Environmental Engineering and Management Journal

December 2019, Vol.18, No. 12, 2729-2738
http://www.eemj.icpm.tuiasi.ro/; http://www.eemj.eu

"Gheorghe Asachi" Technical University of Iasi, Romania

EVOLUTION OF THE MOLLIC REDDISH PRELUVISOL IN A ROMANIAN RIVERINE REGION AND THE ASSESSMENT OF ITS AGRO-PRODUCTIVE PROPERTIES IN FARMS AND AGRO-TOURISTIC HOUSEHOLDS

Jenica Călina, Aurel Călina*

University of Craiova, Faculty of Agronomy, 19 Libertătii Street, 200421 Craiova, Romania

Abstract

The research focuses on the assessment of the main agro-productive properties and the evolution of the mollic reddish (red-brown) preluvisol between the Jiu and Olt rivers, under the new conditions of soil formation and exploitation, created after radical transformations in Romanian agriculture, when most of the lands were passed from state to private ownership. The first comparative analysis of the properties of the soil that evolved on the terrains utilized for crop culture on farms and agritourist households, with soil that evolved forest vegetation, attests to the impact of the anthropic factor – intense modification in the morphological, physical and chemical (deeper profile due to the eluviation - illuviation process, compaction and sealing of lower horizons and an irreversible decrease in natural fertility). The second analysis, of the soil utilized for crop culture, reveals that the morphology, contents, architecture, physical, hydric indicators and chemical proprieties have not undergone any positive or negative modification in a period of 23 years. Relevant for the farms and agritourist households that practice touristic activities is the presence and concertation of heavy metals. The identified heavy metals do not pose any threat to plants or humans, as their concentration does not exceed the normal permitted values, except for chromium, which is still well below the alert threshold. Current conditions enable the mollic reddish preluvisol to support an ecologically based agricultural production, thus ensuring the safety and traceability of the agri-foods offered to tourists.

Keywords: agro-productive properties, agritourist, heavy metals, soil profile, traceability

Received: February, 2019; Revised final: June, 2019; Accepted: June, 2019; Published in final edited form: December, 2019

1. Introduction

In Romania, reddish preluvisol has been separated as an area specific soil by Murgoci (1911), being later characterized by Cernescu (1961) and Chirță (1972). The formation and evolution of this type of soil is closely tied to the temperate climate with a Mediterranean influence, the vegetation formed by *Querce* forests and the parent material composed of loess deposits. It forms under the oak forests and represents a transition soil between the brown earth and Mediterranean soils, being endemic to the South and South-West regions of Romania. Chiriță (1972) considers the reddish preluvisol (red-brown) a late stage evolution of the degraded Chernozem, under the influence of specific climatic and vegetation conditions and Păunescu (1975) specifies that the soil's formation can be determined by an abundance in clay and total contents of carbonates ($CaCO_3$) in the parent rock. Geologically, the area with mollic reddish (red-brown) preluvisol belongs to the Upper Pleistocene.

Since 1995, the research of mollic reddish preluvisols was framed within the context of agritourist activity in the area, in the farms and agritourist households, which started developing in Romania after 1990, when the National Association of Rural, Ecological and Cultural Tourism (ANTREC)

---

[*] Author to whom all correspondence should be addressed: e-mail: aurelcalina@yahoo.com; Phone: +40 (0) 251 418 475; Fax:+ 40 (0) 251 418 475

was founded (Iancu et al., 2017). In agritourism, 80% of the food provided to tourists is home-grown or locally sourced and the quality of the soil represents the point of origin for food security and human health (Bampa et al., 2019; Brevik and Sauer, 2015; Bünemann et al., 2018).

The team desired to further the research made previously in the area between Jiu and Olt rivers, regarding the main agro-productive (physical, hydric and chemical) properties of reddish preluvisol (brown-red soils) and highlight the main changes in these properties, over time. The specific objectives of our research concerned the characterization of the research area from the point of view of the conditions and process of formation and evolution; determining the morphological, physical and mechanical, chemical properties and fertility; the impact of human activity on the evolution of soil properties, the presence of heavy metals and their influence on agricultural products, resulted from the primary production of farms and agritourist households.

The relevance of the research consists in the very high percentage of these types of soils encountered in the focus area. As noted by Șorop and Vasile (1990), the reddish (red-brown) soils in Oltenia occupy an irregularly shaped strip, stretching from Drobeta Turnu-Severin, over the city of Craiova, to the town of Piatra-Olt and Caracal, on an area of approximately 350,000 ha, constituting 47.3% of the total reddish soils in Romania.

2. Material and methods

In order to achieve the stated objectives, field research was necessary, during which several soil profiles were morphologically analyzed, and samples were collected from the most representative soils for laboratory analysis. Field maps and pedestrian mapping works from the County Offices for Pedological and Agrochemistry Studies Dolj and Olt were utilized. 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, color, texture, structure, porosity, compactness, adhesion, neoformation, moisture and parent rock.

Soil samples were collected from every layer of the profiles distributed by soil genesis, replicated 3 times, in its undisturbed and disturbed structure, using cylinders (5x5 cm).

Soil profiles have the following particularities:

- Profile under forest vegetation: location - 3 km North-West from Deveselu in Comanca forest; altitude -120 m average height; relief – piedmont plateau, flat terrain; vegetation-Querce forest formed by: Quercus freinetto, Quercus cerris, Quercus pubescents, Acer campestre, Crataegus monogina, Ulmus sp.; parent material- clay deposits combined with loess deposits; natural drainage – good; groundwater depth- more than 10 m.
- Profiles under agricultural corps - location - 4 km North-West from Deveselu; altitude - 125 m average height; relief - slightly inclined plateau to the North, parent material - loess-sandy deposits with reddish limes, natural drainage-very good; groundwater depth- more than 15 m.

Soil profiles were accomplished in approximately the same place, with a period of 23 years apart, in the same climatic, relief, fauna and anthropic conditions, thus the same pedogenetic conditions.

The mechanical, hydric, physical and chemical analyses of the soil samples were realized at the specialized laboratory at the Faculty of Agronomy and the laboratory of the Office for Pedological and Agrochemistry Studies in Craiova.

a) Determination of physical and mechanical properties

In order to determine the physical properties of soils, the samples collected in their undisturbed structure (in metal cylinders) were analyzed as follows: *particle size distribution* - Kachinsky method; the texture - by the Chiriţă-Burt triangle; *soil density* (D, g/cm^3) - pycnometer method; *bulk density* (BD 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 Eq. (1):

$$Pt(\%) = 100 \cdot (1 - \frac{Da}{D}) \quad (1)$$

air porosity (Pa %)-calculation (Eq. 2):

$$Pa = Pt - Fc \cdot BD \quad (2)$$

b) Determination of hydro-physical properties: water permeability-the National Research and Development Institute for Soil Science, Agrochemistry and Environment method; hygroscopicity coefficient (HC, %) - Mitscherlich method; wilting coefficient (WC, %) - through calculation using (Eq. 3):

$$WC = HC \cdot 1.5 \quad (3)$$

the moisture equivalent (ME, %) - by centrifugation of soil samples with a force greater than 1,000 times the gravitational acceleration; *field capacity* (FC, %)- calculated using (Eq. 4):

$$FC = ME \cdot 0.84 + 2.64 \quad (4)$$

available water capacity (AWC, %)-through calculation, using the formula (Eq. 5):

$$AWC = FC - WC \quad (5)$$

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 using a double glass-calomel electrode, (Stanila, 2019); *humus (H,* %)- determined by volumetric method, Walkley-Black modified by Gogoaşă, wet oxidation (Florea et al., 1978); *total nitrogen* (N%)–the Kjeldahl method (Liu et al., 2015); *mobile phosphorus* (P, ppm)-the Egner-Riehm-Domingo method; *mobile potassium* (K, ppm) -the Egner-Riehm-Domingo method (Lăcătuşu and Lăcătuşu, 2008); *sum of bases* (SBs, me/100g soil)–Kappen-Chiriţă method (Chanarache, 1990; Florea et al., 1978); *hydrolytic acidity* (Ha, me/100g soil) - by percolation at exhaustion with 1N potassium acetate solution (Cernescu, 1964; Stătescu et al., 2013; Spurway, 1917); *cationic exchangeable capacity* (CEC, me/100g soil) - by calculation (Eq. 6):

$$CEC = SBs + Ha \tag{6}$$

percentage of base saturation (BS%), - through calculation (Pierre and Scarseth, 1931) using (Eq. 7):

$$BS = \frac{SBs}{CEC} \cdot 100 \tag{7}$$

Index of nitrogen (IN) by calculation (Eq. 8):

$$IN = \frac{H \cdot BS}{100} \tag{8}$$

d) Heavy metals were determined using the method of 1: 5 acidic mineralization and through flame absorption – the recommended methods of the Avanta GBC SN A 5378 flame atomic absorption spectrometer and of the Milestone microwave disintegration system, model the interpretation of soil contamination ETHOS D series 127327. Atomic Absorption Spectrometry is considered a usual technique for determining metals in a wide range of environmental samples (Dumitru et al., 2011; Haswell et al., 1991).

The soil samples collected from the 0-20 cm depth of the Am horizon. The interpretation of the soil contamination levels with Cr, Cu, Ni, Pb, Cd, Zn was accomplished according to Romanian legislation regarding soil pollution (EM, 1997).

3. Results and discussion

3.1. Spread of Preluvisol

Murgoci (1924), (quoted by Călina et al., 2000) showed that this type of soil is encountered in Russia, where it is included in the class of degraded chernozem, and in Hungary where it is known as Nyrog. In Serbia and Bulgaria, as well as in Western and Central Europe, it occupies narrow areas. Merlescu and Teşu (1982) (quoted by Mihalache, 2006; Popescu and Grecu, 2011) state that the reddish preluvisol, as it 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 of *gainacea*. In Germany they are known as *graue waldboden*, and after the 7th American approximation, under the name of *argiudoll*.

The reddish preluvisol in Romania, according to Murgoci (1924), occupies an area of 760,000 ha and 5.24% of the agricultural area of the country. Detailed research later elaborated by Chiriţă et al., (1964, 1967) showed that the reddish preluvisol (brown-reddish) is found only in the South and South-West regions of the country. It occupies the largest part of the oak sub-area in the High Plains of Muntenia, Oltenia, as well as in Banat and Dobrogea.

In Oltenia it occupies a strip defined in the North by Turnu-Severin, Bistrita, Terpezita, Ghercești, Bals, Piatra-Olt, and in the South by Burila Mare, Branişte, Mărăcinele, Segarcea, Tâmbureşti, Deveselu and Caracal (Fig. 1). Between the Jiu and Olt rivers, the area under observation, of the typical, mollic and podzolic soils, brown-red soils occupy almost the entirety of Leu-Rotunda High Plain, on the Southern side of the Getic Plateau and the North-Eastern part of 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 that exist in Oltenia. They are delimited to the North by Craiova, the towns of Filiaşi, Gherceşti, Balş, and Piatra Olt, and to the South by Tâmbuşti, Deveselu, Caracal. Mollic reddish preluvisol, and mixed to varying degrees with the podzolic type, are generally spread in the Southern part of the area, between Deveselu and Bratovoieşti. The surface occupied by these soils is 25.738.82 ha, representing 18.6% of the reddish preluvisol in the research area.

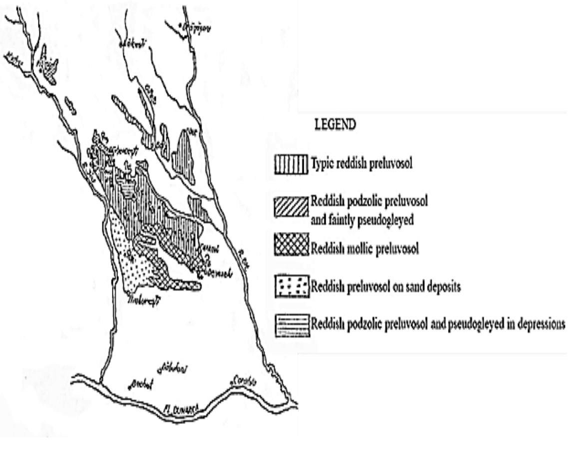

Fig. 1. The spread of reddish preluvisol between the Jiu and Olt rivers

3.2. Agri-pedological characterization of mollic reddish preluvisol

The landscape represents the transition between the plains and plateau. It forms especially on the Leu-Rotunda High Plain and Oltenia Plain. On this territory there are several dry valleys that run parallel, which are oriented from West to East, giving the landscape a wavy appearance. In the southern part of the area there are several gorges, whose heights have diminished due to agricultural works (Canarache, 1990; Chiriță et al., 1967).

The parent material on which the mollic reddish soil was formed and evolved is generally made up of a loess deposits, which includes silty aeolian loess, as well as sandy clay diluvial. Both series contain limestone concretions that are better represented in the clays.

Hydrography and hydrogeology. The area is poorly represented from a hydrographic point of view, as there are only dry valleys and a few temporary water courses. Apart from the reservoir formed in the Pâeliţi valley and a temporary valley South of the Comanca village, there are no other lakes, ponds and important river valleys in the area (Coteţ, 1973). The groundwater in the area ranges from a depth of 12 to 16 m on the plateau of the Leu-Rotunda High Plain, to 3 to 6 m on the valley line.

Climate. The climate regime interpreted by the Caracal Meteorological Station shows a higher degree of continental climate. In summer, the tropical air from the SW creates a particularly hot and dry weather. The average annual temperature is between 10-11°C, attesting to the high thermal potential of this area. Atmospheric precipitations have the same continental influence, falling in the form of rain, the annual average sums oscillating around 525 mm, and potential evapotranspiration being 698 mm. Thus, there is an annual deficit of over 173 mm.

Vegetation. The monotony of the landscape and low altitudes determine a relative uniformity of the vegetation. In most parts of the territory, natural vegetation has been replaced by agricultural crops. The natural vegetation encountered on smaller areas in the valleys comes in the form of clusters of forests (e.g. Comanca), small areas of grassland and poor-quality meadows or as weeds in agricultural crops. The species of wood plants are *Quercus pubescens*, *Quercus pedunculiflora*, *Fraxinus excelsior*, and the brush is represented by the wild privet, the blackthorn, the hawthorn and the rose. Among the most common grassy species there are: meadow fescue, bluegrass, rape field, couch grass, thick knot grass, amaranth, bindweed, foxtail, thistle, chicory, red poppy, plantain, thistle.

a) Morphological characteristics

The comparative analysis of the morphological characteristics (Table 1) highlights a profile with clearly defined horizons, in the case of the reddish mollic preluvisol that evolved under the influence of forest vegetation and the intervention of the anthropic factor through agricultural works, constantly carried out on the surface horizons of the soils that evolved on the lands used for cultivating crops in the farms and agritourist household (Horizon Am 39 cm in 1995 and 37 cm in 2018).

Tabel 1. Morphological characteristics of soil profiles of the reddish mollic preluvisol

Profile layer/ Depth (cm)	***Morphological characteristics***
YEAR – 1995 - Forest vegetation	
Am horizon: 0-33 cm	Dark brown-grey color (10YR 3/2) in wet state and brown-grey (10YR5/2) in dry state; clay loam texture; well-developed medium subangular polyhedral structure (structural elements fixed in larger aggregates); fine pores; weak compaction; friable; moist; weak plastic; weak adhesion; fine ligneous roots and a thicker root oriented horizontally at the base of the horizon; many grassy roots; many worm tunnels with coprogen granules; gradual transition.
Bt_1 horizon: 33-68 cm	Brown-yellowish color and (7.5YR 4/4) in wet state (7.5YR 5/4) and slightly dark reddish in dry state; clay loam texture; well-developed medium angular polyhedral and prismatic texture; firm in wet state and very rough when dry; plastic; adhesive; a continuous film of clay on the vertical and horizontal sides of the structural elements; few pores; many medium and thick ligneous roots; few thin grassy roots; few worm tunnels; gradual transition.
Bt_2 horizon: 68-118 cm	Brown-reddish, dark yellowish color (10YR 5/4) in dry state and (10YR 4/3) in wet state; clay- loam texture; well-developed medium prismatic structure; firm in wet state and rough when dry; plastic; adhesive; compact; fairly continuous clay films on the sides of the structural elements; very few pores; thin ligneous roots; gradual transition.
BC horizon: 118-151 cm	Brown-yellowish, slightly dark red color (10YR 4/4) in wet state and (10YR 6/3.5) in dry state; clay-loam texture; moderately developed, small prismatic structure; firm in wet state and rough in dry state; fairly plastic; fairly adhesive; fairly compact; few discontinuous clay films on the sides of the structural elements; few roots; gradual transition.
C horizon: 151-200 cm	Dark brow-yellowish color (10YR 5/4) in wet state and light (10YR 6/4) in dry; loamy clay texture; weakly structured; friable in wet state and rough when dry; few and hard stains and nodules of $CaCO_3$ with irregular forms; weak effervescence.
YEAR – 1995 – Agriculture crop	
Am horizon: 0-39 cm	Dark brown color (10YR 3/3) in wet state and light-brown (10YR 5/4) in dry; clay texture; well developed, medium glomerular structure; plastic; weak compaction; many roots; frequent worm tunnels with coprogen matter; gradual transition.

Bt_1 horizon: 39-81 cm	Dark brown-reddish color (7.5YR 3/3) in wet state and (7.5YR 5/4) in dry state; loamy-clay texture; wll developed, medium angular polyhedral structure; plastic; adhesive; compact; very few thin; traces of worm tunnels; gradual transition.
Bt_2 horizon: 81-129 cm	Dark brown-reddish color (7.5YR 4/3) in wet state and (7.5YR 5/4) in dry state; loamy clay texture; mediumly developed medium and small angular polyhedral; plastic; adhesive; compact; many fine pores; descending crotovines with matter from the upper horizons; very few roots; gradual transition.
BC horizon: 129-168 cm	Dark reddish brown, slightly dark yellowish (7.5YR 4/4) in wet state and (7.5YR 6/4) in dry state; loamy clay texture; well-developed medium subangular polyhedral structure; plastic; adhesive; moderately compact; many small fine pores; gradual transition.
C horizon: 168-200 cm	Reddish-brown, yellowish color (7.5YR 5/4); loamy clay texture; weakly developed small subangular polyhedral structure; plastic; adhesive; moderately compact.
YEAR – 2018 - Agriculture crop	
Am horizon: 0-37 cm	Dark brown color; loamy clay towards clay texture; small to medium glomerular structure, weakly developed; loose; weak plasticity; adhesive; wet; many roots; gradual transition.
A/B horizon: 37-50 cm	Brown color; loam texture; medium subangular polyhedral structure; plastic; adhesive; fine pores; many thin roots; dry; gradual transition.
Horizons Bt_1: 50 - 82 cm	Yellowish-brown, dark red color; loamy clay texture; well-developed, medium prismatic structure; plastic; adhesive; many roots up to a depth of 60 cm; weak compaction; dry; gradual passage.
Horizons Bt_2: 82 - 120 cm	Light reddish-brown color; loamy clay texture; small and medium angular polyhedral structure; plastic; adhesive; few thin roots; ascending crotovine neo-formations; gradual transition.
Horizon BC: 120 - 150 cm	Reddish-orange towards yellowish color; loamy clay texture, weakly structured, massive; plastic; adhesive; weak compaction; gradual transition.
Horizon C: Appears over 150 cm	Yellowish-brown color; loamy clay texture; weakly structured; plastic; weakly adhesive; wet; cervotocine with matter from the upper horizons.

b) Granulometric composition

The reddish mollic preluvisol that evolved under forest vegetation (Table 2) is characterized by a higher percentage of clay in the particle size distribution (42.1% in horizon Am and 47.3% in BC horizon) which gives the soil a clay loam texture in the first horizon and a loamy clay texture in the next three horizons

The same soil that evolved under agricultural crops presents a less differentiated structure per profile, the texture is medium fine in the Bt horizon and is medium fine towards rough in the A and C horizons, where fine-coarse particles appear, in addition to fine particles. The clay fraction has the lowest value in the humus accumulation in horizon Am (29.6 in 1995 or 22.5 in 2018) and highest in Bt_1 (42.5 in 1995) and Bt_2 (41.1), in 2018 respectively. This tends to increase with depth, due to the washing phenomenon.

c) The main physical properties

In Table 3, for the mollic reddish preluvisol that evolved under forest vegetation, we observe lower values for the apparent density (1.25 g/cm^3) and density of the soil (2.51 g/cm^3) in the Am horizon (rich in organic matter), but also a better aeration sustained by the high value of the total porosity (50.1%), by the air porosity of 20.2% and the resistance to penetration (RP) of just 39 kgf /cm^2 in the first horizon.

In the case of the soil used for agriculture, the total porosity (Pt) and air porosity (Pa) have medium values in the surface horizon, and these decrease at lower depths, due to the degree of soil compaction. The soil profile in 2018 presents a slight increase in aeration porosity Pa, due to the soil being processed with specialized machines, which loosen the surface horizon. The penetration resistance (PR) is medium to high, rising with depth, as highlighted in the table above.

d) The main hydro-physical properties

For the mollic reddish preluvisol under the forest vegetation, the hydro-physical indicators are well corelated with the clay contents and especially in the organic matter (Table 4), presenting values that have a tendency towards the upper limit (wilting coefficient of 13.25 %, field capacity of 23.9 %, active humidity range of 10.68%; values found in the Am horizon, present a tendency of slight increase in the B horizons).

For the mollic reddish preluvisol that evolved under the influence of the anthropic factors, the main hydro-physical indicators of the soil comprised of the hygroscopicity coefficient (HC), the wilting coefficient (WC) and the moisture equivalent (ME) are generally medium and have a tendency towards an increase in the horizons where the clay content is higher. Field capacity (FC) is medium and has higher values in the Bt1 and Bt2 horizons (26.14 and 25.11, 23.22 and 24.81 respectively in 2018) where the amount of clay is higher.

The Active Humidity Range (AHR) is lower in the surface horizon (10.88 and 10.90), where the amount of clay is lower. The water permeability is higher in the upper horizon (4.16), because the total porosity is higher, and it decreases further with depth. From the same table, it is noticeable that soil permeability increased to 5.20 mm/hour in 2018 because the total porosity of this type of soil was increased using new, specialized equipment and machinery for soil loosening and mobilization.

Table 2. Particle size distribution of the mollic reddish preluvisol

Horizon	***Horizon depth (cm)***	***Sampling depth (cm)***	***Particle size distribution (%)***				***Textural class***
			Coarse sand 2-0.2 mm	***Fine sand 0.2-0.02 mm***	***Silt 0.02 -0.002 mm***	***Clay <0.002 mm***	
YEAR – 1995 - Forest vegetation							
Am	0-33	10-20	12.8	23.2	21.8	42.1	Clay loam
Bt1	33-68	60-70	13.2	20.5	21.5	44.4	Clay loam
Bt2	68-118	90-100	14.3	18.7	20.3	46.7	Clay
BC	118-151	135-145	14.8	18.2	21.2	45.8	Clay
C	151-200	180-190	12.1	26.9	20.4	40.6	Clay loam
YEAR – 1995 - Agricultural crop							
Am	0-37	10-20	20.0	27.3	23.1	29.6	Loam
Bt$_1$	50-82	60-70	14.1	20.4	23.0	42.5	Loam
Bt$_2$	82-120	90-100	12.0	29.8	20.2	38.0	Clay loam
BC	120-150	135-145	16.2	27.1	21.9	34.8	Clay loam
C	150-200	180-190	18.1	29.7	17.1	35.1	Clay loam
YEAR – 2018 - Agricultural crop							
Am	0-37	10-20	15.0	36.3	26.2	22.5	Loam
Bt$_1$	50-82	60-70	14.5	32.4	23.5	29.6	Loam
Bt$_2$	82-120	90-100	12.8	25.8	20.3	41.1	Clay loam
BC	120-150	135-145	13.1	30.3	18.3	38.3	Clay loam
C	150-200	180-190	13.6	33.3	16.9	36.2	Clay loam

Table 3. Main physical properties of the mollic reddish preluvisol

Horizon	***Horizon depth (cm)***	***Sampling depth (cm)***	***BD (g/cm^3)***	***D (g/cm^3)***	***Pt (%)***	***Pa (%)***	***RP (kg f/cm^2)***
YEAR – 1995 - Forest vegetation							
Am	0-33	10-20	1.25	2.51	50.1	20.2	39
Bt1	33-68	60-70	1.38	2.58	46.5	7.7	68
Bt2	68-118	90-100	1.52	2.69	43.5	-	61
BC	118-151	135-145	1.55	2.69	42.4	-	50
C	151-200	180-190	1.50	2.71	43.8	-	49
YEAR – 1995- Agricultural crop							
Am	0-37	10-20	1.35	2.57	47.4	18.06	45
Bt$_1$	50-82	60-70	1.41	2.61	45.9	9.04	78
Bt$_2$	82-120	90-100	1.51	2.66	43.2	5.28	88
BC	120-150	135-145	1,53	2.67	42.6	7.76	59
C	150-200	180-190	1.55	2.71	42.8	7.77	48
YEAR – 2018- Agricultural crop							
Am	0-37	10-20	1.25	2.65	52.8	29.23	22
Bt$_1$	50-82	60-70	1.33	2.67	50.2	19.31	42
Bt$_2$	82-120	90-100	1.42	2.69	47.2	11.96	84
BC	120-150	135-145	1.48	2.66	44.36	9.63	79
C	150-200	180-190	1.51	2.70	42.07	9.04	63

BD -Bulk density; D - Soil density; Pt - Total porosity, Pa- Air porosity; RP-Resistance to penetration

Table 4. Main hydro-physical values of the mollic reddish preluvisol

Horizon	***Sampling depth (cm)***	***HC (%)***	***WC (%)***	***ME (%)***	***FC (%)***	***AHR (%)***	***Permeability (mm/h)***
YEAR – 1995 - Forest vegetation							
Am	10-20	9.3	13.25	24.64	23.93	10.68	4.92
Bt1	50-60	9.4	14.06	29.93	28.15	14.09	3.69
Bt2	90-100	11.2	16.80	33.24	31.43	14.63	2.51
BC	135-145	10.3	15.45	32.65	30.98	15.53	2.84
C	180-190	10.1	15.12	30.96	28.64	13.52	2.98
YEAR – 1995- Agricultural crop							
Am	10-20	7.22	10.83	21.1	21.73	10.88	4.16
Bt$_1$	50-60	10.04	15.06	27.2	26.14	11.08	1.78
Bt$_2$	90-100	9.18	13.77	26.0	25.11	11.34	1.70
BC	135-145	8.16	12.24	23.3	22.77	10.53	2.62
C	180-190	8.15	12.22	23.1	22.60	10.38	2.78

YEAR – 2018 - Agricultural crop							
Am	10-20	5.30	7.95	19.3	18.85	10.90	5.20
Bt$_1$	50-60	7.10	10.65	24.5	23.22	12.57	2.80
Bt$_2$	90-100	9.60	14.40	26.4	24.81	10.41	2.20
BC	135-145	9.10	13.65	24.8	23.47	9.82	2.02
C	180-190	8.80	13.22	22.9	21.87	8.65	2.99

HC- Coefficient of hygroscopicity; WC - Wilting coefficient; EU - Moisture equivalent; FC - Field capacity; AHR - Active humidity range

e) Main chemical properties

Under the forest vegetation, the humus percentage in the surface horizon is much higher, 4.08 % (Table 5), in comparison to soils that evolved on the terrains used for cultivating crops, on the farms and agritourist guesthouse (2.72 in 1995 and 2.95 in 2018 respectively), and the depth of accumulation on the profile is up to 80-90 cm. Corelated to the high percentage of organic matter, a greater supply of total nitrogen (0.221% in Am) is noticeable. Still, the supply of phosphorus is weak to medium, the mobile potassium supply is medium and it is rich in colloidal complex, the total cation exchange capacity (T) presenting values of over 27.5 me/100g of soil, and the percentage of base saturation (V%) is high (over 85%).

The mollic reddish preluvisol has a slight acidic reaction (pH=6.38) to the soil profile made in 1995, and after 23 years the soil acidity has increased considerably to 5.94, due to the washing down of the cations of Ca from the processed surface horizon. The medium humus content of 2.72%, increased up to 2.95%, due to the application of modern crop technologies, with proper aeration and mineralization of plant debris, which have not been removed for over 23 years, through burning or use as secondary production (phenomenon noted by Sescu et al., 2018). Nitrogen from the soil, at an average level of 0.198% has seen a slight decrease to 0.186%. The same decrease can also be observed for the nitrogen index, dropping from 3.33 to 2.19 in 2018. The total humus and nitrogen content sharply decrease as depth increases.

The content in mobile phosphorus of 47.25 ppm saw a slight decrease to 32.5 ppm and the low to medium mobile potassium at 111.22 ppm, noticeably increased to 180.70 ppm in 2018, due to the application of a larger quantity of chemical fertilizers with a high potassium content, as plants with high potassium intake were cultivated on this surface. Furthermore, it is also noticeable that the value of P and K mobile content drops sharply in lower horizons.

The soil complex is saturated in the bases and falls under a medium base, accounting for 82.25% in 1995, and decreased in the surface horizon over time to 74.3%, due to the increase in soil acidity and decrease of mineral residue to 36.5%. Hydrolytic acidity has the highest value in the surface horizon, 3.97 me/100 g soil and 3.20 me/100 g soil respectively in 2018, from where the basic cations and clay were washed. The mineral residue increases as the clay and washed salts are deposited on the profile.

3.3. Heavy metals concentration in the mollic reddish preluvisol

In order to prevent the unwanted effects of the presence of heavy metals the research, also includes their presence and concentration in the studied soil type. This is necessary, as plants, through the consumption of nutrients in the soil can extract heavy metals, which have undesirable effects on the animals and humans that consume them. In agritourism, it is mandatory for an agritourist guesthouse or farm practicing such an activity, to have at least one primary agricultural production activity, to ensure for its tourist reception structure, products from plant or animal origin (Călina and Călina, 2015, González-Moreno et al., 2016; Ibănescu et al., 2018, Petrescu et al., 2017; Sáez-Martínez et al., 2016), from an organic source.

The strong, severe and rapid effects of heavy metal intoxications on the human body are readily recognizable. The most common symptoms of accidental contamination are cramps, nausea and vomiting, pain, sweating, headaches, difficulty breathing, confusion, difficulty in thinking, walking and talking and convulsions. In the case of chronic intoxication that occurs after long-term exposure and ingestion, they are equally recognizable, yet can also appear very similar to symptoms of other diseases. The effects of chronic heavy metal poisoning are: difficulty in the ability to think, walk and talk, nervousness and emotional instability, insomnia, nausea and lethargy (Răuţă et al., 1995; Tchounwou et al., 2012).

Considering the particularly serious effects on human beings, and by extension on the possible clients of the agritourist reception facilities, constituted a driving factor to extend the research on a group of heavy metals whose presence in the soils of Romania is well documented and whose effects can be dangerous. The factors that influence the concentration of heavy metals in the soils in the researched area are the use of fertilizers and other chemicals in agriculture; road traffic by exhaust gas emissions through lead (residual pollution) and by depositing metal particles released as a result of the mechanical movement of the vehicles such as copper by the braking mechanisms and zinc by the abrasion of tires (active sources). Emissions from industry and leakage from landfills (Huang et al., 2019; Iagăru et al., 2016), the best known are: Craiova municipality, Craiova's western industrial platform, Podari industrial platform, Calafat industrial platform, Slatina industrial platform - SC Alro SA, Aluminum factory in Slatina, Pirelli tire factory, Slatina and others, industrial platform area of Caracal, the industrial platform of Bals, the industrial platform of Corabia, have the most powerful influence at the local level. An important aspect for the type of studied soil is also rail traffic - mainly by depositing metal particles released from the movement of the trains on the tracks (Cu, Mn), (Bervoets and Blust, 2003; Yadav et al., 2019).

The residual pollution of the area under observation has been characterized over the past 23 years by a strong car-manufacturing, aluminum and rubber industry, industries well documented as heavy metal polluters, as well as by a combination of chemical and organic fertilizer. Analytical data from Table 6 reveals that the chromium concentration is 32.6 mg kg^{-1}, exceeding by 2.6 mg kg^{-1} the normal value of 30 mg kg^{-1}, but well below the alert threshold of 100 mg kg^{-1}.

Chromium is a heavy metal category that is toxic to plants only when it appears as an oxidized anion (hexavalent chromium), and this occurs only under certain pH conditions and redox potential, conditions that do not persist in the soil for longer periods (Beek et al., 1991). Regarding the other heavy metals identified in the mollic reddish preluvisol in the area, for copper, the value was 17.2 mg kg^{-1}, 2.8 mg kg^{-1}, less than the normal amounts, and for nickel the measured value was 19.7 mg kg^{-1}, well below the 75 mg/kg alert threshold. Zinc is a metallic element with the highest measured concentration of 35.8 mg kg^{-1} however, this is well below the normal 100 mg kg^{-1} value. Zinc is an essential element for living organisms, only becoming toxic only after it exceeds the normal value. Cadmium occupies first place in terms of plant, animal and human toxicity, being a non-essential element for living organisms. Even in a very low concentration, of over 1 mg kg^{-1}, it is very toxic, however the measured value is below this limit, with 0.85 mg/kg measured.

Lead is the metal compound which deposits the fastest, with the greatest exceeding of the maximum admissible concentration in almost all environmental components (Mihalache et al., 2014). As such, its concentration can easily and uncontrollably increase, both in the atmosphere and in the soil (Prundeanu and Buzgar, 2011). Lead concentration in the soil is 18.9 mg kg^{-1}, with 1.1 mg kg^{-1} less than the normal, and 31.1 mg kg^{-1} less than the alert threshold, even if the pollution sources presented above are numerous in the area and significant (large numbers of cars and strong industrialization).

Table 5. Main chemical properties of the mollic reddish preluvisol in Deveselu

Horizon	*Sampling depth (cm)*	*pH in (H_2O)*	*H (%)*	*Total nitrogen (%)*	*Index of Nitrogen*	*Mineral residues (mg/100g sol)*	*P*	*K*	*SBs*	*Ha*	*CEC*	*BS (%)*
							ppm		*me/100g sol*			
YEAR – 1995 - Forest vegetation												
Am	10-20	6.08	4.08	0.221	3.47	54.2	32.4	168.3	22.8	4.7	27.5	85.26
Bt1	50-60	6.49	2.13	0.198	1.91	57.8	28.9	130.6	20.4	3.2	23.6	90.13
Bt2	90-100	6.54	1.38	0.146	1.29	60.1	30.6	113.2	24.3	2.6	26.9	94.20
BC	135-145	6.87	0.94	0.138	0.89	74.7	8.2	80.9	27.5	2.2	29.7	95.12
C	180-190	6.96	0.52	0.102	0.49	80.9	10.5	46.2	29.3	1.5	30.8	98.04
YEAR – 1995- Agricultural crop												
Am	10-20	6.38	2.72	0.198	3.33	41.70	47.25	111.22	18.4	3.97	22.37	82.25
Bt$_1$	50-60	6.72	1.98	0.121	1.84	52.10	19.62	139.44	24.4	1.75	26.15	93.30
Bt$_2$	90-100	6.84	1.08	0.147	0.94	54.70	23.98	111.78	28.0	1.75	29.75	94.11
BC	135-145	6.90	0.67	0.140	0.63	55.40	26.68	96.28	28.0	1.43	29.43	95.14
C	180-190	7.18	0.48	0.098	0.45	57.00	22.08	89.64	26.8	1.28	28.08	95.44
YEAR – 2018- Agricultural crop												
Am	10-20	5.94	2.95	0.186	2.19	36.50	32.50	180.7	14.2	3.20	19.10	74.30
Bt$_1$	50-60	5.86	2.04	0.150	1.52	54.20	14.80	152.4	21.0	2.91	28.10	74.70
Bt$_2$	90-100	6.08	1.58	0.088	1.39	57.80	7.99	160.9	24.8	2.84	29.60	83.80
BC	135-145	6.22	0.67	0.077	0.62	57.16	9.83	123.3	26.5	2.03	28.63	92.56
C	180-190	6.36	0.48	0.069	0.45	56.94	12.54	109.4	27.3	1.98	29.08	93.87

H-Humus; P-Mobile phosphorus; K-Mobil potassium; SBs-Sum of bases; Ha-Hydrolytic acidity; CEC-Cation exchange capacity; BS- percentage of base saturation

Table 6. Heavy metals contents in Am horizon of the mollic reddish preluvisol under Agricultural crop

Heavy metals	*Heavy metal concentration*	*Values for heavy metals in agricultural soil**		
		Normal values	*Alert threshold*	*Intervention threshold*
	(mg kg^{-1})			
Cr	32.6	30	100	300
Cu	17.2	20	100	200
Ni	19.7	20	75	150
Zn	35.8	100	300	600
Cd	0.85	1	3	5
Pb	18.9	20	50	100

** EM, (1997)*

From data presented in Table 5, the mollic reddish soils has a slight acidic reaction because it has a pH below 6.5 (6.38 and 5.94 respectively in 2018), which increases the bio-availability of heavy metals for cultivated plants (Fang et al., 2019). Therefore, from the obtained results regarding the concentration of the major heavy metals, we can state that on this type of soil the risk of cultivated plants absorbing excessive amounts of heavy metals is low.

5. Conclusions

The comparative analysis of the agro-productive properties with the initial genesis ones, attest that the reddish mollic preluvisol, which evolved under the pedogenetic conditions of forest vegetation, has an undeniably better natural fertility, then that of the soil which evolved in the conditions created by crop cultivation, where the anthropic factor has had a long sustained impact, which has led to degradation and even contamination with dangerous chemical compounds.

The negative alterations that have occurred over the past 23 years pertain to an accentuation of the washing phenomenon (in horizon Am, the clay percentage has dropped from 29.6 %, in 1995, to 22.5 %, in 2018), an increase in acidity (the pH value has gone from 6.38 to 5.94) due to the washing of Ca cations from the processing of the surface horizon and use of fertilizers with an acidic reaction. Loosening done in the depth of the soil has led to an overall better aeration regime (air porosity has gone up, from 18.06 % to 29.23 %, while resistance to penetration has dropped, from 45 kgf /cm^2 to 22 kgf /cm^2) and a greater water permeability of the soil.

The increase in humus content from 2.72 % to 2.95 %, (in 2018), has led to an overall considerable improvement of the physical, hydric and chemical properties. Utilizing soil-friendly crop culture technologies, proper aeration and mineralization of the plant debris, that were not removed (over the 23 years, through burning or used as secondary production), represents a positive outcome of the anthropic factor's impact on the most essential component of the soil.

After 23 years of evolution under the influence of human activity, the reddish mollic preluvisol has a good towards medium fertility, offering good conditions for sustainable crop production. To improve the natural fertility, it is necessary to continue to incorporate plant debris, applying organic and inorganic fertilizers with NPK contents and utilizing ecological systems and technologies for crop production.

Our investigation regarding the presence and concentration of heavy metals, which could potentially lead to tourist intoxication, showed that the Cr content exceeds with 2.6 mg kg^{-1} the normal value, while the concentrations of Cu, Ni, Zn, Cd, Pb showed no significant accumulation. The results ascertain that the area where the farms and agritourist households have been established is clean and the *mollic reddish preluvisol reluvosol offers favorable conditions for obtaining healthy and safe agri-food products*, in conjunction with the use of ecologic crop culture systems. IN THIS WAY, the good food provided to tourists during their vacations and the products sold right from the farm can comply with the food safety and traceability norms imposed in Romania, as well as the European Union.

Monitoring all the indicators that determine the productive potential of a soil is important for those who practice agriculture today, but even more so for those who will practice agriculture in the future, for them to enjoy the same soil quality and the environment, in general. The longevity of a healthy soil ensures a long and healthy life for us all.

References

Bampa F., O'Sullivan L., Madena K., Sandén T., Heide H., Henriksen B.C., Ghaley B.B., Jones A., Staes J., Sturel S., Trajanov A, Creamer E.R., Debeljak M., (2019), Harvesting European knowledge on soil functions and land management using multi-criteria decision analysis, *Soil Use and Management*, **35**, 6-20.

Beek B., Nagel R., Loskill R., (1991), *Bioaccumulation in Aquatic Systems. Contribution to the Assessment*, Proc. of an Int. Workshop, Berlin, 1990, Nagel R., Loskill R. (Eds.), VCH, Weinheim, 1-5.

Bervoets L., Blust R., (2003), Metal concentrations in water, sediment and gudgeon (Gobio gobio) from a pollution gradient: relationship with fish condition factor, *Environmental Pollution*, **126**, 9-19.

Brevik C.E., Sauer J.T., (2015), The past, present, and future of soils and human health studies, *Soil*, **1**, 35-46.

Bünemann E.K., Bongiorno G., Bai Z., Creamer R. E., Deyn G., Goede R., Fleskens L., Geissen V., Kuyper T.W., Mäder P., Pulleman M., Sukkel W., Groeningen, J.W., Brussaard L., (2018) Soil quality- A critical review, *Soil Biology and Biochemistry*, **120**, 105-125.

Canarache A., (1990), *Physics of Agricultural Soils*, Ceres Publishing, Bucharest, 73-81.

Călina A., Călina J., Iagăru R., (2000), *Brown - Reddish Soils Between Jiu and Olt Rivers and their Main Agriproductive Properties* (in Romanian), Sitech Publishing, Craiova, Romania.

Călina A., Călina, J., (2015), Research on the production of forage for the agro-touristic farms in Romania by cultivating perennial leguminous plants, *Environmental Engineering and Management Journal*, **14**, 657-663.

Cernescu N., (1961). *Classification of Soils with an Excess of Humidity, Pedological Research*, Romanian Academy Publishing House, Bucharest, Romania.

Cernescu D., (1964), *Soil Research Methods* (in Romanian), Romanian Academy Publishing House, Bucharest, Romania.

Coteț P., (1973), *Romania's Geomorphology* (in Romanian), Technic Publishing House, Bucharest, Romania.

Chiriță C.D., Tufescu V., Beldie A., Ceuca D., Haranga P., Stanescu V., Toma G., Tomescu A., Vlad I., (1964), *Naturalistic and Methodological Fundamentals of Typology and Forest Site Mapping* (in Romanian), Romanian Academy Publishing House, Bucharest, Romania.

Chiriţă C.D., Păunescu C., Teaci, D., (1967), *Romania's Soils* (in Romanian), Agrosilivică Publishing House, Bucharest, Romania.

Chiriță C.D., (1972), Ecological classification of soils. The system of taxonomic units. Applications in the Romanian geographical area (in Romanian), *Yearbook of the Institute of Pedological Studies and Research of the Academy of Agricultural and Forestry Sciences (Anuarul Institutului de Studii si Cercetari Pedologice al Academiei de Stiinte Agricole Silvice,* **XXXIX**, 389-410.

Dumitru M., Manea A., Ciobanu C., Dumitru S., Vrînceanu N., Rîșnoveanu I., Calciu I., Tănase V., Preda M., (2011), *Soil Quality Monitoring in Romania*, Sitech Publishing, Craiova, Romania.

EM, (1997), Order 756 for the approval of the Regulation on the assessment of the environmental pollution, Ministry of the Environment, *Romanian Official Journal No 303* bis of November 6, 1997.

Fang A., Dong J., An Y., (2019), Distribution characteristics and pollution assessment of soil heavy metals under different land-use types in Xuzhou City, China, *Sustainability*, 1832.

Florea N., Bălăceanu V., Răuță C., Canarache A., (1987), Soil survey methodology - Part I, II, III (in Romanian), Methods Guidance Reports, National Research and Development Institute for Soil Science, Agrochemistry and Environment, Ministry of Agriculture, Bucharest, Romania.

González-Moreno A., Díaz-García C., Saez-Martinez F.J., (2016), Environmental responsibility among SMEs in the hospitality industry: Performance implications, *Environmental Engineering and Management Journal*, **15**, 1527-1532.

Haswell J., (1991), *Atomic Absorption Spectrometry; Theory, Design and Applications*, Elsevier, Amsterdam.

Huang Y., Wang L.Y., Wang W.J., Li T.Q., He Z.L., Yang X.E., (2019), Current status of agricultural soil pollution by heavy metals in China: A meta-analysis, *Science of The Total Environment*, **651**, 3034-3042.

Iagăru R., Florescu N., Iagăru P., (2016), Strategic management of sustainable development in the countryside of Sibiu depression-basic of environmental protection, *Environmental Engineering and Management Journal*, **15**, 1337-1347.

Iancu T., Brad I., Adamov T., Stanciu S., Pîrvulescu L., Popescu G., (2017), Characterization of rural tourism activity in the mountain area, *Agricultural Management/Scientific Papers, Series I*, **19**, 145-148.

Ibănescu B.C., Stoleriu O., Munteanu A., Iațu C., (2018), The impact of tourism on sustainable development of rural areas: evidence from Romania, *Sustainability*, **10**, 3529.

Lăcătușu R., Lăcătușu R.A., (2008), Vegetable and fruits quality within heavy metals polluted areas in Romania, *Carpathian Journal of Earth and Environmental Sciences*, **3**, 115-129.

Liu H., LI B., Ren T., (2015), Soil profile characteristics of high-productivity alluvial cambisols in the North China Plain, *Journal of Integrative Agriculture*, **14**, 765-773.

Merlescu E., Teșu C., (1982), *Romania's Soils*, Institute of Agronomy Ion Ionescu from Brad Publishing, Iași.

Mihalache M., (2006), *Pedology: Genesis, Properties and Taxonomy of Soils*, Ceres Publishing, Bucharest, Romania.

Mihalache M., Ilie L. Madjar R., (2014), Translocation of heavy metals from sewage sludge amended soil to plant, *Revue Roumaine De Chimie*, **59**, 81-89.

Murgoci M.G., (1911), Natural soil zones in Romania, *Yearbook of the Geological Institute of Romania,* **4**, 1-21.

Murgoci G.M., (1924), *Soil Mapping in Romania* (in Romanian), Cartea Românească Publishing House, Bucharest, Romania.

Păunescu C., (1975), *Forest Soils* (in Romanian), Romanian Academy Publishing House, Bucharest, Romania.

Petrescu D.C., Petrescu-Mag R.M., Burny P., (2017), Resilience to environmental pressure through quality food demand: meat consumption in Romania, *Environmental Engineering and Management Journal*, **16**, 2391-2400.

Pierre W.H., Scarseth, G.D., (1931), Determination of the percentage base saturation soils and its value in different soils and definite pH values, *Soil Science*, **31**, 99-114.

Popescu C., Grecu F., (2011), *Pedology: Practical Works*, Universitaria Publishing, Craiova, Romania.

Prundeanu I.M., Buzgar N., (2011), The distribution of heavy metals and as in soils of the Fălticeni municipality and its surroundings, *Carpathian Journal of Earth and Environmental Sciences*, **6**, 51-64.

Răuță C., Lăcătușu R., Cârstea S., (1995), *Heavy Metal Pollution in Romania*, In: *Heavy Metals: Problems and Solutions*, Salomons W., Forstner U., Mader P. (Eds.), Springer, Berlin, 359-372.

Stanila A.L., (2019), Research on the Presence of Phaeozems in the Suceava Plateau, *Chemistry Magazine*, **70**, 909-914.

Stătescu F., Zaucă C.D., Pavel V.P., (2013), Soil structure and water-stable aggregates, *Environmental Engineering and Management Journal*, **12**, 741-746.

Sáez-Martínez F.J., Avellaneda-Rivera L., González-Moreno Á., (2016), Open and green innovation in the hospitality industry, *Environmental Engineering and Management Journal*, **15**, 1481-1487.

Sescu A.M., Favier L., Ciobanu G., Cîmpeanu S.M., Teodorescu R.I., Harja M., (2018), Studies regarding photocatalytic degradation of two different organic compounds, Scientific Papers. Series E, *Land Reclamation, Earth Observation and Surveying, Environmental Engineering*, **7**, 74-77.

Șorop G., Vasile D., (1990), *Pedology*, University of Craiova Publishing, 78-91.

Tchounwou P.B., Yedjou C.G., Patlolla A.K., Sutton, D.J., (2012), *Heavy Metal Toxicity and the Environment*, In: *Molecular, Clinical and Environmental Toxicology*, Luch, A. (Ed.), Vol. 3, Springer Basel, Basel, 133–164.

Yadav C.I., Devi L.N., Vipin K.V., Li J., Zhang G., (2019), Spatial distribution, source analysis, and health risk assessment of heavy metals contamination in house dust and surface soil from four major cities of Nepal, *Chemosphere*, **218**, 1100-1113.