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RESEARCH REGARDIG THE AGRIPRODUCTIVE PROPERTIES OF THE TYPICAL REDDISH PRELUVOSOL BETWEEN JIU AND OLT RIVERS AND ITS EVOLUTION FROM 1997 – 2017 IN FARMS AND AGRITOURISTIC HOUSEHOLDS

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ABSTRACT

The aim of the research was to identify the main agriproductive properties of the typical reddish preluvosol in the area between Jiu and Olt rivers and to follow its evolution over a period of 20 years, in order to obtain relevant results. This area was chosen as studies had been made since 1993, when rigorous research began to develop into a doctoral thesis. Having well documented and interpreted baseline data, we considered it appropriate to come up with new research in the respective area after a sufficiently long period of time, to identify relevant changes at the level of the main agriproducts of this type of soil. Based on the results of the analyses and their interpretation, we found that at this level of soil there were no substantial changes during this period, considered short in regard to the genesis and the evolution of a type of soil. Moreover, due to the presence of farms and agritouristic households in this perimeter, we considered it wise to carry out research into the presence and concentration of the more common heavy metals. From the main research results we found that several heavy metals such as chromium (Cr), copper (Cu), nickel (Ni), zinc (Zn), cadmium (Cd), lead (Pb) are indeed present, but their concentration does not exceed the normal limits, except for chromium, which slightly exceeds this limit, but still is far below the alert threshold. The results highlight that agricultural producers can obtain high quality agrifood products, that do not pose any safety and traceability risks, and that can be offered to potential tourists without any concerns.

Keywords: soil profile, horizon, agriproductive properties, heavy metals, agritourism.

INTRODUCTION

Reddish preluvosol forms under the oak forests and represents a transitional soil between brown and brown Mediterranean soils. Merlescu and Teşu (quoted by Călina et al., 2000) emphasize in their works that brown-red soils as known in Romania also appear in the northern part of Bulgaria, Yugoslavia, and Germany. In Bulgaria, these soils are known as “gray soils formed on red clays” and in Yugoslavia under the popular name ”gainacea”. In Germany they are known as “grane waldboden”, and after the 7th American approximation under the name of “argiudoll”.

In Romania, the reddish preluvosol (the brown-red soils) occupies an area of 760,000 ha, or 5.24% of the total agricultural area of the country. In works published by Șorop and Vasile (1990), the brown-red soils of Oltenia occupy an irregular shaped strip, stretching from Drobeta Turnu-Severin, over the city of Craiova, to the proximity of Piatra Olt and Caracal, with an area of approximately 350,000 ha, which represents 47.3% the total of brown-red soils in Romania.

Between Jiu and Olt rivers, the area under observation, the typical, mollic, and podzolic brown-red soils occupy almost the entirety of Leu-Rotunda High Plain, on the southern side of the Getic Plateau and part of the northeast Oltenia Plain. These soils are spread over the research area on approximately 138,473.19 ha, representing 39.51% of the total soils of this type existing in Oltenia. They are delimited to the north by Craiova, the towns of Filiaşi, Ghercești, Balş, and Piatra Olt, and to the south by Tâmbuşti, Deveselu, Caracal (Figure 1). The largest area is occupied by the typical and podzolic brown-red soils of around 77,071.15 ha, bounded to the west by Craiova, and to the

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east by Caracal, accounting for 55.6% of all brown-red soils in this area.

The surfaces presented above were calculated by using the square map method and were verified by using the planimetry method (Călina et al., 2000), represented in the map "The spread of brown-red soils between the Jiu and Olt rivers" (Figure 1).

Research in this area is mainly related to the characterization of reddish preluvosol soils and establishing their natural fertility, in view of increasing it. The area of reddish soils, very favourable to the development of agriculture, has undergone profound anthropogenic transformations.

The areas occupied by forests have steadily diminished while the areas occupied by the agricultural crops have expanded considerably, which has led to stalling the migration of elements from deep within the ground to the surface through the trees.

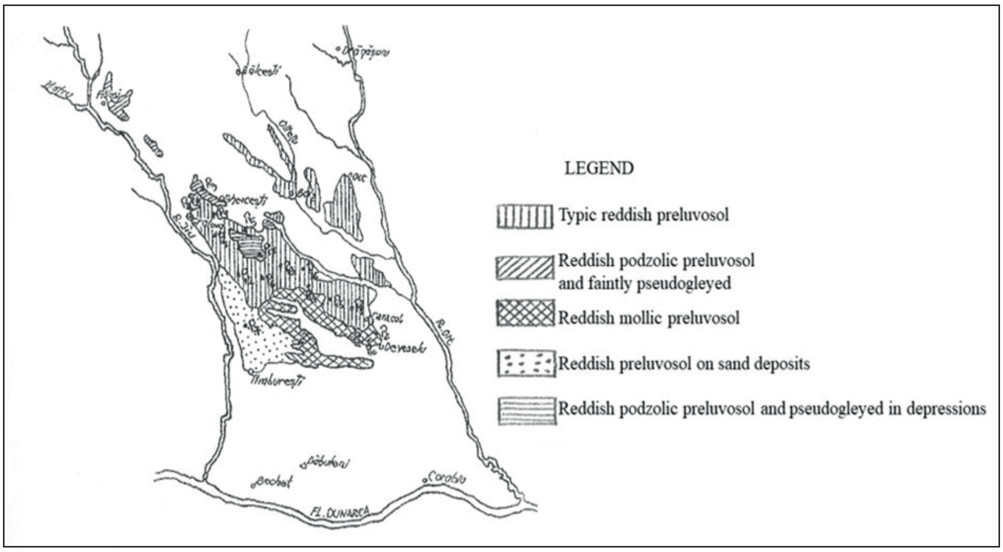

Figure 1. The spread of reddish preluvosol between the Jiu and Olt rivers

Characterized by a medium and heavy texture, starting from horizon A, they are harder to till, and under certain conditions can form boulders. After prolonged rains or snow melting, crust forms on their surface. Considering all the physical and chemical properties, it can be stated that most reddish soils in Oltenia have a medium to good fertility.

A stronger fertility is due to the soils having evolved beneath the forest and recently taken up for agriculture (Șorop and Vasile, 1990).

MATERIAL AND METHODS

The method employed is classic, targeting the following major objectives: establishing the research area and its characterization from the point of view of the conditions and the process of formation and evolution; determining the morphological, physical and mechanical, chemical and fertility properties; the impact of human activity on the evolution of soil properties of this type in the research area; the presence of heavy metals and their influence on agricultural products resulted in primary production of farms and agritourism households.

In order to achieve the stated goal and objectives, field research was necessary, during which several soil profiles were analyzed morphologically, and samples were collected from the most representative soils for laboratory analysis.

Field maps and pedestrian mapping works by the County Offices for Pedological and Agrochemical Studies Dolj and Olt were used. The soil profiles were taken from a depth of about 200 cm. Each profile was morphologically characterized, with the following properties being established: thickness of the horizons, colour, texture, structure, porosity, compactness, adhesion, neoformation, moisture and parent rock.

From each horizon, samples of soil in its natural structure were harvested using cylinders (5 x 5 cm), and then in its disturbed structure. The soil samples were transported to the specialized laboratory of the Faculty of Agronomy and to the laboratory of the Office for Pedological and Agrochemical Studies in Craiova, where mechanical, hydric, physical and chemical analyses were realized such as granulometric analysis, density (DA, %), soil density (D, %), penetration resistance (RP), soil reaction (pH), hygroscopicity coefficient (CH, %), wilting coefficient (CO, %), humidity equivalent (EU, %), electric conductivity and mineral residue, humus, total nitrogen, hydrolytic acidity (Ah, me/100 g soil), sum of bases (SB, me/100g soil), mobile phosphorus (P, ppm.) and exchangeable sodium.

a) Determination of physical and mechanical properties

In order to determine the physical properties of soils the samples collected in natural structure (in metal cylinders) were analysed:

- granulometric composition - Kacinski method;

- the texture - by the Chiriţă-Burt triangle;

- soil density (D, g/cm^3) - pycnometer method; - apparent density (DA, g/cm^3) - the National Research and Development Institute for Soil Science, Agrochemistry and Environment method, by reference to the dry soil mass in the oven at the volume of the cylinder in which the soil sample was taken;

- resistance to penetration (RP, kgf/cm^2) - method of resistance to dynamic penetration, on samples taken in metal cylinders, the soil being brought to a moisture equal to 50% of its capillary water capacity;

- total porosity (Pt %) - calculated with the formula:

$$Pt\ (\%) = 100\left(1 - \frac{Da}{D}\right).$$

b) Determination of hydro-physical properties:

- water permeability – the National Research and Development Institute for Soil Science, Agrochemistry and Environment method;

- hygroscopicity coefficient (CH, %) - Mitscherlich method;

- coefficient of desaturation (CO, %) - through calculation using the formula: CO = CH x 1.5;

- the moisture equivalent (EU, %) - by centrifugation of soil samples with a force greater than 1,000 times the gravitational acceleration;

- field capacity (CC, %) - calculated using the formula: CC = EU x 0.84 + 2.64;

- Active Humidity Range (I.U.A., %) - through calculation using the formula: IUA = CC – CO;

- hydraulic conductivity / permeability (K-mm/h) - under laboratory conditions by infiltration under constant degree - National Research and Development Institute for Soil Science, Agrochemistry and Environment - ICPA Bucharest.

c) Determination of chemical properties:

- pH measured in aqueous solution (soil/water ratio – 1:2.5) - potentiometric determination with a torque of glass electrodes;

- determination of alkaline earth carbonates ($CaCO_3$, %) - gasometric determination - Scheibler method;

- determination of mobile aluminum (Al, me/100 g soil) - by the Socolov method;

- humus (%) - Walkley and Blak method (modified by Gogoașă);

- total nitrogen (N%) - the Kjeldahl method;

- mobile phosphorus (P, ppm.) - the Egner-Riehm-Domingo method;

- mobile potassium (K ppm.) - the Egner-Riehm-Domingo method;

- sum of bases (SB, me/100 g soil) - Kappen method (modified by Chiriţă);

- determination of total acidity (SH, me/100 g soil), by percolation at exhaustion with 1N potassium acetate solution - modified Cernescu method;

- determination of hydrolytic acidity (Ah, me/100 g soil) - by percolation at exhaustion with 1N potassium acetate solution - total cationic exchange capacity (T, me/100 g soil) - through calculation using: T = SB + Ah;

- saturation degree in bases (V, %) - through calculation using the formula:

$$V (\%) = \frac{SB}{T} x 100;$$

- electro-conductance (Ec x 10^6) - conductometric correction of temperature and surface.

d) Heavy metals were determined using the method of 1:5 acidic mineralization and by flame absorption – the recommended methods of the Avanta GBC SN A 5378 flame atomic absorption spectrometer and of the Milestone microwave disintegration system, model ETHOS D series 127327.

RESULTS AND DISCUSSION

To establish the level of fertility of the studied soils, the collected soil samples from 1997 were analysed, which also represented reference values processed in the respective year, then the samples collected after 20 years taken from the same soil unit and type.

In agricultural and agritouristic farms, in order to practice a modern and sustainable agriculture, it is necessary to know the agricultural potential of the land to grow plants and provide the best products for guest and tourists.

Depending on the reference data obtained from soil and agrochemicals of the land, landlords may determine what organic and chemical fertilizers to apply, as well as the doses, ensuring that the agrifood products obtained are as natural as possible and environmentally friendly.

Ideally, after harvesting, the chemical composition of the products obtained should be analysed, to know exactly that there is no retention of the chemical products applied in the culture technology (also mentioned by Ibănescu et al., 2018), a problem that can become a potential future research.

The scope of the present research is only to present the agriproduct properties and fertility level, as well as their evolution over time.

1. Agripedological characterization of the typical reddish preluvosol

Typical reddish preluvosol occupies relatively small areas, especially on drained lands. On larger surfaces it appears as a complex with luvic, occupying between the Jiu and Olt rivers approximately 77,071.15 ha, 55.6% respectively of the area of this type of soils in the area. These soils are found in the northern part of the research area, in the form of a strip, between the towns of Craiova and Caracal (Figure 1).

The landscape is relatively smooth, with a slight inclination towards the SE and falls largely into the Leu-Rotunda High Plain. The research territory is crossed by dry and parallel valleys that give the land a wavy look. The absolute average height of the land is about 121 m. Geologically this area belongs to the upper Pleistocene, represented by loess deposits (Chiriţă, 1961).

The parental material on which this soil is formed is a complex, composed of sloppy wind loess deposits with sands and reddish sandy clay loams.

Hydrography and hydrogeology. The researched area is drained by two large rivers, the Jiu that divides the area to the west and the Olt that represents the eastern border.

The Jiu is characterized by a valley 120 m deep in Craiova, and 80 m deep in Rojişte, compared to the level of the plains that border it. The Jiu valley is much smaller than the Olt River and generally is devoid of large valleys. The lakes and ponds are numerous, located in the depressions, accumulating rainwater or coastal springs in the area.

The Olt is the second basic component of the hydrographical network in this area. On the left side, the most important tributaries are: Dârjov and Iminog. On the right side, the affluent valleys are much larger and longer, the largest being in the central part, such as: Olteţ, Teslui and Caracal valleys, and on the western side the tributaries Buca and Arţăroasa, whose valleys have parallel confluences.

From a hydro-geological point of view, the depth of the groundwater is closely related to the lithology and morphology of the land, this being at a depth of 10-15 m.

On the valley line the level of the ground water is about 5-10 m or even closer to the surface, approximately 2 m, which causes the appearance of the gleying phenomenon.

Climate. According to data recorded in the area, the climate is Mediterranean - continental. Annual average temperatures are between 10-11°C, the average annual precipitation is about 520-530 mm, and the potential evapotranspiration is 698 mm, resulting in a deficit of more than 168 mm annually.

Vegetation. The biological factor of soil formation mainly by the vegetation suffers variations from one area to another, which leads to a notable diversity of the ground flora. The spontaneous vegetation in this perimeter is specific to the silvicultural area with *Quercus* and *Acacia* forests in association with the specific sub-species, falling within the area of the plain forests, represented by the Hungarian oak, the Austrian oak, and the English oak. The forest found today on small surfaces once occupied the area almost entirely, especially in the northern part.

To increase the grazing areas, or to create farmland, forests were cut down for the most part. Currently, most of the research area is used as agricultural land. Meadows and pastures occupy small areas. Herbaceous plants are represented by grass and legume species.

The agripedological characterization of the research soil type (Figure 2) was based on the physical and chemical analyses of the soil samples taken from the soil profiles made at about 4.5 km southwest of the town of Coşoveni near the "Măgura lui Curcă" Hill; at an *altitude* of about 160 m; plan land, plateau on the Leu-Rotunda High Plain; *vegetation*: agricultural crops; *parent material*, clay and loess deposits; *natural drainage*, good; *depth of groundwater,* over 18 m.

a) Morphological characteristics

From a morphological point of view, no major changes were observed on this type of soil, only the succession of horizons in the representative soil profile (Figure 2) being represented.

Horizon Ao: 0-36 cm; brown colour (10YR 3.5/4); clay texture towards clay loam; sub-angular polyhedral structure at the bottom and top structure; poorly compacted at the bottom; malleable; poorly adhesive; frequent roots; towards the base cornevine and cervotocine; rare manganese grains; gradual passage.

Horizon AB: 36-60 cm; brown grey colour (7.5YR 3/4); clay loam texture; developed prismatic structure; poorly compacted; wet; thin roots; light clay films on the surface of the aggregates; gradual passage.

Horizon Bt_1: 60-110 cm; brown-grey red colour (10YR 4/4); a sub-angled polyhedral structure at the top and a lower angled polyhedral; clay loam texture; weak to moderately compacted; malleable; adhesive; thin and rare roots; obvious clay films at the surface of the aggregates; rare cornevine and manganese grains; gradual passage.

Horizon Bt_2: 110-160 cm; brown to reddish yellow (7.5YR 4.5/5); clay loam texture to clay; angular polyhedral structure, well- developed medium; moderately compacted; rare cervotocine; obvious clay films at the surface of aggregates with material leakage from the upper horizons; gradual passage.

Horizon C: 160-200 cm; reddish-yellowish colour (7.5YR 6/6); clay loam texture; no structure; wet; at the base there are efflorescence and calcium carbonate micelles dispersed in the soil mass.

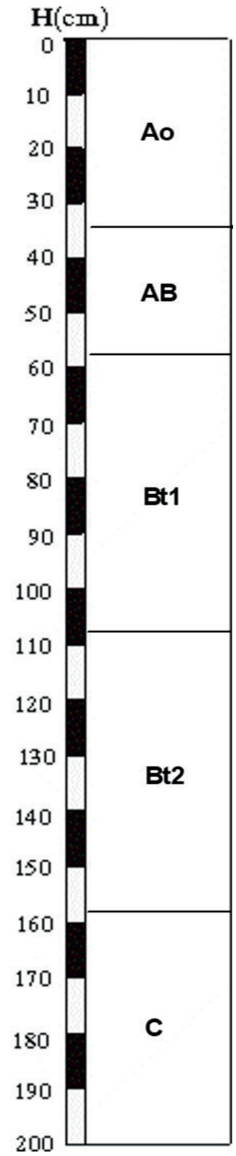

Figure 2. Typical reddish preluvosol profile

Due to the replacement of natural vegetation in this area with cultivated vegetation, its influence on soil formation has declined greatly. The natural vegetation that contributed to the formation of reddish preluvosol in this area is almost extinct due to human intervention, creating new conditions in the process of soil formation. The cultivated crops that find the best conditions for development on these soils are: vines, fruit trees, agricultural and vegetable plants.

Analysing the data obtained from the laboratory researches, the following results were obtained:

b) Granulometric composition

Typical reddish preluvosol has a slightly differentiated texture profile. Thus, the soil texture is lobular in the first horizon and clay loam in all other horizons, but there is a slight differentiation in the AB horizon, from the profile made in 2017, where it is loam (Table 1).

Table 1. Granulometric composition of the typical reddish preluvosol in Coșoveni

Horizon	Horizon depth (cm)	Sampling depth (cm)	Granulometric composition (%)				Texture
			Coarse sand (2-0.2 mm)	Fine sand (0.2-0.02 mm)	Dust (0.02-0.002 mm)	Clay (<0.002 mm)	
Year – 1997							
Ao	0 - 36	10 - 20	14.3	33.8	20.7	31.2	L
AB	36 - 60	40 - 50	11.8	29.7	21.5	37.0	LA
Bt_1	60 - 110	80 - 90	11.3	28.7	24.2	35.8	LA
Bt_2	110 - 160	130 - 140	13.1	30.2	22.3	34.4	LA
C	160 - 200	180 - 190	11.7	33.4	21.9	33.0	LA
Year – 2017							
Ao	0 - 36	0 - 10	16.23	38.28	24.13	21.95	LL
AB	36 - 60	25 - 35	12.74	41.97	23.31	22.54	LL
Bt_1	60 - 110	80 - 90	13.26	34.09	21.37	31.93	LA
Bt_2	110 - 160	120 - 130	13.93	37.12	18.91	30.67	LA
C	160 - 200	160 - 170	15.45	37.02	18.44	29.88	LA

The content of dust and clay has a slight increase from the top to the bottom, a phenomenon found in both situations. The largest amount of clay is present in horizons AB and Bt_1, where there is an increase of 4.6% and 9% of clay, respectively, compared to the surface horizon. It decreases in the lower horizons. The extra clay in the middle of the profile is due to the altering and migration processes that occur here with a higher intensity.

c) The main physical properties

As shown in Table 2, the density (D) and apparent density (DA) of the soil increases from the surface to depth. An increase of up to 0.15 g/cm^3 of apparent density is observed in both determinations made, due to the greater amount of clay migrating from the surface horizons.

Total porosity (Pt) and aeration porosity (Pa) decrease in the same way from surface to depth. From this point of view, the reddish species typically falls into the class of soils with a total porosity and medium to small aeration, as seen from Table 2.

Penetration resistance (RP) varies in the same way as density and vice versa with porosity (Table 2). Thus, the lowest value is recorded in the Ao horizon and doubles value in the depth horizons in the soil profile made in 1997.

However, it is smaller by more than 20 units in the profile made in 2017, due mainly to the effect of loosening deep soil with high-powered tractors, as several scarifications have been carried out over time (phenomenon observed also by Canarache, 1990).

Table 2. Main physical properties of the typical reddish preluvosol in Coșoveni

Horizon	Horizon depth (cm)	Sampling depth (cm)	DA (g/cm^3)	D (g/cm^3)	Pt (%)	Pa (%)	RP (kg f/cm^2)
Year - 1997							
Ao	0 - 36	15 - 20	1.36	2.60	47.69	15.66	46
AB	36 - 60	45 - 50	1.44	2.65	45.66	8.39	76
Bt_1	60 - 110	85 - 90	1.51	2.69	43.87	3.61	81
Bt_2	110 - 160	135 - 140	1.49	2.71	45.01	3.99	96
C	160 - 200	185 - 190	1.49	2.73	45.20	10.88	68
Year - 2017							
Ao	0 - 36	5 - 10	1.42	2.71	46.26	24.60	41
AB	36 - 60	25 - 30	1.57	2.77	45.73	22.34	46
Bt_1	60 - 110	80 - 85	1.56	2.82	45.83	13.25	65
Bt_2	110 - 160	120 - 125	1.55	2.83	47.64	8.16	62
C	160 - 200	165 - 170	1.51	2.85	48.59	6.79	66

d) The main hydro-physical properties

The main soil hydrological indices: the hygroscopicity coefficient (CH), the wilting coefficient (CO), the moisture equivalent (EU) and the field capacity (CC) register increases from the upper to the lower horizons. This variation is mainly due to the increase in clay contents (Table 3).

The variations in their values over time are substantial, as the granulometric composition also varies, but the coefficient of wilting (CO) is lower by 3.28% in 2017 due to climate changes registered in the last decades.

Regarding the Active Humidity Range (UA), it has the highest value in the Ao horizon (12.36% and 14.21% respectively) and decreases with depth, as the amount of humus decreases, confirming the higher value recorded after 20 years (Table 3).

Furthermore, the water permeability of the soil varies in the same sense, being higher in the surface horizon and decreasing at lower depths, where the soil registers a higher degree of compaction.

Table 3. Main hydro-physical values of the typical reddish preluvosol in Coșoveni

Horizon	Sampling depth (cm)	CH (%)	CO (%)	EU (%)	CC (%)	I.U.A. (%)	Permeability (mm/h)
Year – 1997							
Ao	10 - 20	7.46	11.19	24.2	23.55	12.36	5.86
AB	40 - 50	9.88	14.82	26.9	25.88	11.06	2.30
Bt_1	80 - 90	10.21	15.31	27.8	26.66	11.45	1.94
Bt_2	130 - 140	11.49	17.23	28.8	27.53	10.29	1.61
C	180 - 190	7.94	11.91	23.6	23.03	11.12	2.45
Year – 2017							
Ao	10 - 20	5.33	7.91	15.53	21.70	14.21	5.58
AB	40 - 50	5.54	8.37	16.36	16.37	8.27	3.85
Bt_1	80 - 90	7.75	11.55	23.17	22.06	10.69	2.94
Bt_2	130 - 140	7.52	11.23	22.64	21.67	10.57	3.29
C	180 - 190	7.29	10.71	21.39	20.58	9.96	4.25

e) Main chemical properties

In terms of the chemical properties, the typical reddish preluvosol is slightly acidic (pH 6.13, respectively, 6.34) a slight increase observable in 2017, due to the increase in saturation in the bases. Humus and total nitrogen content are medium and there is an increase of 2.54 to 2.77%, due to the non-exploitation of the remaining plant material after harvesting as secondary production, which is chopped up by modern combine harvesters and left on the soil where it decomposes and mineralises, improving soil fertility. The phenomenon is confirmed as these components decrease significantly in the depth of the soil profile, where the intake of vegetal debris is very low (Table 4).

Supply of phosphorus and potassium nutrients is relatively good, even if the soil content in these elements is medium, the variation of these elements over the 20-year period being practically insignificant. Electro conductivity ($ECx10^6$) and mineral residue correlate well with the clay content, showing a rise from the surface to depth. The soil complex is saturated with bases at 83% and 86.3% in 2017, due to the increase in the percentage of humus in the soil which generated improvement over time. Cationic exchange capacity is high, both in 1997 and 2017.

Table 4. Main chemical properties of the typical reddish preluvosol in Coşoveni

Horizon	Sampling depth (cm)	pH in (H_2O)	Humus (%)	Total nitrogen (%)	EC at 25^0C	Mineral residues (mg/100 g sol)	P	K	SB	Ah	T	V (%)
							ppm		me/100g sol			
Year – 1997												
Ao	10 - 20	6.13	2.54	0.176	128.4	43.7	35.52	121.22	19.6	4.11	23.71	83.00
AB	40 - 50	6.41	1.48	0.156	148.5	50.5	39.24	132.80	25.6	1.75	27.35	93.60
Bt_1	80 - 90	6.56	0.86	0.123	167.7	57.0	23.98	111.22	26.8	1.52	28.32	94.60
Bt_2	130 - 140	6.82	0.48	0.106	160.4	70.0	16.87	16.16	26.8	1.19	27.99	95.74
C	180 - 190	7.03	0.38	0.091	171.9	92.9	10.14	96.28	28.0	0.61	28.61	97.86
Year – 2017												
Ao	10 - 20	6.34	2.77	0.179	129.7	52	33.8	148	18.1	3.14	21.2	86.3
AB	40 - 50	6.56	2.09	0.133	142.3	48	19.7	139	19.5	2.26	21.6	90.2
Bt_1	80 - 90	6.75	1.27	0.087	169.8	50	9.5	130	23.9	2.15	25.9	90.8
Bt_2	130 - 140	6.98	0.65	0.049	161.5	61	4.7	107	24.7	1.22	25.7	94.7
C	180 - 190	7.41	0.61	0.033	176.1	79	4.3	78	25.3	0.63	25.8	96.9

From the data presented above, the typical reddish preluvosol has agriproductive properties, with a medium to good natural fertility. Thus, the generally clayey texture towards the clay-loam and the developed polyhedral and glomerular structure determines good water and air circulation, and thus allows a normal development of the root system of plants. From the data presented, it can be observed that by cultivating the land, all the physical properties of the soil have undergone negative changes, which led to a strong growth of the compaction processes, thus influencing the soil properties to a depth of 70-100 cm (Florea et al., 1987). The regulation of the water regime can be achieved by applying rational agricultural works and through irrigation, especially in the dry years.

Deficiencies are also felt in some chemical properties, especially in organic matter content. The soil used for crops has decreased in organic matter by almost half, compared to those under vegetation and grasses, where humus accumulates to a much greater depth of about 1 m. The pH value did not have much influence depending on the use, as the soil contains sufficient basic elements in the colloidal complex.

However, according to the chemical properties presented, highlighted in the tables above, it can be appreciated that on these soils, rich and quality crops can be obtained only by applying organic fertilizers with N, P, K. However, these must be applied in reduced doses and perfectly correlated with the natural degree of soil supply determined from the pedological and agrochemical mappings. These soils are ideal for agricultural crops, plantations of orchards and vines, but less ideal for vegetables.

It can be argued that by utilizing the typical reddish preluvosol between Jiu and Olt rivers for agricultural purposes, it undergoes observable changes. These include: a stronger compaction, a worsening of porosity, a decrease in water permeability, and especially an alarming reduction in the amount of organic matter.

In order to ascertain the degree of contamination of the soil in the research area with heavy metals (Figure 3), a series of analyses were made in order to determine the content of most common heavy metals, such as chromium (Cr), copper (Cu), nickel (Ni), zinc (Zn), cadmium (Cd), and lead (Pb), which was compared to a baseline (normal, alert and intervention threshold) according to O.M. 756/1997, on a sensitive soil. The determinations were made at the solicitation of agritouristic structure owners to ensure the safety and traceability of the products offered to tourists (Călina and Călina, 2015). All these metals pose a danger to plant and human health.

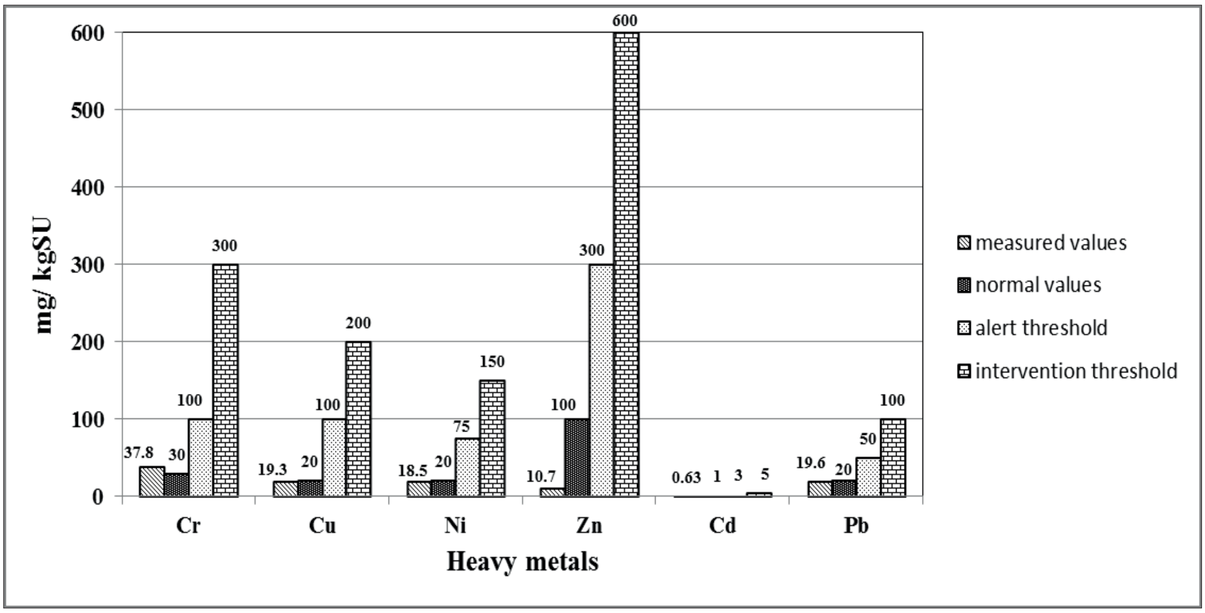

Figure 3. Heavy metal content of the typical reddish preluvosol

Chromium is a heavy metal category that is toxic to plants only when it appears as an oxidized anion (hexavalent chromium), and this phenomenon occurs only under certain pH and potentially redox conditions that do not persist for long periods in soil (Beek, 1991).

Copper pollution affects the physical and chemical properties of the soil, reducing aggregate percentage and water stability, resulting in increased erosion and compaction. Copper used in pesticides is highly toxic being composed of enzymes and hemocyanin, and its deficiency can lead to anaemia (Bervoets and Blust, 2003).

Zinc is a microelement indispensable to all organisms as it is encompassed in a large number of enzymes, but in some circumstances, it can become toxic (manifested by impeding growth). It is present in soils polluted in both the stable and the radioactive form, normally the forms are more stable, except for the franklinite ($ZnFe_2O_4$) (Sescu et al., 2018).

Cadmium is a chemical element with high toxicity. Its effects vary from one species to another and it often produces a decrease in longevity, decreased fertility and strong anaemia. It is present in the soil, particularly in the form of cadmium ($CdCO_3$), and sulphide from the chemical fertilizers that contain these substances.

Lead is the fastest depositing metal element with the highest exceedance of the maximum admissible concentration in almost all environmental compartments. Lead accumulated in the soil has toxic effects, producing inhibition of enzymatic processes, reducing the carbon dioxide removal intensity and reducing the number of microorganisms, all of which have serious consequences in terms of plant nutrient absorption. In large quantities it is poisonous and can give rise to serious diseases (Prundeanu and Buzgar, 2011).

From the data presented in Figure 3, of all the heavy metals found in this type of soil, only chromium exceeded the normal values, its concentration being above 30 mg/kg d.m., but as stated it is toxic to plants only when it occurs as an oxidized anion (hexavalent chromium), a phenomenon signalled only under certain pH conditions and redox potential, conditions that do not persist for a long time in the soil (Mihalache et al., 2014).

Concentrations of copper and nickel in the soil are very low, below the normal range (with -19.3 mg/kg d.m., Ni -18.5 mg/kg d.m., normal value is 20 mg/kg d.m.). These metal elements do not pose any danger to the plants, animals and people who consume the resulting agricultural products.

Also, zinc has a very low concentration, which is well below the normal values of 100 mg/kg d.m., the registered values being only 10.7 mg/kg d.m., demonstrating a deficiency of this element, which also has beneficial effects on all organisms as it encompasses a large number of enzymes. Cadmium exhibits a concentration below the normal range (0.63 mg/kg d.m. measured and 1 mg/kg d.m. normal), which is particularly encouraging since it has a very toxic effect in high concentrations, producing very serious diseases in almost all living organisms.

As for lead, it is also found in slightly lower concentration of 19.6 mg/kg d.m., compared to the normal value of 20 mg/kg d.m., despite the large number of pollution sources (large number of automobiles and strong industrialization) that can lead to large and uncontrollable amounts both in the atmosphere and in the soil. Its low concentration in the soil and in the environment demonstrates that the agritouristic household present in research area comply with the basic and mandatory condition of being located in areas with no pollution and noise sources of high climatic and landscape value, is a true oasis of tranquillity and relaxation for tourists who want to spend an unforgettable stay or holiday amidst the beauties, harmony and purity of the surrounding countryside.

CONCLUSIONS

From the research undertaken it can be stated that due to the substitution of the initial conditions of formation and solidification of the soil determined by natural vegetation, with the cultivated vegetation, its influence on soil formation has decreased greatly. In over 20 years of evolution, it can be noticed that this contribution is basically null, due to the strong and crude intervention of the anthropic factor, in the natural process of the reddish preluvosol in the area through the cultivation of the land. Regarding the morphological features of this type of soil, during the research period, the composition of the soil profile and especially the succession of the horizons and their specific features underwent no significant changes. The granulometric composition, due to the new artificial factors maintaining over the last 20 years (created by the cultivation of the majority of the researched surfaces), the soil did not suffer any significant changes, as noted in Table 1, where only a slight change in the clay content was observed in the AB horizon, where the soil texture evolved from clay loam to clay. The variation in the percentage of clay in the middle of the profile is due to the processes of alteration and migration that occur with a higher intensity at this level. The analyses from the point of view of the physical properties of the soil uncovered no substantial evolutions, the only higher changes being recorded for the aeration porosity (Pa) which increased by approximately 9% and penetration resistance (RP) that fell by more than 3% in the Ao horizon. The largest decrease was recorded in the soil profile in 2017, with more than 20 units, primarily due to the soil loosening effect at this depth. The variations in the values of the hydro-physical coefficients of the soil over time are not very high, as the granulometric composition also varies within the limits, the biggest difference being the wilting coefficient (CO) of 3.28% in 2017, phenomenon due to climate changes that have been recorded in the last decades. The Active Humidity Range (IUA) has the highest value in the Ao horizon (12.36% and

14.21%) and decreases with increasing depth, as the amount of humus decreases. Regarding the chemical properties, the typical reddish soil belongs to the class of weak acidic soils (pH 6.13 and 6.34 respectively), with a medium to good fertility determined by a medium humus content, even if an increase can be observed from 2.54 in 1997, to 2.77 in 2017. Its growth has particularly favourable repercussions on other chemical properties, such as the supply of nitrogen, phosphorus and potassium in the soil complex, the saturation at the bases increasing from 83% to 86.3%, which also lead to an increase of the cationic exchange capacity. The most relevant result of the research on the typical reddish preluvosol is that of the presence and concentration of heavy metals, since the results of the analyses revealed that the majority of the discovered metallic elements are present in concentrations that do not exceed the normal values, with the exception of chromium that exceeds this value, but is still well below the alert threshold, with approximately 67 mg/kg d.m. These results confirm that the studied soil presents no risk in terms of the safety and traceability of the agrifood products and that it is possible to obtain quality culinary specialties that can be sold to tourists under the label of natural or even organic products, if certification is obtained.

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