SOIL SURVEY AND CLASSIFICATION IN A COMPLEX TERRITORIAL SYSTEM: RAVENNA (ITALY)

RELEVE PEDOLOGIQUE ET CLASSIFICATION DES SOLS DANS UN SYSTEME TERRITORIAL COMPLEXE: RAVENNE (ITALIE)

RILEVAMENTO PEDOLOGICO E CLASSIFICAZIONE DEI SUOLI IN UN SISTEMA TERRITORIALE COMPLESSO: RAVENNA (ITALIA).

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Abstract

In the context of the PRIN 2007-2009 project, *"Geochemical evaluation of agro-environmental quality in a complex territorial system: the case of Ravenna"*, thirteen pedological profiles (nine in a coastal pinewood, two in farmland and two in urban park) were established. The profiles were described, sampled and analyzed so as to obtain an overview of the pedological complexity of the studied areas.
Inside the pinewood, the soils were greatly influenced by their topographic location and the vicinity of the superficial aquifer. The deeper layers were Typic Ustipsamments, the more superficial ones Typic Psammaquents and the intermediate ones Aquic Ustipsamments. The two farmland soils were Udifluventic Haplustepts, with slight differences due to the origin of the soil and its use. In the park, both soils were also Udifluventic Haplustepts with a human interfecence evidenced by the abundance of brick fragments in the profiles.
Keyword: *soils classification; soil chemistry; pedological profiles; Ravenna pinewood.*

Résumé

Dans le cadre du projet PRIN 2007-2009 "Bilan géochimique pour l'évaluation de la qualité agro-environnementale dans un système territorial complexe: le cas de Ravenne" treize profils ont été caractérisés d'un point de vue pédologique: neuf d'entre eux se trouvent dans une pinède littorale, deux autres dans une entreprise agricole et les deux derniers dans un parc citadin. Les profils ont été décrits, échantillonnés et analysés dans le but de déterminer un premier cadre cognitif de la complexité pédologique des zones étudiées. Dans la pinède, les sols sont fortement influencés par la position topographique et par la proximité de l'aquifère superficiel. Les *Typic Psammaquents* correspondent aux profondeurs basses de la

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couche, les *Typic Ustipsamments* aux profondeurs supérieures et les *Aquic Ustipsamments* à la position intermédiaire. Les deux sols du domaine agricole font partie des *Udifluventic Haplustepts* avec de légères distinctions déterminées par un usage différent du sol et les origines des dépôts. Dans le parc citadin, les deux sols font partie eux aussi des *Udifluventic Haplustepts* mais, dans ce cas, l'interférence anthropique suggérée par l'abondance de fragments de briques sablées trouvés dans les profils est évidente.
Mots-clés : *relevé pédologique ; classification du sol ; analyses physiques ; analyses chimiques, Pinède de Ravenne.*

Riassunto

Nell'ambito del progetto PRIN 2007-2009 "*Bilancio geochimico per la valutazione della qualità agro-ambientale in un sistema territoriale complesso: il caso di Ravenna*", sono stati caratterizzati da un punto di vista pedologico tredici profili: nove all'interno di una pineta litoranea, due all'interno di un'azienda agricola e due all'interno di un parco cittadino. I profili sono stati descritti, campionati ed analizzati al fine di generare un primo quadro conoscitivo della complessità pedologica delle aree di studio.
All'interno della pineta i suoli risentono in maniera marcata della posizione topografica e della vicinanza all'acquifero superficiale. A profondità di falda elevate corrispondono dei Typic Ustipsamments, a profondità limitata dei Typic Psammaquents ed in posizione intermedia degli Aquic Ustipsamments.
I due suoli dell'azienda agraria rientrano negli Udifluventic Haplustepts con leggere distinzioni determinate da diverso uso del suolo ed origine deposizionale.
Nel parco cittadino i due suoli rientrano anch'essi negli Udifluventic Haplustepts ma in questo caso è evidente l'interferenza antropica suggerita dall'abbondanza di frammenti di laterizio rinvenuti nei profili.
Keyword: : rilievo podologico; *classificazione dei suoli; analisi fisico-chimiche; Pineta di Ravenna*

Introduction

The concepts of pedologic research and soil classification shall be correlated with paradigms depending on the soil quality. The knowledge of pedogenetic processes, the speed they occur at shall be monitored and studied in order to link a specific soil evolution with the concept of quality so as to choose indicators appropriate to soil pedon (MacEvan, 1997). Pedologic surveys are required in the case of studies dealing with soil utilization or environmental researches such as the one on soil sustainability for farming activities. The precision of data involving pedologic surveys is extremely important to take decisions as to the different research aspects (Webster and Oliver, 1990; Domburg *et al*., 1994).
The concentration of trace elements in soils depends mainly on the type of bedrock and on pedogenetic processes developed on it. The influence of the lithological factor tends to decrease with soil development. The most important pedogenesis

aspects, linked with the destination of the potentially toxic elements (PTE) deal with chemical alteration processes of the bedrock and the eventual PTE release, and with the translocation and accumulation processes with iron oxides, clay and organic matter, controlled by several pedogenetic processes (Alloway, 1995).

This work is aimed at characterizing and classifying soils belonging to three territorial situations of the Municipality of Ravenna, having different anthropic pressures, thus becoming preliminary and basic elements for additional surveys on the possible effects of potentially toxic elements. As a matter of fact sites taken into account have been the San Vitale Pinewood, a Site of Community Importance (SCI) concerned by subsidence and aquifer salinization phenomena, bordering to the South the petrochemical industrial pole connected with the activities of the harbour of Ravenna. The urban park inside the town, which is subjected to depositions due to vehicles traffic and the "Luigi Perdisa" extra-urban farm that accounts for the agricultural heart of Ravenna.

Materials and methods

Localization of the area examined. This study has taken into account the observation and monitoring a) of the San Vitale Pinewood soils, along two transects to the North and to the South of the area involved, traced out from West to East; b) of the soils belonging to the Luigi Perdisa farm, by opening a profile in an orchard and one in an arable cultivation; c) of the soils of Ravenna public park in which two profiles have been opened, depending on the distance to the main road (Fig. 1).

Phytoclimatic features. The warm Mediterranean climate of the area is the typical climate of mild coastal environments, with about 600 mm of rainfall spread over the spring-autumn period and annual mean temperatures of about 13 °C.

The San Vitale Pinewood is a protected area of about 1222 ha of surface within the "Parco del Delta del Po" (Park of the Po Delta) and represents a remnant of pinewoods where man has settled, on beach-ridge sands that deposited after the XII century. The Pinewood develops on a substrate made up of sand deposits (www.regione.emilia_romagna.it) stemming from sediments contributions of an old branch of the Po Delta (Veggiani, 1974; Bondesan *et al.*, 1995). The dune-interdune system, which formed in 500 to 1000 years, has an almost parallel trend to the coastline. The vegetable component derives from the association of dry and wet environments where ashes (*Fraxinus ornus* and *F. oxycarpa*) and white poplars (*Populus alba*) alternate with umbrella pines (*Pinus pinea*), maritime pines (*Pinus Pinaster*) and oaks (*Quercus robur*), and the brushwood is rich in common hawthorn (*Crataegus monogyna*), ivy (*Hedera helix*) and dog rose (*Rosa canina L.*) (Piccoli *et al.*, 1991).

The area, boasting a remarkable environmental consideration, is subject to subsidence (Teatini *et al.*, 2005) and aquifer salinization phenomena (Aquater, 1988; Ugolini, 1997; Giambastiani *et al.*, 2007; Antonellini *et al.*, 2008), owing to

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the closeness to the sea and to a lowlands system (Piallassa Baiona) connected to it, which contributes to the saltwater intrusion, thus provoking the aquifer salinization. To the detriment of its intrinsic natural features, the San Vitale Pinewood is located within a strongly anthropized context, subject to different pressures such as the contiguousness with an extended industrial area (the Ravenna petrochemical pole) and with a traffic-congested thoroughfare, the SS 309 Romea; hence the possibility of dry and wet deposition phenomena of organic and/or inorganic compounds that might get in and accumulate in the environmental system.

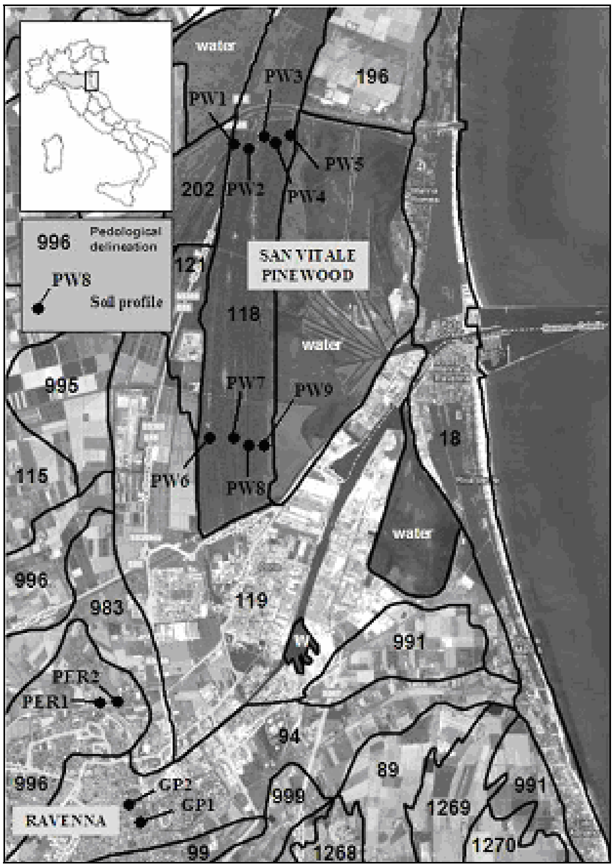

Figure 1

Localization of examined soil profiles on the Emilia-Romagna region soil map (modified from http://gias.regione.emilia-romagna.it/suoli.asp).

Profile	WGS84-UTM33	
	E (m)	E (m)
PW1	279845	4934006
PW2	280023	4933960
PW3	280408	4933986
PW4	280655	4933957
PW5	280819	4933724
PW6	279119	4928551
PW7	279731	4928557
PW8	280209	4928509
PW9	280253	4928520
GP1	277768	4921580
GP2	277702	4921749
PER1	276899	4923884
PER2	277105	4923765

Pedologic delineations. From the pedologic point of view, the San Vitale Pinewood falls within delineation 118, which comprises the soil complex CER3/SAV1/PIR1 (www.regione.emilia-romagna.it). It is characterized by sandy and calcareous soils formed on consolidated beach-ridge deposits. The mostly widespread soils are represented by Ustipsamments (SSS, 2006) turning to Psammaquents in interdune lowlands.

The Luigi Perdisa farm, covering an overall surface of 13.9 ha, is located in the Northern outskirts the town of Ravenna and can be considered as representative of the agricultural scene of Ravenna surroundings. It stands in an alluvial plain characterized by the presence of canal, levee and river course as well as floodable plain sediments deposition (RER, 2009). As far as the farm is concerned, cultivation regulations provide for planting vineyards, pear orchards and apple orchards, and for a portion dedicated to extensive crops mainly made up of maize and wheat in an annual succession.
The public park, covering a surface of about 3.7 ha, is located within the historical centre of Ravenna, not far from the railway network and from roads with an intensive vehicles circulation.
It stands in an alluvial plain characterized by the presence of canal, levee and river course sediments deposition (www.regione.emilia_romagna.it). Its realization dates back to ancient times and at present the arboreal vegetation that can be found in is mainly made up holm oaks (*Quercus Ilex*). Both delineation, 996 which includes the "Perdisa" farm, and delineation 94, which includes Ravenna public park, are represented by soils belonging to the Haplustepts great group (SSS, 2006).

The pedologic survey. The pedologic survey has entailed the opening and observation of soils profiles within the three environmental contexts. In the pinewood nine pedologic profiles have been described and sampled; they were distributed along two transects, with West to East course, positioned in a Northern area (PW1-PW5) and in a Southern area (PW6-PW9), the latter being close to the town industrial pole.
According to knowledges acquired in previous studies (Zannoni, 2008; Buscaroli and Zannoni, 2009) said sampling strategy has made it possible to intercept the different microtopographical situations and the relevant soils associated to them.
According to the descriptive parameters indicated by Richardson *et al.* (2001), sites PW1, PW3, PW5, PW7 and PW9 have been detected in low-lying interdune areas, at a level more or less equal to the sea level. Profiles PW2, PW6 and PW8 are located next to dune tops while profile PW4 can be found at the bottom of a dune alignment, in a connection position with a wide depression.
Two profiles (PER1 and PER2) have been opened in the farm by means of a mechanical excavator; the first is in an allotment of arable soil and the second inside an apple orchard. Two profiles (GP1 and GP2) have been observed in the public park; the first where the arboreal vegetation is very scattered, near the road axis and the second in a much more internal position near a holm-oaks area. Table 1 shows the morphological descriptions of the 13 profiles observed according to what proposed by Schoeneberger *et al.* (2002).
The samples of soil taken from the different horizons have been air dried, hand-ground and dry-sieved with a 2 mm mesh sieve.

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Table 1 - *Main descriptive elements of investigated soil profiles. Codes according to Schoeneberger et al. (2002).*

Profile	Horizons	Depth (cm)	Color Munsell Dry	Color Munsell Moist	Structure (a)	Texture (b)	Roots (c)	Rock (d)	Boundary e)
PW1	Oi	5 - 0							CW
	A1	0 - 5	2,5Y 3/2	2,5Y 3/1	gr f1	s	2f	0%	CW
	A2	5 – 20	2,5Y 5/2	2,5Y 3/2	sg	s	1f1m	0%	AS
	Cg1	20 – 80	2,5Y 7/1	2,5Y 5/1	sg	s	1m	0%	CW
	Cg2	80 - 100	2,5Y 6/1	GLEY1 5/1	sg	s	0	0%	U
PW2	Oi	4 - 2							AW
	Oe	2 - 0							AW
	A1	0 – 4	2,5Y 4/2	2,5Y 3/2	sg	s	2f	0%	AW
	AC	4– 17/23	2,5Y 5/6	2,5Y 5/4	sg	s	2f2m	0%	CS
	C	17/23 – 70+	2,5Y 6/3	2,5Y 5/3	sg	s	1f2m	0%	U
PW3	Oi	3 - 0							AW
	A1	0 – 5	2,5Y 3/2	2,5Y 2,5/1	gr f1	s	2f	1%fSFB	CS
	A2	5 – 10	2,5Y 4/1	2,5Y 3/1	gr f1	s	1f1m	1%fSFB	CW
	ACg	10 – 35	2,5Y 4/1	2,5Y 3/1	sg	s	1m	1%fSFB	AW
	Cg1	35 – 45	2,5Y 6/1	GLEY1 5/1	sg	s	1f	0%	CW
	Cg2	45 - 100+	2,5Y 6/1	GLEY1 6/1	sg	s	0	0%	U
PW4	Oi	1 - 0							AW
	A1	0 - 5	2,5Y 4/2	2,5Y 3/2	gr f1	s	2f2vf	0%	CS
	A2	5 - 20	2,5Y 6/3	2,5Y 4/2	sg	s	2m2co	0%	CW
	AC	20 - 60	2,5Y 5/4	2,5Y 5/2	sg	s	1m1co	0%	CS
	C1	60 – 80	2,5Y 7/2	2,5Y 7/1	sg	s	1m	0%	GS
	C2	80 – 100+	2,5Y 6/2	2,5Y 6/1	sg	s	1m	0%	U
PW5	Oi	2 – 1							AW
	Oe	1 - 0							AW
	A1	0 – 5	2,5Y 4/4	2,5Y 4/2	gr f1	s	3f1m	1%fSFB	AS
	A2	5 – 15	2,5Y 5/2	2,5Y 4/2	sg	s	2f1m	1%fSFB	AS
	Cg1	15 - 30	2,5Y 7/2	2,5Y 6/2	sg	s	1f	0%	CW
	Cg2	30 - 70+	2,5Y 7/1	2,5Y 6/1	sg	s	1f	0%	U
PW6	Oi	2 - 0							AW
	A1	0 – 3/4	2,5Y 3/2	2,5Y 3/2	gr f1	s	2f2vf	0%	CW
	A2	3/4 – 20	2,5Y 5/3	2,5Y 4/2	sg	s	2f2m	0%	CW
	C	20 – 80	2,5Y 6/2	2,5Y 5/3	sg	s	1f1co	0%	GS
	Cg	80 - 100	2,5Y 7/2	2,5Y 6/2	sg	s	1m	0%	U
PW7	Oi	3 - 1							AW
	Oa	1 - 0							AW
	A1	0 - 5	2,5Y 3/1	2,5Y 2,5/1	gr f1	s	2f2vf	0%	CS
	A2	5 – 13	2,5Y 4/3	2,5Y 4/3	gr f1	s	2f	0%	AS
	Cg1	13 – 50	2,5Y 7/1	2,5Y 5/2	sg	s	1vf1m	0%	CW
	Cg2	50 – 80	2,5Y 6/2	2,5Y 6/1	sg	s	1vf	0%	GW
	Cg3	80 – 100+	2,5Y 6/4	GLEY1 6/1	sg	s	0	0%	U
PW8	Oi	5 - 2							AW
	Oa	2 - 0							AW
	A1	0 – 5	2,5Y 4/3	2,5Y 4/2	gr f1	s	2f2vf	0%	CW
	A2	5 – 20	2,5Y 5/4	2,5Y 4/4	sg	s	2m2co	0%	CW
	C1	20 - 80	2,5Y 6/3	2,5Y 5/3	sg	s	1co1vc	0%	CW
	C2	80 - 100+	2,5Y 6/4	2,5Y 5/4	sg	s	1m	0%	U
PW9	Oi	3 – 1							AS
	Oa	1 - 0							AW
	A1	0 – 5	2,5Y 3/2	2,5Y 2,5/1	gr f1	ls	3f3vf	1%fSFB	CS
	A2	5 – 10	2,5Y 5/2	2,5Y 4/1	sg	ls	2vf	1%fSFB	AS
	Cg1	10 – 30	2,5Y 6/4	2,5Y 5/3	sg	ls	1vf	1%fSFB	CW
	Cg2	30 – 80	2,5Y 6/3	2,5Y 5/1	sg	ls	1vf	0%	GW
	Cg3	80 - 100+	2,5Y 5/3	GLEY1 6/1	sg	ls	0	0%	U

Table 1 - (follows)

Pro ile	Hori zons	Depth (cm)	oolor Munsell Dry	Moist	Stru- cture (a)	Tex- ture (b)	Roots (c)	Rock (d)	Boundary (e)
GP1	Oi	0,5 - 0							AW
	Au1	0 - 3	2,5Y 5/2	2,5Y 4/2	sbk f2	l	2f2vf	1%fA	CW
	Au2	3 – 7	2,5Y 5/2	2,5Y 4/3	sbk f2	sil	1f1m	1%fA	CW
	Au3	7 – 25	2,5Y 5/2	2,5Y 4/3	abk m3	sil	1vf1co	3%mA	CS
	Bwu	25 – 57	2,5Y 7/2	2,5Y 5/4	abk co3	sic	1co	5%mA	CS
	BCu	57 – 80	2,5Y 7/2	2,5Y 6/3	abk co3	sic	0	3%mA	CS
	C	80 – 100+	2,5Y 6/3	2,5Y 5/4	abk co3	sic	0	0%	U
GP2	Oi	0,5 - 0							CW
	Au1	0 – 5	2,5Y 5/2	2,5Y 4/2	sbk f2	sl	2f2vf	5%mA	AW
	Au2	5 – 30	2,5Y 6/4	2,5Y 5/4	sbk m3	cl	1f1m1c	3%mA	CS
	BWu	30 - 50	2,5Y 7/4	2,5Y 6/4	abk co3	sicl	1m	5%mA	CS
	BCu	50 - 65+	2,5Y 6/4	2,5Y 5/4	abk co3	l	0	7%mA	U
PER1	Ap	0 – 40	2,5Y 6/3	2,5Y 4/3	sbk m2	sil	2vf1m	1%fA	CW
	Bw1	40 – 65	2,5Y 7/3	2,5Y 5/2	sbk m2	sil	1vf1f	1%fSF B	GW
	2Bw 2	65 – 81	2,5Y 7/3	2,5Y 5/3	sbk m2	sicl	1vf1f	5%fSF B	AW
	3Cg1	81 – 110	2,5Y 5/4	2,5Y 5/3	sg	sl	1vf1f	0%	CS
	3Cg2	110 –140	2,5Y 5/4	2,5Y 5/3	sbk f1	sl	0	0%	CW
	4Cg3	140 - 200+	2,5Y 7/2	2,5Y 6/2	sbk m2	sic	0	0%	U
PER2	Oe	3 – 0							AW
	Ap1	0 – 28	2,5Y 6/3	2,5Y 4/3	abk m2	sicl	2vf1m	1%fA	CS
	Ap2	28 – 53	2,5Y 6/4	2,5Y 4/3	sbk m2	sicl	2vf1m	1%fA	CS
	Bw1	53 – 83	2,5Y 4/3	2,5Y 5/3	sbk co2	sil	1f1co	0%	CS
	2Bw 2	83 – 130	2,5Y 7/3	2,5Y 5/3	sbk co2	sicl	1f1vf	1%fSF B	GS
	3Cg1	130 – 153	2,5Y 7/3	2,5Y 5/3	sbk m1	sil	1f	0%	CS
	3Cg2	153 – 194	2,5Y 7/3	2,5Y 5/4	sbk m1	sil	1vf	0%	CS
	3Cg3	194 – 210+	2,5Y 6/4	2,5Y 5/2	sbk m1	sil	0	0%	U

(a)**Structure** 1 = weak, 2 = moderate, 3 = strong, gr = granular, abk = angular blocky, sbk = subangular blocky, sg = single grain, f = fine, m = medium, co = coarse.
(b)**Texture** (field estimation) s = sand, ls = loamy sand, l = loam, sil = silt loam, sic = silty clay, sl = sandy loam, cl =clay loam, sicl = silty clay loam.
(c)**Roots** 0 = absent, 1 = few, 2 = common, 3 = many, vf = very fine, f = fine, m = medium, co = coarse, vc = very coarse.
(d)**Rock fragments** % vol, f = fine, m = medium, co = coarse, SFB = shell fragments, A = artefacts.
(e)**Boundary** A = abrupt, C = clear, G = gradual, S = smooth, W = wavy, U = unknown.

The fraction having a diameter below 2 mm has been submitted to pH, total $CaCO_3$, electrical conductivity (EC), total organic carbon (TOC) and total nitrogen content (Tot. N) analytical determinations, carried out according to what provided for by the Official Methods for soil chemical analysis (MiPAF, 2000). The data obtained from analytical determinations are reported in table 2.

Results and discussion

Soils morphological features. Soils of the San Vitale Pinewood highlight a typical A/C sequence. The organic-mineral horizons (A1 and A2), about 20 cm thick, usually have a darker colour, between 2,5Y3/1 and 2,5Y5/4 (dry colour).

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Table 2 - *Chemical properties of investigated soil profiles.*

Profile	Horizons	Depth (cm)	pH	EC (1:2,5) dS m^{-1}	Tot. $CaCO_3$ g Kg^{-1}	TOC g Kg^{-1}	Tot. N g Kg^{-1}	C/N
	A1	0 - 5	7,1	1,95	26	71,2	5,5	13
PW1	A2	5 – 20	7,6	0,71	13	36,6	2,4	16
	Cg1	20 – 80	8,3	0,17	85	1,3	0,7	2
	Cg2	80 – 100+	8,2	0,15	60	1,8	0,1	34
	A1	0 – 4	6,4	0,24	7	52,3	3,0	17
PW2	AC	4– 17/23	8,0	0,12	20	5,0	1,7	3
	C	17/23 – 70+	8,5	0,10	56	0,8	1,0	1
	A1	0 – 5	7,3	5,47	9	76,7	5,7	14
	A2	5 – 10	6,8	5,18	9	51,7	3,7	14
PW3	ACg	10 – 35	7,0	5,14	7	28,9	2,3	13
	Cg1	35 – 45	8,0	2,29	87	4,0	0,3	14
	Cg2	80 –100+	8,2	2,64	89	1,9	0,2	8
	A1	0-5	7,4	0,22	20	31,9	3,0	11
	A2	5-20	7,8	0,13	18	16,9	1,2	14
PW4	AC	20-60	7,9	0,10	25	11,0	1,0	11
	C1	60-80	8,1	0,21	61	1,3	0,2	6
	C2	80-100+	8,3	0,36	82	/	0,2	/
	A1	0 – 5	8,3	1,46	18	34,0	2,4	14
PW5	A2	5– 15	8,6	1,86	25	10,8	1,0	11
	Cg1	15-30	9,1	0,94	96	0,7	0,2	3
	Cg2	30-70+	8,7	1,61	114	2,9	0,0	96
	A1	0 – 3/4	7,4	0,58	11	100,8	6,1	17
PW6	A2	3/4 – 20	7,6	0,23	13	28,1	2,1	13
	C	20 – 80	8,1	0,09	31	6,0	0,3	18
	Cg	80-100+	8,4	0,08	51	1,5	0,1	16
	A1	0 - 5	7,4	4,25	11	118,1	7,6	16
	A2	5 – 13	8,1	4,02	36	25,9	2,2	12
PW7	Cg1	13 – 50	8,6	1,46	116	4,3	0,7	6
	Cg2	50 – 80	8,5	1,24	118	6,3	0,2	42
	Cg3	80 – 100+	8,5	1,05	118	2,1	0,2	14
	A1	0 – 5	5,8	0,44	0	139,8	6,9	20
	A2	5– 20	7,2	0,28	18	46,5	3,0	16
PW8	C1	20-80	8,4	0,18	123	4,2	0,2	24
	C2	80-100+	8,5	0,31	123	7,0	0,2	30
	A1	0 – 5	8,1	3,01	11	49,3	4,1	12
	A2	5 – 10	8,5	3,00	24	21,4	2,1	10
PW9	Cg1	10 – 30	8,7	2,28	103	3,9	0,5	8
	Cg2	30 –80	8,5	3,57	147	2,1	0,3	8
	Cg3	80-100+	8,6	3,56	130	2,0	0,2	9
	Au1	0 - 3	7,7	0,60	141	73,1	7,1	10
	Au2	3 – 7	7,9	0,49	168	42,9	4,4	10
	Au3	7 – 25	8,0	0,33	179	31,8	3,2	10
GP1	Bwu	25 – 57	8,5	0,17	232	5,8	0,8	7
	BCu	57 – 80	8,6	0,19	221	2,9	0,8	4
	C	80 – 100+	8,6	0,24	201	0,0	3,2	0
	Au1	0 – 5	7,8	0,15	176	33,9	1,0	34
	Au2	5 – 30	8,1	0,13	226	6,8	0,8	9
GP2	Bwu	30 - 50	8,4	0,15	234	6.1	0,8	0
	BCu	50 - 65+	8,4	0,13	237	3,5	1,3	3
	Ap	0 – 40	7,9	0,19	203	12,4	1,3	10
	Bw1	40 – 65	8,3	0,15	208	8,2	1,0	8
	2Bw2	65 – 81	8,2	0,22	234	6,4	0,9	7
PER1	3Cg1	81 – 110	8,3	0,21	219	3,2	0,3	10
	3Cg2	110 –140	8,3	0,28	214	3,1	0,4	9
	4Cg3	140-200+	8,6	0,40	250	8,5	0,7	13
	Ap1	0 – 28	8,5	0,17	203	11,3	1,3	9
	Ap2	28 – 53	8,5	0,17	204	9,5	1,1	8
	Bw1	53 – 83	8,8	0,20	237	5,9	0,7	9
PER2	2Bw2	83 – 130	9,0	0,48	234	5,6	0,6	10
	3Cg1	130 – 153	9,1	0,37	228	3,9	0,4	10
	3Cg2	153 – 194	8,7	0,31	241	3,7	0,3	12
	3Cg3	194 – 210+	8,8	0,33	221	2,5	0,4	6

C horizons that make up the parent material are characterized by lighter colours, between 2,5Y6/3 and 2,5Y7/2 (dry colour).

Most of the radical apparatus, usually fine and very fine, are located in the epipedon, which are characterised by a fine granular structure that shows an extremely weak aggregation degree. The parent material has fewer roots, generally having a medium or sometimes coarse size, destined to the physical anchorage of plant species present. The trend often turns out to be subhorizontal, mainly as to horizons subject to periodical water saturation, highlighted by the presence of mottles (g).

The texture, assessed in quick way through the sample manipulation, proves to be always sandy, except for the PW9 profile, where it is sandy-loam. The rock fragments are usually absent, except for the presence of scattered fragments of shells, and the distinctness class of the boundaries between the horizons are either abrupt or clear, having a wavy or smooth topography.

The soils of the "Perdisa" farm are very deep, with a sequence of A/B/C horizons. The colour shows quite a moderate variability range (2,5Y7/3 – 2,5Y4/3, dry colour) but with poorly linear trends. This aspect, together with the different texture and structure features that can be observed in both profiles, is referable to transport and deposition of sediments, that occurred in these environments. The texture of surface horizons is silt loam (PER1) and silty clay loam (PER2), while in depth it becomes sandy loam and silty clay as to PER1, and silt loam as to PER2. The surface structure, usually sub-angular blocky of moderate degree at surface, becomes loose (PER1) or weak (PER2) at depth. The biological activity, expressed through the presence of radical apparatus, is generally present up to a depth of about 100 cm while, as far as the PER2 profile observed inside the orchard is concerned, it reaches higher depths.

The two profiles observed in the public park of Ravenna show a sequence of A/B/C horizons. The colours of said horizons are between 2,5Y5/2 and 2,5Y7/4 (dry colour); and similarly to what observed for the farm soils, they have irregular textures and structures due to the stratigraphy of river course sediments. However, the remarkable presence of brick fragments along the profiles (u) shall be highlighted, as an evidence of rearrangements and disturbance actions carried out by man during the centuries.

Soils chemical-physical features. As far as total organic carbon (TOC) is concerned, the soils of the San Vitale Pinewood are characterized by significant rates in the A1 epipedon (139 to 31 g of $Corg \cdot kg^{-1}$), but show a sudden decrease already in A2 horizon, below 5 cm of depth, with rates between 51 and 5 $g \cdot kg^{-1}$ (Vittori Antisari et al., 2008).

A similar situation occurs in the profiles of the public park while, as far as the farm is concerned, the values are remarkably lower and typical of tilled and cultivated soils.

Similarly to what observed for TOC, also the total nitrogen content (Tot. N) of surface horizons turned out to be elevated at surface, in the pinewood soils and in the

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public park GP1 profile, and rapidly decreased next to C horizons. In the Perdisa farm, values are remarkably lower, probably in connection with removals determined by crops typologies and by the homogenization of surface horizons, determined by periodical tillage activities.

The pinewood soils are usually poorly or weakly calcareous at surface and became moderately or very calcareous in subsurface horizons. Said trend reveals a remarkable surface decarbonation, favoured by the coarse texture and by the consequent high permeability of these soils. The decarbonation process is also indicated by the pH trend, which is basically neutral or subacid at surface and turns into subalkaline or moderately alkaline at depth.

The soils of both the public park and the farm appear very calcareous from the surface and become strongly calcareous at depth. Therefore in these soils the decarbonation process seems to be not so evident as against surface horizons, both due to the reduced permeability (finer textures) and to the rearrangement operated by man. Moreover the values of $CaCO_3$ show a discontinuous trend in relation to depth, which is suggestive of subsequent sediments contributions, unlike what observed in almost all the pinewood soils. As a direct consequence of the elevated rates in $CaCO_3$, the pH value of public park or farm soils prove to be weakly to strongly alkaline, with trends generally decreasing with depth, except for profile PER2 that shows non-linear trends.

As to soils electrical conductivity (EC), table 2 shows that no salinization problems arise either in the public park soils or in the farm ones. However things are different inside the pinewood where a more articulated situation can be observed.

Some soils have a widespread salinity all along the profile (PW3, PW5, PW7 and PW9); others only at surface (PW1), and some others absence of salinity (PW2, PW4, PW6 and PWN8).

The electrical conductivity recorded in soils results to be, in said litoraneous environments, strongly related with the one of groundwater. Studies recently carried out in the same area (Zannoni, 2008; Buscaroli and Zannoni, 2009) clearly indicate how, in soils belonging to more elevated areas from a topographical point of view (PW2, PW4, PW6 and PW8), the stratum is located at such a depth as to determine any possible consequence on deep horizons only (beyond 1 m of depth) while not affecting the surface.

In inter-dune depressions, where the water table is at lower depths, it can significantly affect the soils characteristics. In particular, when the water table is strongly characterized by salinity as in the case of profiles PW2, PW4, PW6 and PW8, the EC of the whole profiles turns out to be elevated. Moreover, during the summer period, to coincide with strong surface evapotranspiration phenomena, a large increase in surface horizons EC has been observed, mainly due to saline accumulations, which can be observed also in investigated profiles.

Soils classification. Data gathered have made it possible to locate soils from a taxonomical point of view, according to what provided for in the *Keys to soil taxonomy*, 10th edition (SSS, 2006), up to the family hierarchical level (table 3).

The soils of the San Vitale Pinewood fall into the Psamments suborder. Studies carried out in the same area (Zannoni, 2008; Buscaroli and Zannoni, 2009) have highlighted how, under conditions similar to those of profiles PW3, PW7 and PW9, values of Sodium Adsorption Ratio (SAR) and of Exchangeable Sodium Percentage (ESP) observed are such so as to make soils fall within the Sodic subgroup (SSS, 2006).
Besides a strict taxonomic arrangement, the presence of soluble bases and even more their mutual relation (SAR) can substantially affect the flora development.
With this respect, some authors (Álvarez-Rogel *et al*., 1997, 2007; Alaoui-Sossè *et al.*, 1998) stress how, within environmental contexts similar to those under study, the variations in soils salinity are among the main variables in the diffusion of plant species. Other authors (Gerdol *et al.*, 1985; Piccoli *et al.*, 1991; Blaylock, 1994; Reinman and Breckle, 1995; Álvarez-Rogel *et al*., 2001) associate the presence of plant species to the relation of some ionic forms and to the soil S.A.R..

Profile	Soil Survey Staff, 2006
PW1	TYPIC PSAMMAQUENTS, mixed, calcareous, mesic
PW2	TYPIC USTIPSAMMENTS Mixed, calcareous, mesic
PW3	SODIC PSAMMAQUENTS Mixed, calcareous, mesic
PW4	AQUIC USTIPSAMMENTS Mixed, calcareous, mesic
PW5	TYPIC PSAMMAQUENTS Mixed, calcareous, mesic
PW6	AQUIC USTIPSAMMENTS Mixed, calcareous, mesic
PW7	SODIC PSAMMAQUENTS Mixed, calcareous, mesic
PW8	TYPIC USTIPSAMMENTS Mixed, calcareous, mesic
PW9	SODIC PSAMMAQUENTS Mixed, calcareous, mesic
GP1	UDIFLUVENTIC HAPLUSTEPTS Fine-silty, mixed, mesic
GP2	UDIFLUVENTIC HAPLUSTEPTS Coarse-loamy, mixed, mesic
PER1	UDIFLUVENTIC HAPLUSTEPTS Fine-loamy, mixed, superactive
PER2	UDIFLUVENTIC HAPLUSTEPTS Fine-silty, mixed, superactive

Table 3

Classification of soil profiles (SSS, 2006)

Conclusions

Chemical-physical pedologic surveys carried out on 13 soils profiles have made it possible to confirm the taxonomic definitions indicated in the pedologic delineations of the Emilia-Romagna region soil map (RER, 2009). The survey carried out in the San Vitale Pinewood, along two transepts located at right angles with the dune system, has highlighted such a close relation between microtopography, surface stratum depth and relevant saline concentration as to enable a taxonomic selection at subgroup level, within the Ustipsamments/Psammaquents complex (Fig. 2).
In the specific instance, profiles PW2, PW4, PW6 and PW8 located in the highest spots of the dune structure suffer either moderately (Aquic Ustipsamments, PW4 and PW6) or not at all (Typic Ustipsamments, PW2 and PW8) the presence of the water-table.

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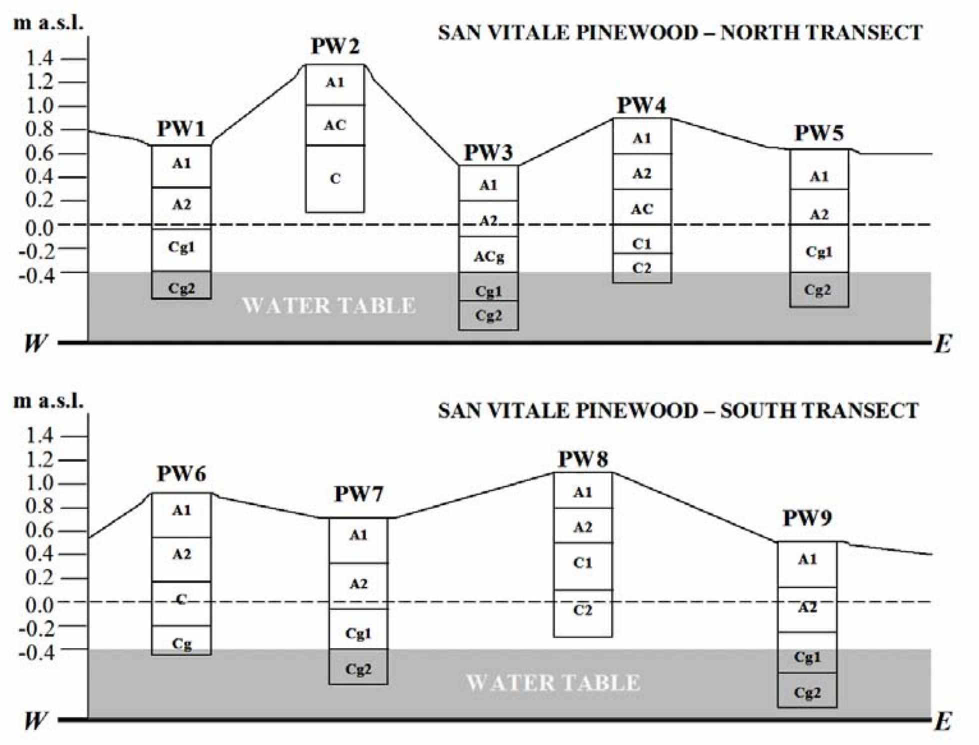
Figure 2 – *Topographical position of soil profile in regard to water-table.*



On the contrary, profiles PW1, PW3, PW5, PW7 and PW9 localized in positions that are morphologically depressed, are involved by a periodical hydric saturation (Typic Psammaquents, PW1 and PW5) that may sometimes affect the chemism, owing to the high saline concentration (Sodic Psammaquents, PW3, PW7, PW9). This last condition shall be taken into account in future analytical determination regarding cation exchange capacity (CEC) and metal extraction.

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