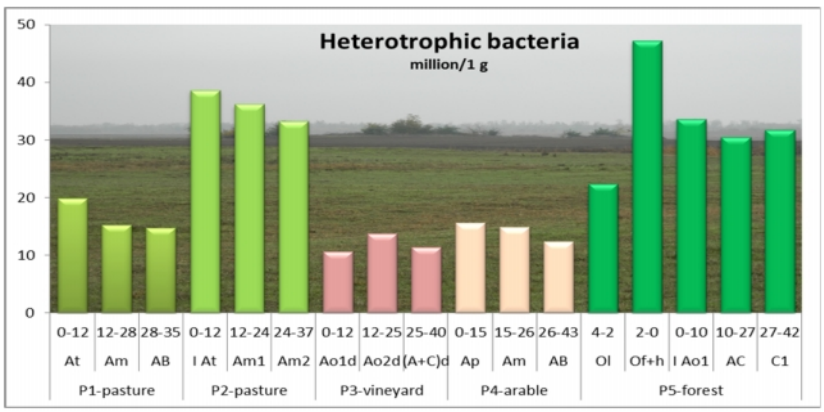

Figure 4. Total number of bacteria within the first 40 cm of the soil profiles

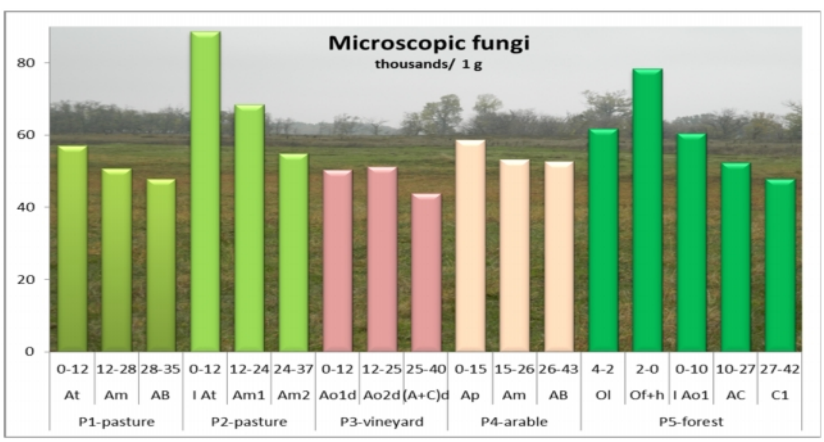

Figure 3. Total number of fungi within the first 40 cm of the soil profiles

DISCUSSIONS AND CONCLUSIONS

Physical and chemical properties of analysed soils (sandy texture, with high percentage of coarse sand, slightly acid reaction, low soil organic matter content due to intense mineralization of organic residues) create conditions for a reduced activity of microflora.

Soil respiration, as a global indicator of soil microbial activity, has the highest values for pasture, while lowest values have been determined for vineyard.

The highest level of soil respiration was determined for P2 - pasture profile, reaching double values compared to similar horizons of the other profiles in the 0-40cm depth. We consider that situation is due to shallow water table and to annual Danube overflows, which favor vegetation development and create conditions for an intense microbial activity in that soil. That explain also the differences registered between P2 and P1, both soil profiles beeng under pasture.

The number of both fungi and bacteria showed a normal tendency to decrease with increasing depth, excepting P3 – vineyard, where the higher number has been reached wihtin the second (Ao2d) horizon.

The activity of bacterial microflora is substantialy higher within P2 - pasture and P5 - forest (the highest values were recorded in organic horizon of P5) than within arable and vineyard, while the number of fungal microflora has more closed values within the four land uses (excepting the first horizon of P2 and the second organic horizon of P5).

The lowest values of bacterial microflora and fungi on the soil profile were determined for P3 - vineyard compared with the rest of the analyzed soil profiles, as result of the low amount of annual organic residues within that agricultural use.

Evaluation of the degree of development of bacterial and fungal microflora in examined horizons of the soil profiles shows an average to high load of soil bacteria and fungi. The lowest values for bacterial and fungal microflora were recorded under vineyard, reflecting soil life response to anthropic interventions.

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