XVI Congresso della Società Italiana di Ecologia - Viterbo/Civitavecchia 2006
16th Meeting of the Italian Society of Ecology
Talk

Relationships between pedological matrix and soil mesofauna in the Natural Reserve of Decima-Malafede (Latium): a new approach and possible applications

Andrea Podrini,[a] Andrea Di Fabbio,[b] Carlo Jacomini,[c] Giuseppina Dowgiallo[a,*]

[a]*Dipartimento di Biologia Vegetale, Università degli Studi di Roma, Piazzale Aldo Moro 1, 00185 Roma, Italia*

[b]*Lungotevere Pietra Papa, 159, 00146 Roma, Italia*

[c]*Commissione III, Biologia del suolo, Società Italiana di Scienze del Suolo, Via Prati della Farnesina, 58, 00194 Roma, Italia*

Abstract

Although the soil ecosystem has been defined as a complex system, with several subsystems interacting and influencing reciprocally, most of the contributions available in the scientific literature do not focus on the relationships between the soil community and the soil parameters. In order to start collecting information following this research line, fundamental according to the authors for an integrated vision of the ecosystem, an experimental campaign started in three forested areas in the Natural Reserve of Decima Malafede, South of Rome. In this protected area, soil had been already characterized both with chemical-physical methods and following soil taxonomy. The three study areas have plant associations typical for Latium plain woods, very deep and well-preserved soils characterized by a very old evolutionary history, and showed a very rich and diverse biological community. To compare the results with other areas investigated in Italy, the Parisi's Soil Biological Quality Index for soil microarthropods (QBS-ar) was used, as this method does not require the taxonomic classification of soil mesofauna, although it allows to assess, on the basis of morphological adaptations to edaphic environment, the level of suffering of the environment. Methodology statements are also discussed and new applications proposed.

Keywords: Soil; Pedological analysis; Decima-Malafede; Protected Areas; Microarthropods; Biological Indicators.

1. Introduction

Among the European countries, Italy has the greatest variety of soils and a very high density of human settlements. This determines a strong pressure on the natural areas and a general concern about the strategies to develop in order to protect and preserve these areas.

Soil is the most complex environmental matrix, capable of registering within its own variables all the impacts upon the environment; therefore it represents an optimum system to evaluate environmental sustainability. Nevertheless all the processes and interrelations taking place into the soil still represent an unexplored world, particularly from an ecological standpoint.

* Corresponding author. Phone: +39-06-4991-2463; fax: +39-06-4457540; e-mail: giuseppina.dowgiallo@uniroma1.it.

During the three-year period 2003-2005 within the APAT (Italian National Agency for Environmental Protection and Technical Services) project "Natural Protected Areas and Conservation of Environmental Diversity" (APAT/ARPA/APPA) a project unity called "Soil Biomonitoring" has been carried out, which is the result of collaboration among local Environment Protection Agencies and Institutions directed towards promoting exchange of both data and methodologies.

In 2005, at the end of the project, the 3rd Commission "Soil Biology" of the Italian Soil Science Society (SISS) carried on the APAT's work in order to improve the knowledge on the soil ecosystem and also to put in touch with each other all the experts in this matter.

With the aim of relating the soil characteristics of a protected area to the biotic components and proposing an operational synthesis, which could be standardized, a preliminary soil survey has been carried out in the Natural Reserve of Decima-Malafede. This Reserve, created with the Regional Law n°29/1997, is included in the areas protected by RomaNatura (VV.AA. 2002).

In three forested sectors of the Reserve soils have been analyzed from a physical and chemical standpoint and classified (Di Fabbio 2003). Afterwards, in selected plots where soils had been better defined, investigations on soil mesofauna have been carried out; finally, for each plot a synthetic table is presented, where both soil physical-chemical parameters and biological indicators are reported.

2. Study Area

The Natural Reserve of Decima-Malafede represents a small sector of the Campagna Romana; it is located SW of Rome, just beyond the Raccordo Anulare, covering an area of 6,145 hectares.

This study has been carried out in 3 sectors of the Reserve (Figure 1): Northern ("*Sugherata di Vallerano*"), Western ("*Bosco di Catavanni*") and Southern ("*Macchia di Capocotta*"), these being the areas with the highest naturalistic value within a territory for the most part strongly disturbed by human activities.

These sectors are located on a nearly level plateau (average altitude 80-100 m a.s.l.), which has been largely covered by pyroclastic products of the Latium Volcano (Dai Pra & Arnoldus-Huyzendveld 1984) and it is dissected, from E to W, by the "*Fosso* (ditch) *di Malafede*" and its tributaries.

Figure 1. Natural Reserve of Decima Malafede – the three forested study sectors: "*Sugherata di Vallerano*" (N), "*Bosco di Catavanni*" (W), "*Macchia di Capocotta*" (S).

The system "*Fosso di Trigoria*" – "*Fosso di Malafede*" separates the two main geological formations, which outcrop in the Reserve area (Funiciello *et al*. 2001):

- on the left side the "Red Dune", also known as "Ancient Dune" or "Continental Dune" dating back to the Tyrrhenian period (Milli & Zarlenga 1991): this formation is exposed in the Catavanni and Capocotta areas;
- on the right side the volcanic products included in the "Pyroclastic scoriaceous-cineritic unit": "*Pozzolane rosse*", "*Conglomerato giallo*", "*Pozzolane nere*" belonging to the 2nd and 3rd pyroclastic flow of the Tuscolano-Artemisio phase (Middle Pleistocene). These deposits mostly cover the Vallerano area.

From a bioclimatic standpoint, Catavanni and Capocotta are included in the Mediterranean region, phytoclimatic unit 13, whereas Vallerano belongs to the Transitional Mediterranean region, phytoclimatic

unit 9 (Blasi 1994). For these two units, the meteorological stations of Pratica di Mare (32 m a.s.l., airport) and Ciampino (137 m a.s.l., airport) supplied temperature and precipitation data over a 30 years period (1955-85). The climate of the Reserve area is characterized by a period of summer drought of 3 months (Ciampino) or 4 months (Pratica di Mare) as shown by the ombrothermic diagrams (Figure 2).

From a pedoclimatic point of view, the soil temperature regime estimated with U.S.D.A. methods (1999) resulted to be "thermic", as the mean annual temperature ranges between 15 °C and 22 °C (more precisely 15.96 °C at Capocotta – Catavanni and 16.07 °C at Vallerano) and the difference between mean summer and mean winter temperatures at a depth of 50 cm is more than 6 °C.

As for the soil water balance, all profiles resulted to have a "xeric" moisture regime according to the definition of Soil Taxonomy, in spite of their moderately high to very high water storage capacity (AWC = 120 mm to over 200 mm). In fact their soil moisture control sections undergo 3 to 4 months of water deficit (July-September or June – September), depending upon their AWC values.

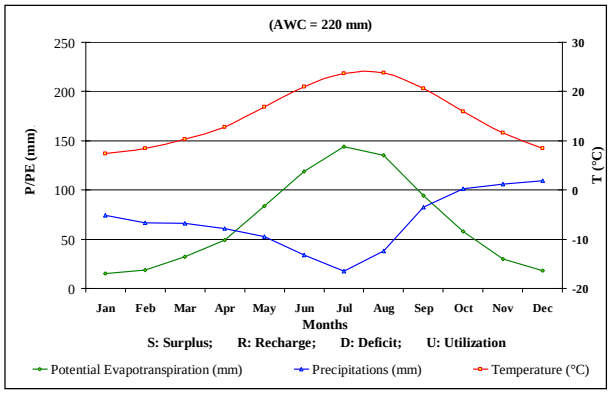

Figure 2. Soil Water Balance of Profile n. 5 "*Sugherata di Vallerano*"

The vegetation of Catavanni and Capocotta is a mixed oak wood with *Quercus cerris*, *Quercus frainetto* and *Quercus suber*. In the former area the average canopy coverage is 50-60 % and tree height 7-8 m, whereas in the latter canopy coverage is more than 80 % and tree height up to 12 m. In the Vallerano area, at least in the sampled plots, a *Quercus suber* oak wood occurs, with plant cover more than 80 % and tree height up to 10 m.

From the syntaxonomic point of view, according to the Map of Vegetation Series of Decima-Malafede Reserve scale 1:50,000 (Blasi *et al.* 2001) both the *Quercus cerris* and *Quercus frainetto* woods of Catavanni and Capocotta and the *Quercus suber* woods of Vallerano, are included in the association *Quercetum frainetto-suberis* Blasi, Filesi, Fratini & Stanisci 1997.

3. Materials and Methods

The nature and distribution of soils in the study areas were determined by examinations of excavated pits, natural and artificial exposures and auger borings. Both site and profile characteristics were described following the FAO-ISRIC manual (1990).

After air-drying, the soil samples were sieved through a 2-mm sieve and physical-chemical analyses were carried out following standard methods of the Ministero delle Politiche Agricole e Forestali (2000). Based on fieldwork and laboratory data, soils were classified to the subgroup level according to the American taxonomic system (U.S.D.A. 1999, U.S.D.A. 2006).

In these areas, where soils were better known, we investigated also on soil mesofauna populations. We chose to adopt as a starting point the Index of Soil Biology Quality ("*Indice di Qualità Biologica del Suolo*" – QBS-ar) (Parisi 2001; Jacomini *et al.* 2003; APAT 2004; Parisi *et al.* 2005). This Index allows a fast assessment of soil microarthropod populations – the component of soil fauna of simplest extraction and analysis, without entering the laborious and demanding soil zoological taxonomy.

In each study sector, within a 10 m diameter plot where no lateral variations of soil are likely, three soil cores were extracted with a cubic steel sampler of 10 cm side. The sampler, inserted in the soil to 10 cm depth, was set free on one side digging a small trench, to let a steel blade cut and close the bottom of the core sample. As a result, the cubic samples of 1 dm^3 of soil suffered from a minimum disturbance.

Soil samples were transported to the laboratory closed in a hermetic container and protected from thermal shock or bumps. There, they were carefully

placed in modified Berlese–Tullgren extractors, with 2-mm sieve and 60 W lamps, for 10 days. The time of extraction has been selected by means of preliminary samples that allowed reckoning the microarthropods' extraction curve (Parisi *et al*. 2005), i.e. the most effective time of extraction for the soil under study in the sampling period.

The results of extraction were kept in hermetic canisters filled with preservative solution (3 parts 75 % ethanol and 1 part glycerol) before examination under a stereomicroscope at low magnification (4-100 x), to sort out the detritus and to score the eco-morphological indices (Sacchi and Testard 1980; Parisi 2001; Parisi *et al*. 2005).

4. Results

The investigated areas resulted to be rather uniform in the soil pattern, being characterized by very deep soils with an A Bt C profile, nearly always showing distinct clay illuviation phenomena which have formed strongly developed argillic horizons. These soils of advanced evolution are the result of pedogenic processes of long duration, which have occurred in the two main geological substrates outcropping in the Reserve area (Ancient Dune and volcanic materials) also favored by the nearly level morphology as well as by the Mediterranean climate.

In order to make this interdisciplinary approach to the site characterization more immediate, for each study site the description and the physical-chemical data of a selected profile as well as the results of QBS-ar have been reported in a synthetic table (Tables 1-3).

The detailed results of the QBS-ar Index are shown for each sector study in the lower part of these tables (Tables 1-3). In all the three study sectors, mesofauna richness and diversity determined very high values of the QBS-ar Index.

The within-sector analysis of the three core samples confirmed the sampling hypothesis that all of them had been taken in homogeneous areas from the naturalistic point of view. The spectral analysis, actually, did not bring to light any significant difference among the replicated samples within each sector.

From the zoological point of view, it is interesting to note the capture of a rare specimen of palpigrad (*Eukoenenia* sp.) in one of the samples from the *Macchia di Capocotta*.

Moreover, it is noteworthy to highlight the richness and diversity of mites, springtails, beetles and flies (both larvae and images), symphylans, pauropods and other small microarthropods, which will be described in a specialized paper. Finally, it is important to draw attention on the results attained in the *Macchia di Capocotta* sector, where a QBS-ar value of 289 marks the maximum value ever recorded in Italy.

5. Conclusions

The richness of taxa of edaphic mesofauna in the three examined sectors showed very high values, particularly at Capocotta; very rarely values so high have been found, very close to the maximum limits calculated with the QBS-ar index, specially if compared with the data of other researches on biodiversity (Parisi *et al*. 2003; Jacomini 2004; Parisi *et al*. 2005). Therefore these results confirm the very high naturality already pointed out through soil and vegetation investigations.

These results confirm the validity of this method, when correctly utilized, to evaluate the naturality of an area with low costs and in an expeditious way. However, in order to apply it at a smaller scale, an appropriate standardization (possibly at a national level) is necessary for the methods of sampling, analyzing and data processing, in order to homogenize results and make possible useful comparisons between different areas.

With this purpose we are planning to carry out a database with all the information taken from literature as well as from the laboratories in Italy, which utilize the QBS-ar Index, relatively to areas well know from a pedological standpoint. A preliminary investigation performed by APAT on soil biomonitoring in Italy showed that a great number of researches on soil fauna have been carried out by local Environment Protection Agencies (ARPA/APPA), Research Institutes and Universities, but most of their results have not been published yet. Unfortunately, most of these data have not been

correlated to soil properties, as it would be necessary for a correct ecological assessment.

The final goal of the above mentioned database would be to find robust correlations among the standardized QBS Index values and the state of the soil where samples have been taken. This should produce a classification on a graduated scale of the numerical values of this index that might allow at low costs and in a fast way to assess the state of the environment.

In order to increase the knowledge on the soil fauna of Latium, we suggest the application of these methodologies to the network of protected areas of RomaNatura or, more diffusely, to the Natura 2000 Protected Areas of the Latium Region.

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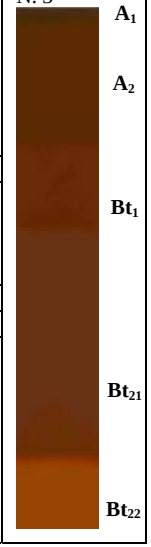
TABLE 1 – “*Macchia di Capocotta*”

In this sector, very deep (more than 2 m) soils are found, reddish brown colored in all the horizons (Hue 7.5 YR of the Munsell Soil Color Charts), with clear evidence of clay translocation. They consist of a coarse textured eluvial horizon, of variable thickness (40–70 cm), overlying a well developed argillic B horizon (up to 1.5 m thick) with a maximum clay content of 25-32 % very slightly decreasing with depth (**Tipic** and **Ultic Palexeralfs**). Available water capacity of these profiles is high (AWC = 180-200 mm). Redoximorphic features, such as Fe-Mn concretions, are common throughout the B horizon (sometimes already in the A_2), indicating somewhat poor a water drainage for significant periods.
As for the chemical characteristics, pH values are neutral or slightly acid in the *topsoil*, slightly acid or moderately acid in the *subsoil* and base saturation is always rather high (>60%). The organic matter is abundant in the surface layer (A_1 horizon), ranging between 5 % and 9 %, but sharply decreases already in the A_2 horizon and is very scarce in Bt (<1%). Also nitrogen and available phosphorous show the same pattern, being high in the A_1 horizon and decreasing to very low levels in the underlying horizons. In the surface layer, also the exchangeable bases are concentrated; they sharply decrease in the A_2 horizon, but slightly increase again in the argillic horizon, following clay translocation.

Soil Profile N. 3



Location	Macchia di Capocotta	*Landform*	Plateau	*Vegetation*	*Quercetum frainetto-suberis*
Altitude	104 m a.s.l.	*Slope gradient*	Nearly level	*Plant cover*	70 %
Aspect	-	*Rock outcrops*	None	*Notes*	Auger boring
Parent material	“Ancient Dune” sands	*Surface corse fragments*	None	*Geogr. Coord. (WGS84 UTM 33)*	41°41’32.8948” - 12°26’8.6762”

Field description		
Hor. OL	5-2 cm	Unaltered litter of freshly fallen leaves
Hor. OF	2-0 cm	Fragmented plant residues, parly decayed, permeated by fungal hyphae; common very fine roots.
Hor. A_1	0-5 cm	Dark brown (7.5YR 4/2). Weak fine granular structure, with a tendency to be loose. Sandy loam. Common fine roots. Abrupt and smooth boundary to
Hor. A_2	5-70 cm	Dark brown (7.5YR 4/4). Loose, sandy loam. Common fine roots. Abrupt and smooth boundary to
Hor. Bt_1	70-100 cm	Brown (7.5YR 4/6). Sandy clay loam. Very hard (dry); sticky and plastic (wet). Very few Fe-Mn nodules (7.5YR 3/1). Clear and smooth boundary to
Hor. Bt_{21}	100-165 cm	Bright brown (7.5YR 5/8). Sandy clay loam. Very hard (dry), sticky and plastic (wet). Few to common Fe-Mn (7.5YR 3/1) and Fe (7.5YR 6/8) nodules. Few medium roots. Clear and smooth boundary to
Hor. Bt_{22}	165-210+ cm	Bright brown (7.5YR 5/8). Sandy clay loam. Sticky and plastic (wet). Common Fe-Mn (7.5YR 3/1) nodules; many to few coarse Fe (7.5YR 6/8) nodules.

Horizons	Thickness (cm)	pH (H_2O)	pH (KCl)	Org.C %	O.M. %	Tot. N %	C/N	Available P mg/kg	Exch. Ca^{++}	Exch. Mg^{++}	Exch. Na^{+}	Exch. K^{+}	Exch. Acidity cmol/kg	C.E.C. cmoll/kg.	Base Sat. %	Corse Sand %	Medium Sand %	Fine Sand %	Total Sand %	Silt %	Clay %	AWC (mm)
A_1	0-5	6.6	5.6	3.52	6.08	0.28	13	9.0	21.77	3.11	0.28	0.59	3.77	29.52	87.2	3.4	24.1	36.0	63.5	21.5	15.0	11
A_2	5-70	6.1	4.6	1.29	2.23	0.14	9	3.0	9.94	2.08	0.28	0.30	3.84	16.44	76.6	3.8	24.0	36.6	64.4	29.6	6.0	126
Bt_1	70-100	5.8	4.3	0.46	0.79	0.06	8	0.0	6.37	2.65	0.25	0.33	5.04	14.64	65.6	2.5	18.1	30.1	50.7	21.3	28.0	52
Bt_{21}	100-165	5.7	4.4	0.36	0.63	0.07	6	0.0	7.33	3.34	0.36	0.33	6.75	18.11	62.7	3.0	18.3	28.7	50.0	19.3	30.7	111
Bt_{22}	165-210+	6.0	4.7	0.24	0.40	0.06	5	0.0	7.44	3.19	0.37	0.28	5.30	16.58	68.0	2.8	20.6	32.1	55.5	17.5	27.0	75

Micro-arthropod Groups		Protura	Diplura	Collembola	Microcoryphia	Zygentomata	Dermaptera	Ortoptera	Embioptera	Blattaria	Psocoptera	Hemiptera	Tysanoptera	Coleoptera (larvae)	Coleoptera (adults)	IHymenoptera	Diptera (larvae)	Diptera (adults)	Lepidoptera (larvae)	Lepidoptera (adults)	Pseudoscorpionida	Palpigrada	Opilionida	Araneida	Acarida	Isopoda	Diplopoda	Pauropoda	Symphyla	Chilopoda	**Total QBS-ar**
Macchia di Capocotta	**1**	20	20	20	10	0	0	0	0	0	1	1	1	10	20	5	10	1	10	0	20	0	0	0	20	10	20	20	20	20	**259**
	2	20	20	20	0	0	0	0	0	0	1	0	1	10	20	5	10	1	0	0	0	0	0	0	20	10	10	0	20	20	**188**
	3	0	20	20	0	0	0	0	0	10	0	1	1	10	20	0	10	1	0	0	20	20	0	0	20	10	20	20	20	0	**223**
QBS-ar	**maximum**	**20**	**20**	**20**	**10**	**0**	**0**	**0**	**0**	**10**	**1**	**1**	**1**	**10**	**20**	**5**	**10**	**1**	**10**	**0**	**20**	**20**	**0**	**0**	**20**	**10**	**20**	**20**	**20**	**20**	**289**

Table 2 – *"Boschi di Catavanni"*

In this sector, soils are mostly **Typic Haploxeralfs,** reddish to brownish (Hues 7.5 YR or 10 YR), consisting of an eluvial horizon, sandy or sandy loam, 20 to 50 cm thick, underlain by a Bt horizon, finer textured (26 – 34 % clay). However, in comparison to the soils of Capocotta, the argillic horizon of these profiles is not as thick, its base being normally < 1.5 m below the soil surface, and it shows a sharper decrease of clay with depth: this probably can be considered a result of the major disturbance occurring in this area. In some profiles, within 1-meter depth, a sandy C horizon is found, cemented by silica and iron oxides, with the characters of a "duripan", thus identifying the great group of **Durixeralfs**.
The chemical and hydrological characteristics of these soils are similar to the soils of Capocotta; but in these profiles pH values are acid to slightly acid in the *topsoil* and increase to neutral toward the base of the *solum* and base saturation in the argillic horizon is always very high (> 75%).

Soil profile N. 7

Locality	Bosco di Catavanni	*Landform*	Plateau	*Vegetation*	*Quercetum frainetto-suberis*
Altitude	81 m a.s.l.	*Slope gradient*	Level	*Plant cover*	70-80%
Aspect	-	*Rock outcrops*	None	*Notes*	Auger boring
Parent material	"Ancient Dune" sands	*Surface corse fragments*	None	*Geogr. Coord. (WGS84 UTM 33)*	41°43'39.4915" – 12°26'16.8613"

Field description		
Hor. OL	6-3 cm	Unaltered litter of freshly fallen leaves
Hor. OF	3-0 cm	Fragmented plant residues, partly decayed, permeated by fungal hyphae; common very fine roots.
Hor. A_1	0-8 cm	Brownish black (7.5YR 3/2). Weak very fine granular structure, tendency to be loose. Soft (dry). Sandy loam. Very few Fe-Mn nodules (7.5YR 3/1). Common fine roots. Abrupt and wavy boudary to
Hor. E	8-38 cm	Dull brown (7.5YR 5/3). Structureless, loose (dry). Loamy sand. Very few Fe-Mn (7.5YR 3/1) and Fe (7.5YR 6/8) nodules. Common fine and medium roots. Abrupt and smooth boundary to
Hor. A/B	38-66 cm	Dull orange (7.5YR 6/4). Sandy clay loam. Slightly hard (dry); slightly sticky and slightly plastic (wet). Many Fe-Mn (7.5YR 3/1) and Fe (7.5YR 6/8) nodules. Clear and smooth boundary to
Hor. Bt_1	66-92 cm	Bright brown (7.5YR 5/8). Sandy clay loam. Hard (dry); slightly sticky and slightly plastic (wet). Many Fe-Mn (7.5YR 3/1) and Fe (7.5YR 6/8) nodules. Few medium roots. Gradual and smooth boundary to
Hor. Bt_2	92-118 cm	Bright brown (7.5YR 5/6). Sandy clay loam.Very hard (dry); very sticky and plastic (wet). Many Fe-Mn (7.5YR 3/1) and Fe (7.5YR 6/8) nodules. Gradual and smooth boundary to
Hor. Bt_3	118-185+ cm	Dull brown (7.5YR 5/4) to bright brown (7.5YR 5/6). Sandy clay loam. Hard (dry); sticky and plastic (wet). Many to common Fe-Mn (7.5YR 3/1) and Fe (7.5YR 6/8) nodules.

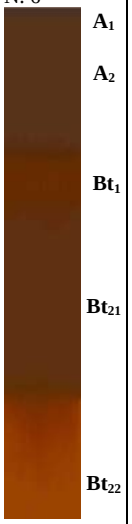
Horizons	Thickness (cm)	pH (H_2O)	pH (KCl)	Org.C %	O.M. %	Tot. N %	C/N	Available P mg/kg	Exch. Ca^{++}	Exch. Mg^{++}	Exch. Na^{+}	Exch. K^{+}	Exch. Acidity cmol/kg	C.E.C. cmoll/kg	Base Sat. %	Corse Sand %	Medium Sand %	Fine Sand %	Total Sand %	Silt %	Clay %	AWC (mm)
A_1	0-6/8	5.7	4.6	8.62	14.88	0.50	17	12.0	20.13	7.72	0..39	0.49	14.15	42.88	67.0	3.0	22.9	33.4	59.3	26.1	14.6	23
E	8-38	4.7	3.7	1.34	2.31	0.11	12	0.5	0.98	1.04	0.44	0.13	5.72	8.31	31.2	4.6	29.3	38.8	72.7	22.3	5.0	56
A/B	38-66	5.8	4.1	0.35	0.61	0.04	9	1.0	1.61	1.96	0.44	0.13	1.74	5.88	70.4	5.4	29.2	37.6	72.2	7.8	20.0	44
Bt_1	66-92	5.9	4.3	0.08	0.14	0.05	2	0.3	3.86	8.17	0..33	0.19	3.37	15.92	78.8	4.0	24.7	31.7	60.4	18.6	21.0	43
Bt_2	92-118	6.2	4.2	0.07	0.12	0.03	2	0.0	7.72	12.26	0.77	0.23	3.64	24.62	85.2	4..3	26.5	23.0	53.8	17.2	29.0	42
Bt_3	118-185+	6.9	4.7	0.07	0.12	0.04	2	3.5	8.55	12.27	1.11	0.28	2.17	24.36	91.1	5.6	26.2	28.9	60.7	17.8	21.5	109

Micro-arthropod Groups		Protura	Diplura	Collembola	Microcoryphia	Zygentomata	Dermaptera	Ortoptera	Embioptera	Blattaria	Psocoptera	Hemiptera	Tysanoptera	Coleoptera (larvae)	Coleoptera (adults)	IHymenoptera	Diptera (larvae)	Diptera (adults)	Lepidoptera (larvae)	Lepidoptera (adults)	Pseudoscorpionida	Palpigrada	Opilionida	Araneida	Acarida	Isopoda	Diplopoda	Pauropoda	Symphyla	Chilopoda	**Total QBS-ar**
Bosco di Catavanni	**1**	20	0	20	0	0	0	0	0	0	1	0	0	10	5	5	10	1	0	0	0	0	0	5	20	0	10	20	20	20	**167**
	2	20	0	20	0	0	0	1	0	0	0	1	1	10	10	5	10	1	0	0	20	0	0	5	20	0	20	20	20	20	**204**
	3	0	0	20	0	0	0	0	0	0	1	1	1	10	20	5	10	1	10	0	0	0	0	5	20	0	0	20	20	0	**144**
QBS-ar	**maximum**	**20**	**0**	**20**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**1**	**1**	**10**	**20**	**5**	**10**	**1**	**10**	**0**	**20**	**0**	**0**	**5**	**20**	**0**	**20**	**20**	**20**	**20**	**225**

Table 3 - *"Sugherata di Vallerano"*

In this sector soil profiles are very deep (up to 2.5 m), generally with red to reddish brown colour s (Hues of 5 YR, 7.5 YR but also 2.5 YR). Their main feature is the presence of a well developed argillic B horizon, where the clay content can be very high (up to about 60 % or more) and Fe-Mn concretions are common to abundant. The Bt is overlain by a thick mollic *epipedon* (**Typic** and **Ultic Argixerolls)**, or, less frequently, by an ochric epipedon (**Typic Palexeralfs)**.
The pH values of these soils are near neutral in the A_1 horizon, slightly to moderately acid in all the others; base saturation is always fairly high. The organic matter, nitrogen and available phosphorous contents are particularly abundant in A_1, but they sharply decrease in A_2, becoming very scarce in B.
If compared with the profiles on the dune sands, these soils on volcanic deposits have much higher contents of clay and considerably higher values of the cation exchange capacity. Also, among the exchangeable bases, Ca concentrations are much more abundant. The available water capacity is much higher as well (200 to 250 mm).

Soil Profile N. 6



Locality	Sugherata di Vallerano	*Landform*	Plateau	*Vegetation*	*Quercetum frainetto-suberis*
Altitude	55 m a.s.l.	*Slope gradient*	Nearly level	*Plant cover*	70 %
Aspect	-	*Rock outcrops*	None	*Notes*	Soil augering
Parent material	Scoriaceous-cineritic deposits	*Surface stone fragments*	None	*Geogr. Co-ord. (WGS84 UTM 33)*	41°47'25.7836" – 12°27'24.8071"

Field description

Hor. OL	4-2 cm	Unaltered litter of freshly fallen leaves
Hor. OF	2-0 cm	Partly decomposed fragments of plant residues, with abundant mycelia.
Hor. A_1	0-4/6 cm	Brownish black (7.5YR 3/2). Strong fine granular structure. Slightly hard (dry); sticky and plastic (wet). Silty clay loam. Common fine roots. Abrupt and wavy boundary to
Hor. A_2	4/6-23 cm	Dull orange (7.5YR 6/4). Moderate fine granular structure. Soft(dry). Silt loam. Common fine roots. Clear and smooth boundary to
Hor. Bt_1	23-36 cm	Orange (7.5YR 6/6). Silty clay loam. Hard (dry); sticky and plastic (wet). Common Fe-Mn nodules (7.5YR 3/1).
Hor. Bt_{21}	36-122 cm	Orange (7.5YR 6/6). Clay. Hard (dry);very sticky and very plastic (wet). Many fine Fe-Mn nodules (7.5YR 3/1). Common tufaceous fragments strongly weathered (10YR 7/8). Gradual and smooth boundary to
Hor. Bt_{22}	122-210+ cm	Dull brown (7.5YR 5/4). Silty clay. Hard (dry); very sticky and plastic (wet). Many fine Fe-Mn nodules (7.5YR 3/1); many weathered fragments of tufaceous rocks (10YR 7/8).

Horizons	Thickness (cm)	pH (H_2O)	pH (KCl)	Org.C %	O.M. %	Tot. N %	C/N	Available P mg/kg	Exch. Ca^{++}	Exch. Mg^{++}	Exch. Na^{+}	Exch. K^{+}	Exch. Acidity cmol/kg	C.E.C. cmoll/kg	Base Sat. %	Corse Sand %	Medium Sand %	Fine Sand %	Total Sand %	Silt %	Clay %	AWC (mm)
A_1	0-4	7.3	6.5	15.00	25.86	0.94	16	23.6	62.31	10.00	0.55	1.36	7.83	82.05	90.5	1.1	3.6	4.7	9.4	59.0	31.6	17
A_2	4-23	6.9	5.4	1.47	2.54	0.15	10	3.4	16.35	4.54	0.22	0.94	4.78	26.83	82.2	2.7	6.7	6.5	15.9	65.1	19.0	45
Bt_1	23-36	6.5	4.9	0.89	1.54	0.11	8	4.0	21.80	5.90	0.33	1.22	7.08	36.33	80.5	2.7	4.7	4.9	12.3	48.7	39.0	27
Bt_{21}	36-122	6.1	4.7	0.41	0.71	0.08	5	1.4	18.75	7.72	0.33	1.29	8.94	37.03	75.9	2.0	3.0	3.3	8.3	33.7	58.0	162
Bt_{22}	122-210+	5.9	4.4	0.08	0.14	0.03	2	1.9	21.64	11.14	0.94	0.50	11.59	45.81	74.7	2,9	3.8	3.3	10.0	45.5	44.5	204

Micro-arthropod Groups		Protura	Diplura	Collembola	Microcoryphia	Zygentomata	Dermaptera	Ortoptera	Embioptera	Blattaria	Psocoptera	Hemiptera	Tysanoptera	Coleoptera (larvae)	Coleoptera (adults)	IHymenoptera	Diptera (larvae)	Diptera (adults)	Lepidoptera (larvae)	Lepidoptera (adults)	Pseudoscorpionida	Palpigrada	Opilionida	Araneida	Acarida	Isopoda	Diplopoda	Pauropoda	Symphyla	Chilopoda	**Total QBS-ar**
Sugherata di Vallerano	**1**	0	0	20	0	0	0	0	0	0	1	1	1	10	10	5	10	1	0	0	20	0	0	5	20	10	10	0	20	10	**154**
	2	20	20	20	0	0	0	0	0	0	1	0	1	10	20	5	10	1	0	1	20	0	0	1	20	10	10	20	20	10	**220**
	3	0	0	20	0	0	0	1	0	0	1	0	1	10	10	5	10	1	0	0	20	0	0	5	20	10	0	0	20	10	**144**
QBS-ar	**maximum**	**20**	**20**	**20**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**1**	**1**	**10**	**20**	**5**	**10**	**1**	**0**	**1**	**20**	**0**	**0**	**5**	**20**	**10**	**10**	**20**	**20**	**10**	**226**