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DIOXINS, TRACE ELEMENTS, BIOINDICATORS AND BIODIVERSITY IN SOILS

Roberto M. Cenci and Fabrizio Sena

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2009

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S. Brenna, S. Solaro, M. Sciaccaluga, V. M. Sale. (2005). ERSAF. *Relazione tecnica finale. Contratto n. 38515.*

F. Bo, E. Sobiecka, L. Roncari, B. M. Gawlik. (2005). *Internal report. Characterization of soil and sediment samples for CHN in the context of the Pavia Project.* SWCT Report n. 01-08-2005. 26 pp.

F. Sena, G. Locoro, B. M. Gawlik (2004). *Sampling Planning. Project Pavia, Sampling campaign AM1.* SWCT Report 05-10-2004. 17 pp.

Università Cattolica del Sacro Cuore di Piacenza. Istituto di Chimica Agraria ed Ambientale. Relazione tecnica. Contratto n. 22438-2004-10 FISC ISP IT. *Raccolta, trattamento e analisi di elementi in tracce in campioni di suolo e muschio.*

A. Benedetti, L. Pompili, C. Meconi, B. D'Angelo, L. Nisini. (2005). Report on the activity carried out within the project *"Biodiversità e Bioindicazione nella Provincia di Pavia"* CRA - Istituto Sperimentale per la Nutrizione delle Piante, Roma.

Credits

We would like to personally thank the numerous colleagues who participated in the realisation of this vast project. A particular and personal thanks goes to our colleague Franco Bo, who departed prematurely; thank you Franco.
We would also like to thank our colleagues and friends Abbenante Claudia, Alessio Annalisa, Benedetti Anna, Beone Gian Maria, Bidoglio Giovanni, Bouraoui Faycal, Braghieri Roberto, Brangi Anna, Brenna Stefano, Carlon Claudio, Casale Monica, Christoph Eugen H, D'Angelo Barbara, Filippi Nicola, Gaulio Walter, Ghiani Michela, Ghisetti Giovanna, Lodigiani Gustavo, Lodigiani Paolo, Mariani Giulio, Meconi Claudia, Montanarella Luca, Musmeci Loredana, Nisini Luigi, Pompili Letizia, Privitera Marisa, Puglisi Marta, Roncari Luigi, Rusco Ezio, Sale Vanna Maria, Sciaccaluga Marco, Skejo Helle, Solaro Silvia, Trincherini Pier, Umlauf Gunther, Guardie Ecologiche della Provincia di Pavia, Vigili del Fuoco di Milano.
Some of the aforementioned colleagues were co-authors of the following two volumes:

- Il suolo della Provincia di Pavia. Valutazione della concentrazione di composti organici e inorganici persistenti attraverso lo sviluppo di una monitoring network del suolo. (2006). EUR 22132 IT. ISBN 10-92-894-8619-8. 128 pp.
- Il suolo della Provincia di Pavia (Parte due). (2007) EUR 22132 IT/2. ISBN 92-79-03877-x. 238 pp.

PROVINCE OF PAVIA

PREFACE

Soil holds a primary strategic importance for the life of all living beings. Soil offers the support for our houses, roads and recreation. It is the filter for rainwater, and is the base for trees, plants and daily life produce growing in the soil. It offers us a countless and evident number of gifts.
Our task as citizens consists in respecting soil as a source of life and a living entity, taking care not to damage it. It takes hundreds of years to form soil, but just few moments to destroy damage, contaminate or kill it.
Contrived by Professor Cenci of the Joint Research Centre of European Commission, the Pavia Project heads in the right direction. It is an informative tool which precisely “captures” the quality of surface and deep soil of the Province of Pavia under all aspects, chemical, physical and biological.
The information contained in this project are and will be an essential tool for the proper planning of all the activities carried out on the soil of Pavia.
In this zone agriculture has always held a cultural and social importance, besides the economical role. Agriculture is a historical connective tissue linking the lives of hundreds of thousands of people, thus the protection of its quality is of vital importance.
Every common citizen, and above all the Pavia governors, must know how to manage this heritage taking care of leaving a healthy soil to future generations, able to provide high quality products. The Pavia Project is and will be the proper tool to correctly manage and preserve this health during the following years.
We hope that in the future we will be able to continue the collaboration with Professor Cenci to update with new data the scientific results of The Pavia project, setting out the aspects linked to the use of sewage sludges in agriculture.

COUNCILLOR RUGGERO INVERNIZZI

Assessorato Tutela Ambientale della Provincia di Pavia since June 2006

PREFACE TO THE "PAVIA PROJECT"

Soil represents one of the four main elements along with air, water and life forms. It plays an important and indispensable number of functions in life itself on Planet Earth.
Sludges, fertilizers, manure, pesticides, pollutants dispersed in the atmosphere, agricultural practices and the innumerable activities of human beings affect the soil and its quality causing a negative impact over time.
Also the natural processes can determine the degradation of the "soil resource", whose regeneration often takes very long periods. The need to prevent the ongoing degradation of soil resource is becoming necessary and urgent.

The European Commission included soil protection among the priorities of the 6^{th} ten-year program for environmental action. Among the soil protection projects there is the preparation of an executive regulation for soil protection.
The major degradation risks threatening the European soils are: sealing, salination, local and spread contamination, reduction of the biodiversity, erosion, reduction of organic material, compaction, floods and landslides.

The data obtained with this project comply with the indications of the European Commission. They are a tangible example of an environmental monitoring integrated study to assess the soil quality and health.

Environmental researches and investigations in the biodiversity and bioindication sectors carried out in recent years are experiencing an important impulse and they are more and more applied to evaluate a part of the environment quality.
The Pavia project is an innovation in its field and aims at evaluating the soil quality. It presents itself as a pilot study because of the huge area investigated the huge number of parameters investigated and above all because of the combination between the bioindication and biodiversity concepts connected to soil physical-chemical measures.

The principal aptitude of the Pavia territory is agriculture, and the management of the soil health has a primary importance for a qualitative and economically efficient planning which will allow future generations to live in a healthy environment

DR. GUIDO SCHMUCK

Director of the Institute for Environment and Sustainability
European Commission JRC Ispra (Va)

EVALUATION OF THE "PAVIA PROJECT" BY THE SCIENTIFIC COMMITTEE

The present study, which has been directed with proficiency and expertise by Prof. Roberto Cenci of the Joint Research Centre of Ispra (Va), Institute for Environment and Sustainability, was carried out according to internationally accepted criteria. It enables the obtaining of a good knowledge of the current conditions of the soil of the province of Pavia.

In particular, the use of the LUCAS-EUROSTAT (Land Use Cover Area from Statistical Survey) network to identify the soil sampling points makes the province of Pavia an international point of reference for the policies of environmental soil protection. In fact, the mass of data presented in this report, besides the methodological quality adopted, constitutes one of the most important surveys concerning the soil, as requested by the European Union policy. Indeed, The European Commission included soil protection among the priorities of the 6th ten-year Programme of environmental action.

Clearly there is a general need for the prevention of soil degradation involving Europe (sealing, salination, local and diffused contamination, biodiversity reduction, erosion, organic matter reduction, compaction, flooding and landslides). Monitoring studies considering physical, chemical and biological parameters are the most useful indicators of the efficacy of the policies for the soil management.

The analyses were aimed at determining: heavy metals, macro-elements, nutrients, pH, water retention, pedological profile and bacteria. Furthermore, persistent organic compounds were researched as polychlorobiphenyls, dioxins and furans, whose presence constitutes a reference data at national and international levels for significantly man-made areas.

This study also concerned the use of moss as bioindicators to evaluate the drops of the contaminants dispersed in the atmosphere and a survey of the sediments of some oxbows to infer the course of certain pollutants over an extended period of time (100 years).

The research of persistent pollutants in soil treated with sewage sludges is of great interest, also from a health point of view. Given the lack of data in literature, the results obtained can provide better knowledge to set environmental quality standards for soil amended with sludge and for the "sewage sludges" matrix itself.

In conclusion, this study is original, comprehensive, effective and well written. It is clear and can be understood without great difficulty. The latter is a great credit, because the mass of data is so huge that it can hinder an analytical reading and evaluation. Finally, we hope this study will represent the first step of an effective and continuous process to monitor the evolution of the Pavia province soil; and that it will be spread at local, national and international levels to let the scientific community know the precise data obtained, besides giving credit to the body promoting it.

DOTT. PIERSANDRO ASSANELLI Dipartimento A.R.P.A. di Pavia

DOTT. GEOL. ROBERTO BRAGHIERI, Provincia di Pavia

PROF. SERGIO FACCHETTI, Università Statale di Milano

DOTT.SSA LOREDANA MUSMECI, Istituto Superiore di Sanità

PROF. CARLO ALBERTO REDI, Università degli Studi di Pavia

DOTT.SSA ILARIA VECCHIO, Provincia di Pavia

Aim of the project

The aim of the project is to obtain a detailed spatial evaluation of the possible impairment or "quality" condition of the Pavia zone soil, setting a provincial soil monitoring network which could have international value.
To optimize the resources assigned by the Pavia District to environmental monitoring, a survey activity was set in consideration of its potential integration with other ongoing or future actions at local, regional or national levels.
The resolution level of this study is connected to the needs of the Assessorato alla Tutela Ambientale of the Provincia di Pavia: it is more detailed in the areas where the anthropogenic pressure is higher.
Particular attention was given to trace elements, dioxins, to the study of bacteria and their products and to the use of moss, without disregarding the soil physical-chemical measures, which are essential for a proper and complete analysis of the "health state" of the Pavia zone soil.

Summary

Description of the project
Soils of the Province of Pavia has been object of a biological, physical and chemical survey in order to obtain a detailed assessment of their "quality". For this purpose, standard international methods were used to identify sampling, collection, handling and analysis points. With the use of the Land Use Cover Area from Statistical Survey (LUCAS) network, 7 Primary Points and 34 Secondary Points have been identified. On the basis of the same network, 116 sampling points (Tertiary Points) have been selected within six areas of prevalently industrial nature. A sample of soil being 0-30 cm thick was collected from each Secondary and Tertiary Point, while in the Primary Points the samples were up to approximately 1 metre thick. A moss sample was collected in the surroundings of all the 157 points to enhance the information for the study. The moss analysis allowed the evaluation of the soil depositions of inorganic elements.

The bio-physical-chemical analyses of all the soil samples were the following:

- trace elements (As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Ti and Zn)
- macro elements (C_{tot}, C_{org}, Al, Ca, Fe, K, Mg, N, Na, P and Si)
- dioxins and furans
- pH, water retention, pedological profile
- bacteria

The analysis carried out on moss samples were:

- As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Pt, Rh and Zn.

Besides what is listed, soil belonging to three areas with different management was considered: biological area, area fertilized with manure and area treated with sewage sludges. These areas were also subjected to an analysis carried out four times over a year with the use of bacteria. In two oxbows, sediment cores were collected. The analysis, carried out on 1 cm sections, aimed at evaluating the concentration of trace elements, macro elements, dioxins and furans over time.

Results

The soil concentrations of all the elements considered, including dioxins and furans, pointed out levels which are typical of agricultural and low anthropogenic pressure areas. Only some chrome and nickel levels in the surroundings of the River Po slightly exceed the limits of the Decree Law 152, but they are of natural origin. It is worth noting that only one area presents high levels of trace elements, dioxins and furans. This area is on the border between the provinces of Pavia and Milan. A detailed survey was carried out in this area in order to evaluate the extent of the contamination (*R. M. Cenci and F. Sena*, 2007).

The study of bacteria stressed a generally positive condition of biological fertility. However, it should be pointed out that a decrease in biological fertility can occur over time in the northern areas, where intensive cropping and/or monoculture are executed. Moss allowed the quantification of deposition of trace elements to the ground. They are quite limited and similar to those observed in areas with low anthropogenic pressure. The trace element levels within the industrial areas led to a graphic visualization confirming a spatial distribution of the concentration which was quite homogeneous and limited.

Depositions of trace elements, both of human and crustal origin, do not significantly increase the concentration levels in soil.

If these drops are compared with the results obtained in other previously studied areas, they appear to be similar to those observed in agricultural areas - they are significantly lower than in urbanized areas or in zones where industrial and agricultural activities are present.

Moss also led to the identification of the origin of the drops, 74% of which is of crustal origin.

The survey on the three areas with different fertilization pointed out a positive general condition of biological fertility. Increases in trace elements were not observed in the soil treated with sewage sludges. A marginal dioxins and furans concentration difference was observed among the surveyed areas.

The results derived from the analysis of all the soil parameters did not point out any sanitary risk in the surveyed areas.

No particular increases in sediment concentration were observed in the most superficial layers.

The concentrations obtained reflect the values of the soil within the catchment basins of River Ticino and other rivers, because they largely derive from them.

The values obtained for dioxin and furan content are modest and stable over time. An exception is only represented by one level which was found within the deep layer core sample collected in San Massimo Groppello.

In conclusion, two significant observations come up:

- The first aims at underlining the importance of the monitoring, its approach and the solidity of the results obtained; these aspects are the base for developments and surveys which could be carried out in the future.
- The second concerns the quality and health of the soil. Its overall positive condition indicates present and past respect and proper management of this territory.

Introduction

Soil is in strict relation to other environmental elements and sectors, as air, water, waste, agriculture and forests.
Sewage sludges, fertilizers, manure and pesticides are distributed on the soil. Pollutants dispersed in the atmosphere could settle on the soil and even the agricultural activities entail a negative impact over time.
Finally, the several anthropogenic pressures and the natural processes can in different ways determine the degradation of the "soil resource", whose regeneration is often very lengthy.
Suggestions about the effectiveness of the environmental protection policies can only be derived from soil monitoring studies which consider chemical, physical and biological parameters.
The necessity of preventing the ongoing European degradation of the soil resource and assuring its sustainable use led the European Commission to include soil protection among the priorities of the 6th ten-year Programme of environmental action.
The recent Communication by the Soil Protection Commission *"Towards a Thematic Strategy for Soil Protection"* identifies the principal danger menacing the European soils. In particular, it points out degradation phenomena as: sealing, salination, local and diffused contamination, biodiversity reduction, erosion, organic matter reduction, compaction, flooding and landslides.
The European Commission included the preparation of a Directive concerning soil monitoring among the initiatives of soil protection outlined in the Communication of April 2002. This Directive will be the legal base for the formation of a European monitoring network, aiming to control the soil impact course over time of the threats listed in the Communication aforementioned.
It is important to consider that this European network will have to be based on regional and national initiatives, to make best use of the experience developed in this field.
In a further stage, the data acquired with this project can be integrated with information about the areas with higher anthropogenic pressure, in order to provide an overview helping Provincia di Pavia to make the decisions concerning environment.

Scientific Committee

The administrators of Provincia di Pavia appointed a Scientific Committee in order to critically and precisely carry out the project suggesting modifications, corrections and developments.
The Control Scientific Committee is made up of experts representing national, regional, provincial and university institutional levels.
All the suggestions of the Control Scientific Committee were taken into account and applied to integrate the Pavia Project.
The report of the Control Scientific Committee is presented herein at page 9.

The Province of Pavia

The territory of the province of Pavia covers a surface of 2,965 km^2. It borders west with Piedmont, north with the provinces of Milan and Lodi and south with Emilia Romagna.
74% of the territory is plain and is part of Pianura Padana; the hill area accounts for 16%; the mountain zone represents 10% of the territory.
Pavia is the principal city of the province. The latter has 190 towns with a residential density of 167 inhabitants per km^2, considerably lower than the regional average of 375 inhabitants per km^2.
Its climate is typically continental: moderately cold winters (January is the coldest month) and humid and hot summers. Mist is a constant characteristic of its climate, also because of the presence of large bodies of water.
Within the territory of Pavia there are important rivers as the Po, Ticino and smaller watercourses such as Agogna and Terdobbio in Lomellina and Staffora in Oltrepo.
As pointed out above, three different zones can be identified in the territory of the province of Pavia: Pavese, Lomellina and Oltrepo. These geographical areas present differences of morphology, culture, traditions and soil use.
Pavese is a fertile plain whose soil is mainly cultivated with wheat, corn and rice. In order to favour this last crop, this area is crossed by a thick network of irrigation ditches and canals.
Lomellina is characterised by canals, vast expanses of water, rice fields and by the presence of woodlands and marshes.
Oltrepo is a hill area rich in vineyards. The highest mountain is Lesina at 1,724 metres high.
Parco del Ticino does not constitute a separated zone. It is a naturalistic area of great value and rich in waters where many animal, plant and flower species can be observed. The principal cultivation is rice.

Population
In 2003, population was 507,694 inhabitants (ISTAT, 2003), distributed over 190 towns. Most of the population dwells in flat land towns, a small proportion lives in hill towns and a very small part is in mountain towns.
In Pavese there are 51 towns with 166,150 inhabitants; 60 are in Lomellina with 187,300 inhabitants; the remaining 79 towns are in Oltrepo and have 136,300 inhabitants.
Pavia, Vigevano and Voghera are the principal centres and account for 34% of the inhabitants distributed over 23% of the total surface.
The residential density in 2001 was 167 inhabitants per km^2, which is less than the national (189) and Lombardia (379 inhabitants per km^2) average.

Economy
The main human activities on the Pavia territory can be classified as such: Agriculture, Industry, Carrying Trade, and Tourism.
The province of Pavia is also concerned with the progressive and unrelenting national trend of service industry expansion.
The service sector has 111,789 employees, and they are mainly in the large urban centres and plain zones. The employees of the industrial sector are 51,554 (26%), and the distribution of the activities is almost uniform over the whole province, with some zones presenting a particular density. Agriculture engages 17% of the employees (33,359), and it covers the totality of the usable territory (Provincia di Pavia, 2004).

Agriculture
The province of Pavia is characterised by a significant presence of agriculture. A trend towards reduction is noted only in some zones:

- mountain areas because of the interruption of no longer competitive agricultural practices;
- growing urban concentrations taking soil to agriculture;
- pit areas for the extraction of sandy and gravelly matter mainly located along the River Po (Provincia di Pavia, 2002).

The decrease in the used agricultural area, in the number of employees and of agricultural enterprises expresses what was observed at regional and national levels.
The agricultural and zootechnic enterprises respectively went from 33.544 and 16.085 in 1970 to 11.222 and 1.396 in 2000 (ISTAT, 2003).
The agricultural landscape changes on the basis of the availability of the water resource, which abounds on the whole territory, influencing and guiding the type of cultivation of the three zones.
Lomellina is rich in cultivations such as wheat, corn and in particular rice. Of these, rice accounts for 66%.
Woodlands, vineyards, grasslands and meadows characterise Oltrepo. Meadows are prevalently present in the mountain areas. Vine is cultivated over 14,000 hectares. Other cultivations as beet, soy and poplars (for paper production) are present to a lesser extent (Provincia di Pavia, 2002).

Sewage sludges

Intensive cropping causes an impoverishment of the soil organic matter over time. The use of opportunely treated and controlled sewage sludges is a valid alternative to the use of manure or fertilization in zones where it is hard to find due to the absence and/or lack of breeding.
In agriculture, the use of sludges respecting precise rules (assessments of the sludges chemical and biological characteristics for their agricultural use suitability, periodical analysis of soils to verify both if they can receive the sludges and if it will provoke negative alterations over time) enables us to solve two problems:

- Counterbalance and restore the organic matter loss due to intensive monoculture.
- Recover and reuse the waste organic fraction reducing the amount of wastes that have to be sent to dump and incinerators.

Soil and the sludges for soil improvement are constantly controlled (note that sludges is considered as a waste – Ronchi Decree, 1997, DGR Lombardia, 2003) to guarantee that it does not contain dangerous substances which can lead to negative alterations over time.
In the province of Pavia about 200,000-250,000 tons of sludges were used every year over an agricultural surface of 8.2 millions of m^2 from 2000 to 2004.

Organic farming

Organic farming is an agricultural production method banning the use of synthesis chemical compounds and of biologically modified organisms.
Organic farming guarantees a high level of environment respect, maintains the soil fertility, protects biodiversity and assures a high level of *"biological guarantee"* for the benefit of consumer health (CEE, 1991).
In 1993 there were 33 organic farming enterprises; ten years later they were 276, accounting for 25% of the whole organic sector in Lombardy.

Industry

The number of enterprises in Pavia territory increased over time. In 1971 they were 7,656, while in 2002 they came to 12,724.
Most of the enterprises operate in the building and manufacturing sectors. The second is principally represented by engineering, footwear, food and woodworking sectors.
65% of enterprises have from 1 to 19 employees. In the province of Pavia there are three enterprises having more than 500 employees (ASPO, 2003).
Currently on the Pavia territory there are 25 major hazard enterprises (Environmental Protection and Value Adding Sector, 2004) according to Legislative Decree no. 334/99 and the Presidential Decree no. 175/88. The energy sector falls within the industrial activities. It includes the

production of electric energy and the gas and water supply. We note that while the enterprises decreased from 1971 to 1998, in the same period the employees grew from 314 to 1,313 (Stato dell'Ambiente della Provincia di Pavia, 2004). In 1998 the renewable sources for energy production accounted for 1%. The remaining was represented by fossil fuel use.

Transports

In 2000 the overall road network of the province of Pavia was 3,200 km, comprising subsidiary roads (1,680 km), extra-urban municipal roads (1,060 km), highways (440 km) and 80 km of motorways (Provincia di Pavia, 2001).

The vehicles running in the province of Pavia in 2000 were divided as follows:

80.91% cars; 11.04% trucks; 7.9% motorbikes; 0.16% buses for public transports. The number of electricity driven cars is too small to be quantified.

The pollution provoked by internal combustion vehicles derives in part from the age of the vehicles. In 2000 the average age of the cars running on the Pavia province territory was 7.3 years; for the buses it was 10.3 years (ACI, 2000).

In 2000, the railway network covered 263 km, and it was well distributed over a considerable part of the territory. The negative aspect is the age of the rolling stock.

Tourism

Tourism has a dual importance for the economy of cities, towns or any other place both for the direct economic source and the possibility of showing and underlining the natural and artistic beauties of the territory.

A significant aspect is the connection between the tourism, its forms and modes, and the environment with its impact and protection.

Tourism exerts a noticeable pressure on the environment, above all during seasonal tourism or when the areas used are limited and the attendance is high.

In 2002, 129 accommodation services with 4,323 beds were present as a whole in the province of Pavia (ISTAT, 2003).

A significant aspect which is developing in recent years is sustainable tourism, aiming to meet the economical expectations and safeguarding the environment, and respecting the physical and social facilities as well as the population demands where tourism is present. Agritourism, being a form of eco-friendly use, is a possible answer. In 1999 in the province of Pavia there were 118 agritourisms which took the second place in Lombardy (Regione Lombardia).

The annual touristic flow in 2001 and 2002 was almost stable, with 194,000 presences (APT, 2002). The artistic heritage of Pavia and of other cities meets a significant interest. The spa of Salice Terme and wine-and-food tourism are the principal attractions. There is also an important university centre.

Sampling Methods and Results

Method selection

In the province of Pavia the human activities are interconnected and the agricultural activities prevail on the industrial, artisan and service activities. They all coexist over a territory subjected to different pressures.

The preparation of an environmental monitoring project requires very profound considerations taking into account several technical, scientific and political aspects which can have an effect on the success of the project itself.

Concerning the methods employed to identify the sampling points, standard methods have been used for collection, treatment and analysis of soil and moss samples in order to meet two essential aspects.

The first is linked to the possibility of comparing the levels obtained through other national and international experiences towards a better and more accurate interpretation of the phenomena involving soil and environment.

The second aspect is part of the *desiderata* of the administrators of the Province of Pavia: to have a network monitoring which permits the integration of information that can be collected over time in other environmental domains as air, water and biota, thus realising specific links with Regione Lombardia, the regional and provincial ARPA (Regional Environment Protection Agency) and the Centro Tematico Nazionale per i Suoli (Soil National Thematic Centre).

Soil

Sampling campaign AM1

According to the technical Annex, concerning the Contract No. 21827-2004-03 T1ED ISP IT drawn up between the Institute for Environment and Sustainability of the European Commission (Joint Research Centre of Ispra) and the administrators of the Provincia di Pavia - Settore Tutela e Valorizzazione Ambientale (Environmental Protection and Value Adding Sector), the sampling campaign called Monitoring Action 1 (AM1) was carried out using the information reported in EUROSTAT (2003).

The sampling campaign AM1 is based on the LUCAS EUROSTAT (Land Use Cover Area from Statistical Survey) network. This network was born from the collaboration between the Statistics Office of the European Commission (Eurostat) and the Directorate-General for Agriculture, and principally aims at monitoring the soil cover and use. It has the advantages of already being standardized and operative at a European level; providing significant data for the integrated assessment of soil and the related anthropogenic pressures; and disposing of detailed documentation concerning the sites to be investigated.

The LUCAS network considers grids of 18 x 18 km. A close survey is carried out in the surroundings of each mesh node called Primary Sampling Units (PSUs) of 10 sites called Secondary Sampling Units (SSUs). Sampling is carried out in the most representative of the 10 SSUs (also called Primary Point).

In the Province of Pavia there are 7 nodes of the first level network AM1. This division identifies 7 PSU areas in the territory (figure 1). In each PSU the most represented SSU (Primary Point) has been selected out of the 10 SSUs. The soil sampling is carried out within the 4 horizons (if present) up to a maximum depth of 100 centimetres.

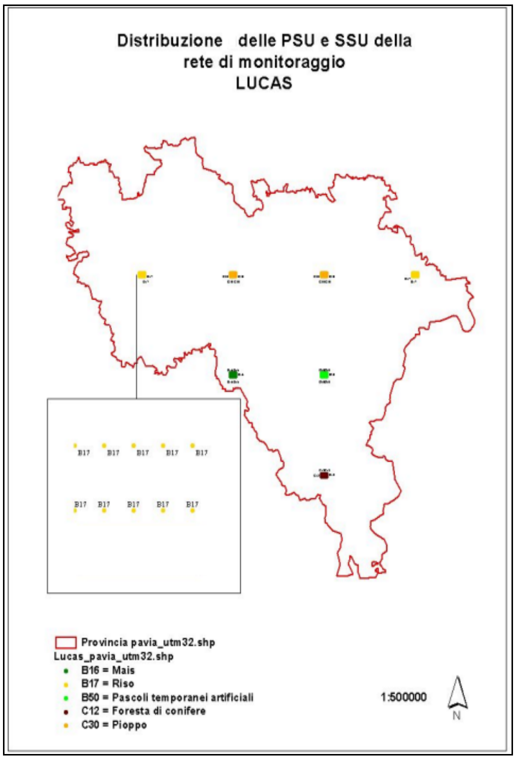


Figure 1. Sampling network LUCAS used for the Monitoring Action AM1 (the distance among SSU sites is of 500 metres)

The soil samplings for the Monitoring Action 1 (AM1) and the Sewage sludges Sub-Monitoring Action (SAMA) were executed between October 25th, 2004 and November 26th, 2004.
The soil sample collection was effected by specialized staff of the Soil and Waste Unit of the JRC – Ispra.
All the work for area surveying, sampling, transport and stocking of the soil samples is described in the SWCT-Report N°. 05/10/2004 (Sena et al., 2004) and a part of it is reported in the following.

Georeferentiation
The terrestrial coordinates of the PSUs (Primary Points), Secondary Points and Tertiary Points are reported in Appendix A. Appendix F reports the pictures, the cartographic maps and the information concerning the 7 sampling areas AM1, the area 9 SP (an example related to AM2) and Cor 13 as an example for AM3.

Sampling strategy
The sampling strategy adopted derives from the studies carried out by the French researchers (Jolivet *et al.*, 2003). It provides the creation of an area of 20 x 20 metres divided into 25 sub-areas having sides of 4 x 4 metres for each SSP selected. Samples of composite soil belonging to the respective horizons were collected up to a maximum depth of 100 centimetres using the information concerning the soil profile in advance, which were described in the Soil Survey paragraph. The litter, roots, stones and other coarse materials had been removed from the field during the sampling procedures.

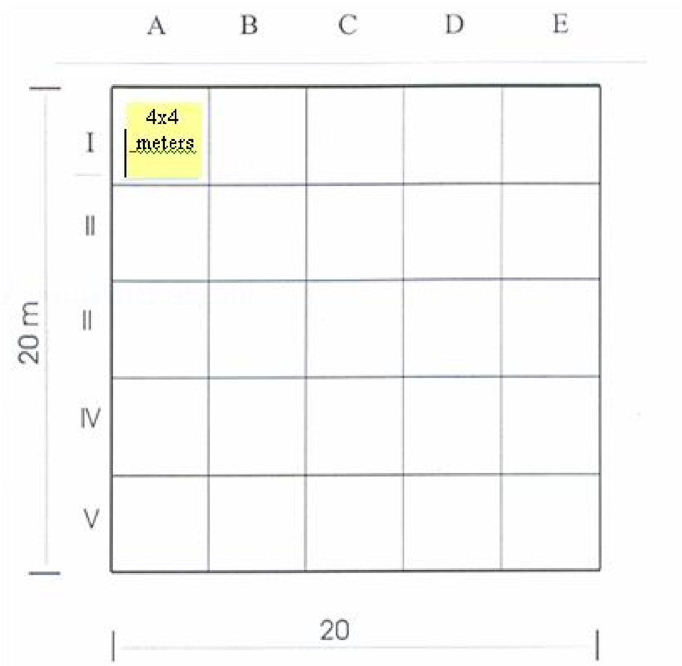


Figure 2. Type of grid used for each of the 7 SSUs

Sampling
Soil samples were manually collected by a drill using the aforementioned information (figure 3).

Figure 3. Particular of a manual drill for the collection of soil samples

The 25 sub-areas (figure 4) relative to each SSU were differently sampled as a function of the aimed analytical information described in the following.

- Dioxins: a sample was collected in each of the 25 sub-areas and was mixed on the field to form an individual sample. This process was repeated for the 4 horizons. Sample total 1 (SSU) x 4 (horizons) x 7 (PSU). Total: 28 samples. The soil samples were placed in dark glass bottles. The bottles were subsequently covered with an aluminium sheet, introduced in a plastic bag and kept frozen until the analysis. The analysis concerned only the first and fourth horizon (14 samples).

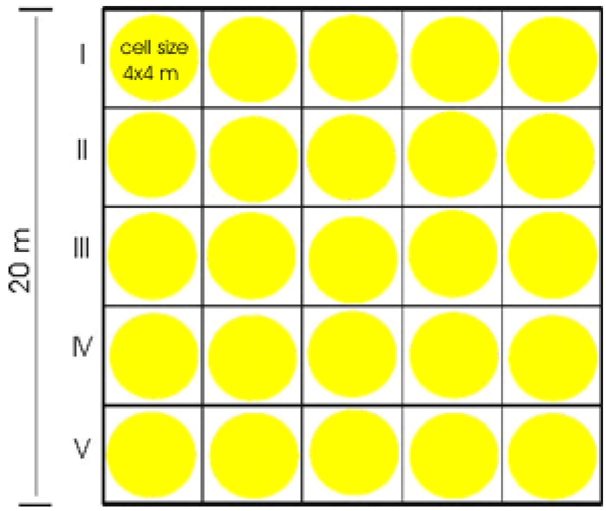


Figure 4. Dioxins analysis, sampling system for the soil samples

- Microbiology, trace elements, macro-elements, total C, organic C and pH: on the basis of the division shown in figure 4, a sample from A to E was randomly collected in every division numbered from I to V (figure 5) and manually mixed. With this operation 5 composite samples were obtained for each of the 7 SSUs. This operation was carried out for the first and fourth horizons. Sample number 5 (SSU) x 2 (horizons) x 7 (PSU). Total: 70 samples. Division by a cone-and-quartering technique was executed on each of the 70 soil samples. After having been adequately treated, the first subsample was for the measure of pH and macro-element concentration. The second subsample was delivered to the technician of the "*Università del Sacro Cuore*" of Piacenza to analyse the trace elements. The third subsample, after air desiccation of the soil samples, was delivered to the Istituto Sperimentale Nutrizione delle Piante of Rome for microbiological analyses.

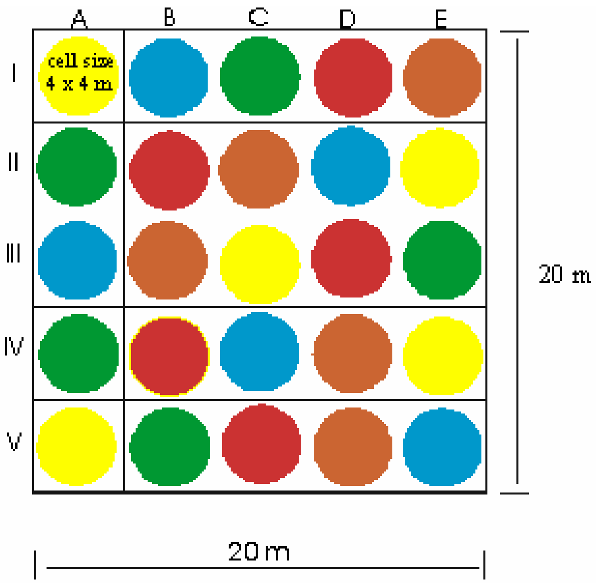


Figure 5. Random sampling method; the composite samples were obtained mixing the 5 sub-samples collected in the 5 sub-cells (same colours)

Sampling campaign AM2 and AM3

According to the technical Annex, concerning the Contract No. 21827-2004-03 T1ED ISP IT drawn up between the Institute for Environment and Sustainability of the European Commission and the administrators of the Provincia di Pavia - Settore Tutela e Valorizzazione Ambientale (Environmental Protection and Value Adding Sector), the sampling campaign called Monitoring Action 2 (AM2) and Monitoring Action 3 (AM3) were carried out by the technicians of the Università del Sacro Cuore of Piacenza, who won the bid for sampling activity, treatment and analysis of the soil and moss samples (Contract number 22438-2004-10-F1SC ISP IT).

The sampling campaign AM2 and AM3 was also based on the Land Use Cover Area from Statistical Survey (LUCAS EUROSTAT) network, using submultiples of the same. The distances among the sampling points were of 9 km for AM2 and of 3 and 1,5 km for AM3.

For AM2, 34 sampling points were identified by the LUCAS network within the area of the Province of Pavia, while for AM3 116 points were identified as a whole. The areas of interest for AM3 were recommended by the technicians of the Province of Pavia and include 6 mainly industrial localities. The areas and the respective sampling points are listed in table 1.

Table 1. Location and number of sampling points for AM3

Location	Nr of samples	Location	Nr of samples
Parona	25	Corteolona	19
Giussago	4	Pieve Porto Morone	9
Sannazaro dei Burgondi	35	Voghera	24

The collection campaign of soil and moss samples started on November the 5th, 2004 and ended on February the 5th, 2005.

Sampling strategy

The adopted sampling strategy derives from numerous researchers (Cenci *et al.*, 2003; Beccaloni *et al.*, 2004) and provides the creation of a 5 x 5 square for each point identified in AM2 e AM3. A sample of soil was collected up to 30 cm of depth at each of the four vertexes and at the diagonal intersection (figure 6). The 5 sub-samples were homogenised on the field and subsequently divided in other sub-samples, as described for AM1 action.

Figure 6. On-the-field example of sampling area delimitation

Preparation and treatment of soil samples

The ISO 11466 procedure was used for the mineralization operations of soil collected with the three Actions AM1, AM2, AM3, for the 9 SAMA samples and for the sections of the sediment samples collected in the two oxbows.

The principal directions for all the soil samples are reported:

Stove drying of soil at 40° for 72 hours; sieving with a 2 mm mesh sieve; grinding the 2 mm or lower fraction with an agate ball mill. A Fritsch mod. Pulverisette 7 planetary mill with jars and agate balls was used. The granulometry was lower than 125 microns.

Materials and methods; quality control

The following instruments were used:

Reflux system with microwave heating Prolabo mod. Microdigest 3.6, class A glassware, high-purity HNO_3 67% (w/v) (obtained by distillation of the acid by Merck with acid distiller Milestone mod. Subpur), high-purity HCl 37% (w/v) (obtained by distillation of the acid by Merck with acid distiller Milestone mod. Subpur), high-purity H_2O, prepared with Milli-Q system, multiple standard solutions prepared from standard solutions available on the market (Merck Titrisol 1.000 g/l).

About 3 g of each sample were weighed with an analytical balance directly in the reflux digestion vessels. 21 ml HCl and 7 ml HNO_3 were added. This was brought to boil and the reflux was kept for 2 hours. The solution of each vessel was quantitatively transferred with EP or BD water to 100 ml flasks. One standard sample of reference and one blank sample were equally treated every 8 mineralized soil or sediment samples. The blank sample was composed of the same quantity of reagents used for the samples according to the process described above.

Analytical methods

The trace element concentration levels of the soil, moss and sediment samples have been measured by AAS (Atomic Absorption Spectrometry), ICP-OES (Optical Plasma) and ICP-MS (Inductively coupled plasma-mass spectrometry). The instruments were selected on the basis of the elements to be analysed and of the different concentrations.

The macro-elements in soil and sediments were measured by XRF (X-Ray Fluorescence).

The hydrogen ion concentration (pH) in soil was measured using the ISO 10390 method, in KCl 2M.

The C and N concentration in soil and sediments was measured by a CHN analyser.

Bulk density and water retention

For each Primary Point and for the three areas of the SAMA Action, undisturbed soil samples were collected in double in the different horizons by a manual sampler with steel rolls with a diameter of 53 mm and a height of 50 mm.

Every sample was assessed for:

- Bulk density using the ISO method number 11272.
- Water retention at the different tensions.

The soil porosity and the saturation water content were derived from the results obtained.
The diagrams and the obtained levels were reported in Appendix B as an example.
The data confirm a moderate compaction tendency, caused by the local agricultural practices. This was generally found also in soil of the Padano-Veneta plain.

Quality of the analytical data

The quality of the analytical data was continuously monitored for all the parameters considered in this study using a proper number of Certified Materials.
We tried to use Certified Materials having a matrix which is similar to that of the real samples.
The levels measured for each element fell within the permissible variation range.

Discussion of results for soil

AM1 (pH, Ca)

All the levels measured for AM1 are reported in tables 3 and 4. The spatial distributions of the pH and calcium concentration levels result as analogous and strictly connected to the nature of the pedogenetic materials and to the evolution processes of the different types of soil. This is confirmed by the low levels observed in the profile up to about one metre, relative to Primary Point 2 (PP2). Here the carbonate washout processes with the consequent soil acidification are particularly present.
This influences the pedogenetic classification of the soil (Orthidystric Luvisol, according to the World Reference Base for Soil Resources, 1999).
In Primary Point 7 (PP7) the highest pH and calcium levels can be observed. Soils of this area are formed by arenaceous lithoidal materials rich in carbonates. Here, the pedogenetic processes determined dissolution of these elements without significant washout and the subsequent internal reorganisation of the soil (Calcaric Cambisols) (World Reference Base for Soil Resources, 1999). A similar situation is observed in the entire southern zone of the province, where Primary Points 5 and 6 are present along with the aforementioned PP7.

AM1 (Al, Fe, K, Mg, Mn, Na, P, S, Si and Ti)

The concentrations of macro element as aluminium, iron, potassium, magnesium, sodium, phosphor, sulphur, silica and titanium in Action M1 soils match typical contents of the analysed environment. The local concentrations of iron and manganese observed in Primary Point 1 (PP1) can be attributed to segregations due to redox phenomena connected to the local hydromorphy.
The concentration of aluminium, sodium and titanium shows a reduction from the North down to the South; no differences are found among the surface and deep layers. High levels are observed in Primary Point 4 at the deep layer between 75 and 100 cm. The spatial distribution of the remaining element concentration is quite homogeneous over the entire area.

AM1 and AM2 (total carbon, organic carbon and nitrogen)

The concentration distribution of the total carbon is not homogeneous in the Pavia province territory (figure 7). The highest levels are observed in southern areas. Viticulture is the prevalent crop in such areas, and present are important woodlands. Also, there is a direct relation with the presence of organic carbon: its concentration distribution is directly influenced by the soil use. Low levels even at the shallowest horizons can be attributed to the crop type (here rice fields); whereas the highest levels are found at the same horizon in the areas where the soil is assigned to forestry. The general distribution of nitrogen is almost uniform. PP7 shows the highest levels of organic carbon-nitrogen ratio, which indicates the moistening process.

AM1, AM2 (As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb and Zn)

AM1 (Primary Points)

The concentration in the seven Primary Points is homogeneous both in spatial and vertical distribution, because almost all the elements and the monitored points present similar levels at the deepest and the surface horizons.

Note how the levels of cobalt and manganese in Primary Point 1 are higher at the surface layer. The same is observed for arsenic, cadmium, copper, tin and zinc. Primary Point 2 presents analogous distributions of some of the aforementioned elements, but the sequence is inverted.

The concentration course of cobalt, chrome and nickel is associated to significant differences in the sediment granulometry or of pedogenetic origin (Primary Point 1). Local concentrations of manganese can be attributed to segregations due to reduction phenomena connected to the temporary hydromorphy.

AM2 (Secondary Points)

The concentrations of the 34 Secondary Points are reported in table 6. The levels of Secondary Point 4 were not used for statistical elaborations. This Point was subjected to a detailed observation presented in the specific report (Cenci and Sena, 2007).

Note how the considered elements do not point out particular concentration increases and how the concentration spatial distribution is almost homogeneous.

The average levels of arsenic, cadmium (figure 8), chrome, copper (figure 9), mercury (figure 10), nickel, lead (figure 11) and zinc are almost entirely within the range of Legislative Decree 152 list A of 2006 (Repubblica Italiana, 2006) and of the Guidelines of Regione Lombardia (Pitea *et al*, 1998). Concerning the analysed elements, the connection with the pH and texture levels is not very evident, differently from what is generally observed over the European soils (Utermann *et al.*, 2003).

Normally the spatial and vertical concentrations are quite low and homogeneous. In fact, the levels of almost all the elements and the monitored points are similar at the deepest and the surface horizons. This aspect allows us to state that human activity marginally and sporadically influenced and influences the increase in the element concentrations, which proved to be of prevalently natural origin.

In some soils of the River Po there are few levels of chrome and nickel which exceed the aforementioned ranges also at low depths (some metres): this can be attributed to the nature of the alluvial sediments which have deposited over the centuries.

The levels of copper (whose spatial distribution is presented in figure 9) slightly exceed the aforementioned levels of the Legislative Decree only in those areas which are or were assigned to viticulture. An example is Primary Point 6 (PP6), where the vine is present.

The cobalt level distribution is presented in figure 12. A general observation of the levels points out how the results are homogeneous and within the limits suggested by Legislative Decree 152 list A of 2006 (Repubblica Italiana, 2006). An exception is represented by Secondary Points 23 and 24, whose levels are respectively 21 and 22 mg/kg. The highest levels (chrome and nickel) are observed in the areas with fluvial sediments deposited over the centuries principally by the River Po. Their origin can be attributed to the nature of the sediments.

The distribution of the manganese levels is presented in figure 13. The distribution is almost homogeneous on the entire territory of Pavia. The Secondary Point 4 was excluded also in this case.

The occasional higher local concentrations in the centre-south zone of the province can be attributed to redox phenomena of pedogenetic origin (SP 18) and to geological conditions (SP 29 and 33).

Tertiary Points AM3 (total carbon, organic carbon, Al, N, As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb and Zn)

Tables 7-12 report the concentration levels of the elements analysed in the Pavia soils at the Tertiary Points.

Cobalt and manganese were not analysed for the soil samples of the Pieve Porto Morone area.

The survey concerning all the analysed elements (carbon forms, macro-elements, trace elements and metalloids) in soil sampled over the six prevalently industrial areas points out how in Parona, Giussago, Sannazzaro dei Burgundi, Corte Olona and Pieve Porto Morone the obtained levels match those of analogous soils where there is no direct industrial pressure, and are quite similar to those observed over the entire province of Pavia.

The chrome and nickel levels are nearly completely within the aforementioned range also in the area of Voghera, which is in the fluvial plain of the River Po.

In this area, such levels are "normal". In fact, they are due not to human activities but to the inherent nature of the alluvial sediments which have deposited over the centuries (as with analogous soil typologies).

Figure 14 shows the total carbon distribution in the areas of Voghera and Sannazzaro dei Burgondi. In the area of Voghera, the lowest levels can be attributed to the cultivation types practised. Here a peculiar kind of onion is cultivated, and this crop could be the cause of the carbon impoverishment in the soil.

The soil concentration of cobalt in the prevalently industrial areas witnesses how the present activities do not increase its concentration levels (Parona and Giussago). As pointed out above for cobalt, nickel and chrome, it is clear that the historic sediments brought by the River Po are the principal cause of the higher levels. The latter are found in the zones with a historical presence of fluvial sediments, for example Voghera, and occasionally Corte Olona and Sannazzaro dei Burgondi.

Some levels of the latter are slightly higher than the limit levels of Legislative Decree 152 of 2006.

In the industrial areas there are low and stable levels (for example Parona and Giussago), whereas more inhomogeneous and higher levels are observed in the other zones.

Arsenic and copper in the areas of Voghera and Sannazzaro dei Burgundi are shown in figures 15 and 16. The highest levels, as well as total carbon, are found in Sannazzaro. The spatial distribution of lead and mercury concentrations (figures 17 and 18) is homogeneous in both areas, with levels which are similar to those found in the province of Pavia.

The sole exception is represented by the data observed in Secondary Point 4 (SP4). Here, almost all the levels of the trace elements are particularly high. The zinc (4038 mg/kg), cadmium (34.6 mg/kg), lead (674 mg/kg) and mercury (3.15 mg/kg) concentrations are reported as an example. A further sampling was carried out in this zone extending the survey area to a 1 hectare surface where 5 independent soil samples were collected using the methods described for AM2. Four of these samples were collected at the vertexes of a square having sides of 100 metres. The fifth was collected at the centre of the diagonal intersection and more precisely at the point where the soil was previously collected. The analyses results are reported in table 13.

Geostatistical analysis *(of carbon and element distributions in soil)*

The geostatistical analysis was focused on the following elements analysed in the surface soil: total carbon, arsenic, mercury, lead, cadmium and copper. Sampling on a regular grid of 18 and 9 km was applied for the entire province of Pavia (AM1 and AM2 grids) was considered separated from the six intensified samplings (meshes of 3 and 1.5 km) carried out in specific sub-areas (AM3 grids), which characterise distribution phenomena on a different scale and proved difficult to compare. Concerning the thick sampling sub-areas, the geostatistical analysis was focused on the zones of Voghera and Sannazzaro dei Burgondi, which were considered as parts of an individual area given their contiguity.

An explorative analysis of the experimental data was realised through basic statistics, frequency distribution of the data and experimental variograms. All the analysed elements showed an almost log-normal distribution, characterised by the presence of few sampling points presenting levels up to one or two orders of magnitude higher than the database. The spatial correlation analysis of the data was carried out calculating the experimental variogram. It was then used to develop an interpolation model according to the Kriging method (Isaaks e Srivastava, 1989); for the methodological system of Carlon and colleagues (2000); and for the specific application to contaminated soils.
The spatial correlation of the data was generally significant and was sufficient to derive an interpolation function. In some cases this correlation was very weak. This indicates a spatial representativeness of the observed data which is too low to enable an interpolation assessment of the contaminant distribution. In these cases (cadmium and arsenic on a province scale, lead and mercury in the area of Voghera and Sannazzaro dei Burgondi), the contaminant distribution was represented by sampling point maps divided into concentration classes.
A model of the experimental variograms was created with spherical functions characterised by the range, sill and nugget levels reported in table 2. The intercept with the origin was set equal to zero (nugget = 0) in order to meet the measured levels. A logarithmic transformation of the data was almost always applied to normalize their distribution and to better show the spatial correlation with a new transformation in the original scale of the assessed data.
The variographic model was assessed through a cross-validation method.
The analysis was carried out with the software ArcGIS 9.0, ESRI, extension Geostatistical Analyst.

Table 2. Classification of the used variograms

Data (element, sampling site)	data Nr	Log transf.	Model	Range (m)	Sill	Nugget
C, AM1+AM2	41	YES	Spherical	41000	0.64	0
Cu, AM1+AM2	41	YES	Spherical	23800	0.72	0
Hg, AM1+AM2	41	YES	Spherical	23800	0.63	0
Pb, AM1+AM2	41	YES	Spherical	26400	0.48	0
C, AM3 Vogh/Sann	66	YES	Spherical	8750	0.63	0
Cu, AM3 Vogh/Sann	66	YES	Spherical	3000	0.22	0
As, AM3 Vogh/Sann	66	NO	Spherical	3500	12	0
Cd, AM3 Vogh/Sann	66	YES	Spherical	8000	0.28	0

As previously described, the data used concern the Monitoring Actions AM1 and AM2. The data obtained from the analysis of soil collected in the areas of Voghera and Sannazzaro dei Burgondi were used for the Monitoring Action AM3.
The total carbon distribution over the whole Province of Pavia (figure 7) points out the highest levels in the Southern area. The reasons for such a distribution are described in relation to the organic carbon, the use of the soil and the carbonates.
Figures 8 and 10 refer to cadmium and mercury (by point symbologies) and stress a uniform concentration distribution with quite low levels over the whole survey area. The area of Secondary Point 4 (where anomalous concentration levels were already observed) represents an exception.
Copper distribution is shown in figure 9: the highest levels are in the southern zone, where the soil is typically used for viticulture. High levels were also found in the SP4 area.

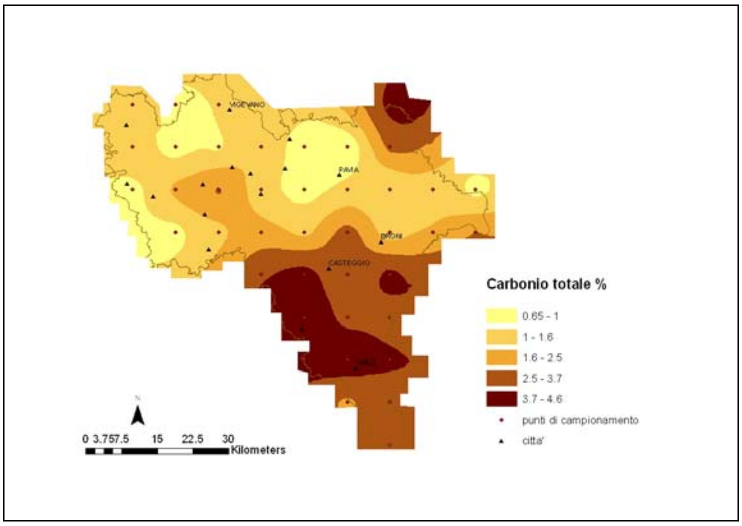


Figure 7. Spatial distribution of total carbon concentration

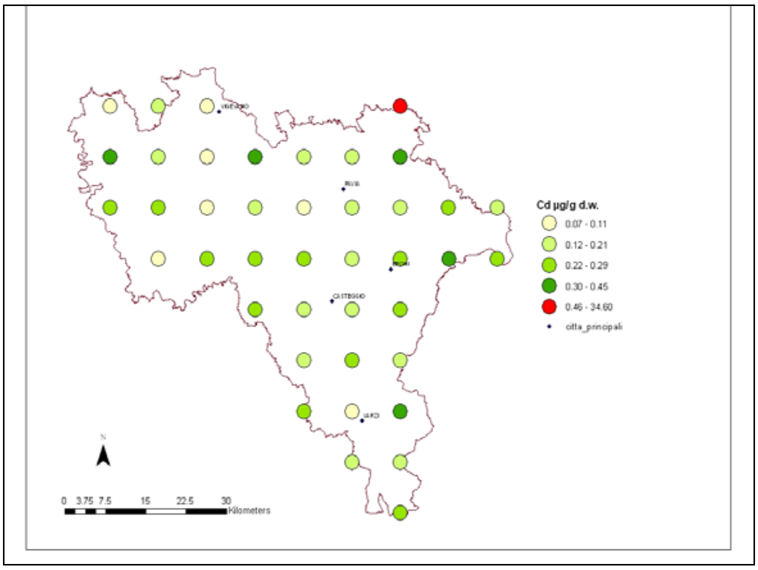


Figure 8. Point symbologies of Cd concentration for AM1 and AM2 actions

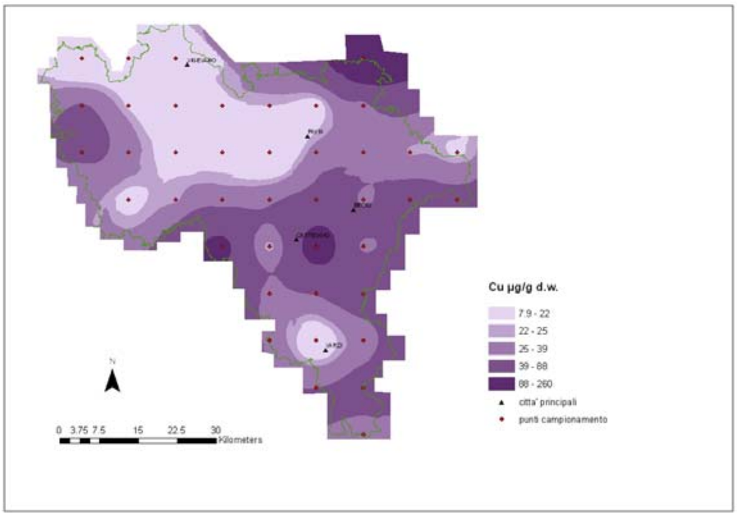


Figure 9. Spatial distribution of the concentration of Cu

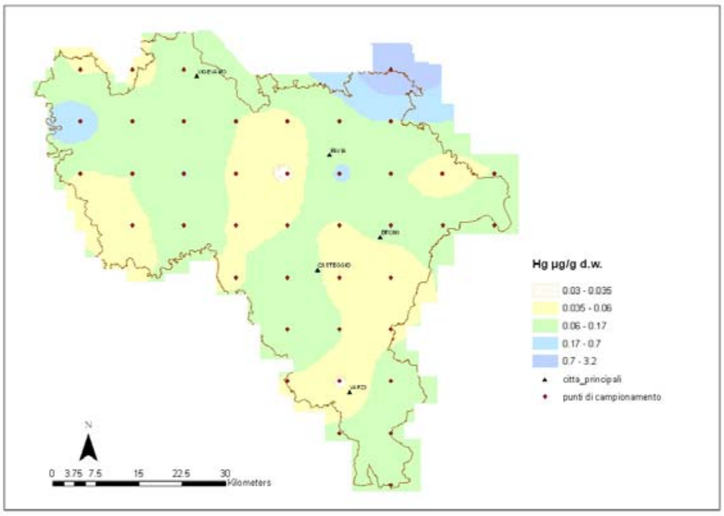


Figure 10. Spatial distribution of the concentration of Hg

Lead distribution is represented in figure 11.
Also the levels of this element are higher in the SP4 area.
The spatial distribution is characterised by stable levels tending to be higher north of the province of Pavia. These levels can be considered low and typical of moderate anthropogenic impact areas. It seems that the use of fuels containing tetraethyl lead until some years ago did not significantly contribute to the common increase in the soil concentration levels.

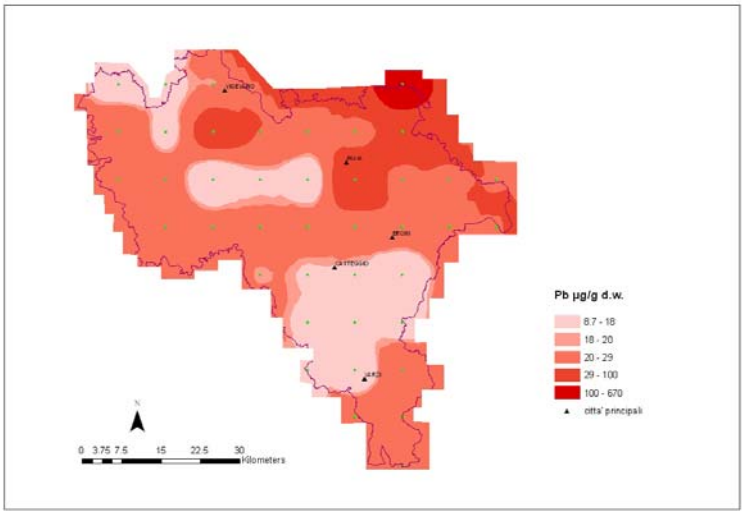


Figure 11. Spatial distribution of the concentration of Pb

The concentration levels of the areas of Voghera and Sannazzaro dei Burgondi were considered for the areas of the Monitoring Action 3 (AM3).
Figure 14 shows the total carbon distribution within the two most industrialized areas of Sannazzaro dei Burgondi and Voghera. The highest levels are found in the area of Voghera, because of a different usage of soil.

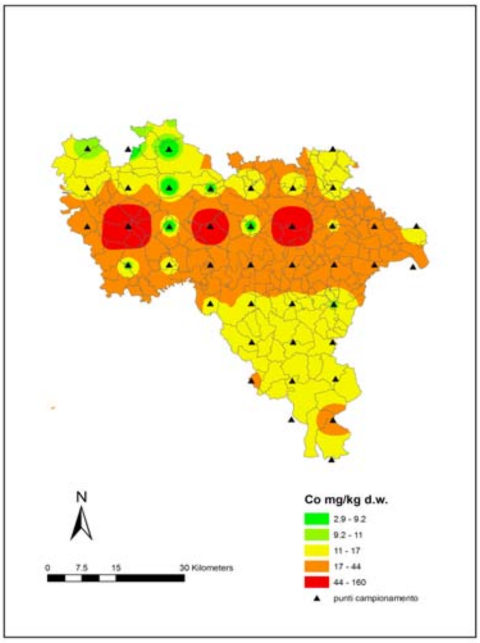


Figure 12. Distribution of Co (mg/kg) in soil of the province of Pavia

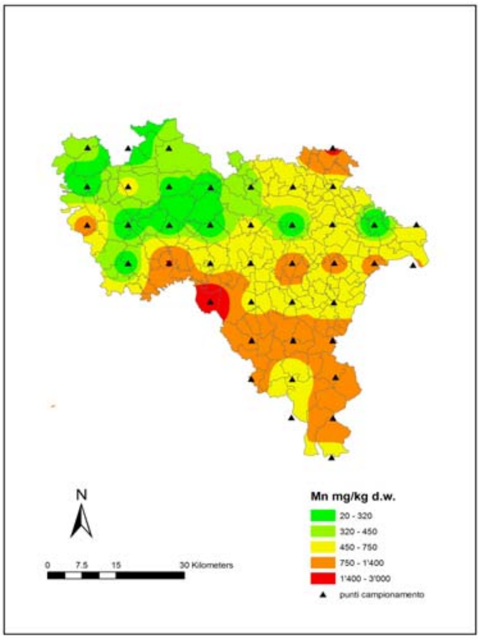


Figure 13. Distribution of Mn (mg/kg) in soil of the province of Pavia

Figures 15 and 16 show the concentration distribution of arsenic and copper. The highest levels, largely below the lower limits imposed by Legislative Decree 152 of 2006 of 1999, are present in the South-Western areas. The graphical representation of mercury (figure 17) shows an oscillating distribution over the whole area without high concentration zones. Also the levels of mercury are significantly below the national limits.

The graphical representation of the lead concentration levels is shown in figure 18. The distribution appears to be consistent and reflects what was previously observed for the whole area of the Province of Pavia.

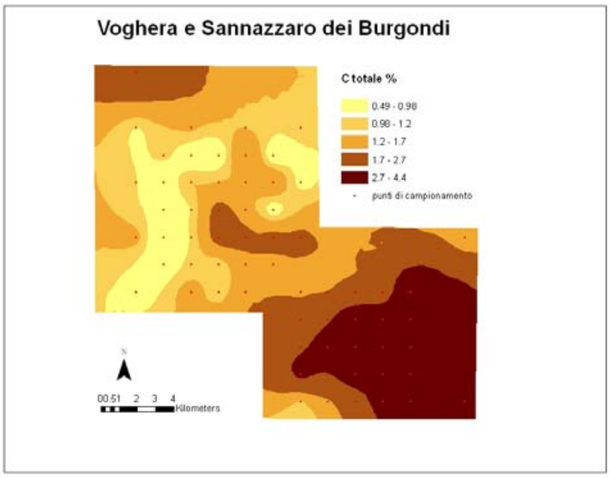


Figure 14. Concentration distribution of total C in the area of Voghera and Sannazzaro dei Burgondi

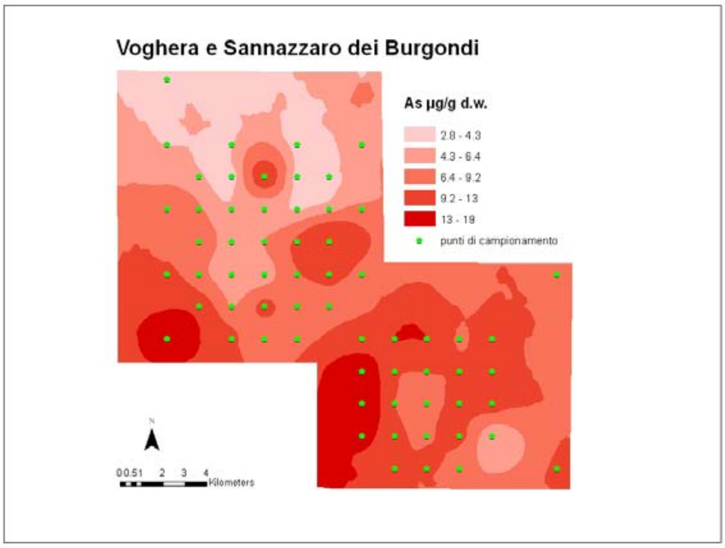


Figure 15. Concentration distribution of As in the area of Voghera and Sannazzaro dei Burgondi

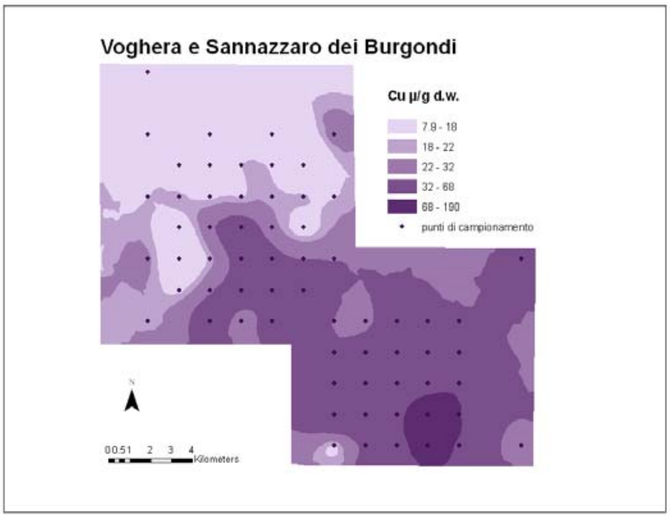


Figure 16. Concentration distribution of Cu in the area of Voghera and Sannazzaro dei Burgondi

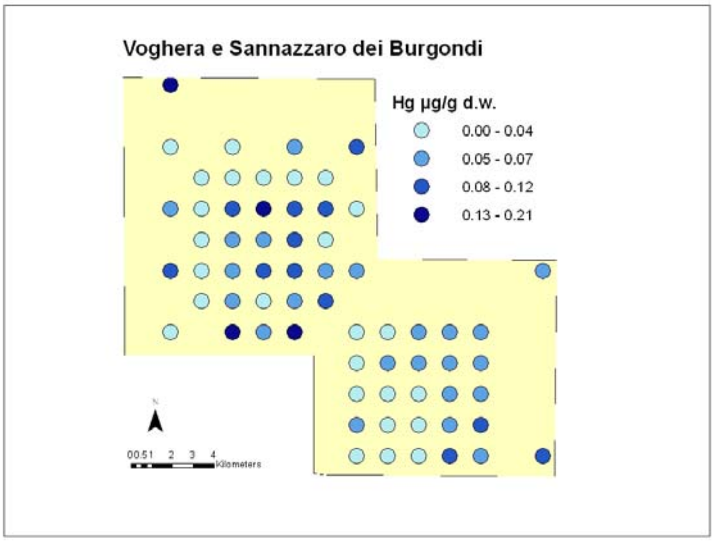


Figure 17. Concentration point symbologies of Hg in the area of Voghera and Sannazzaro dei Burgondi

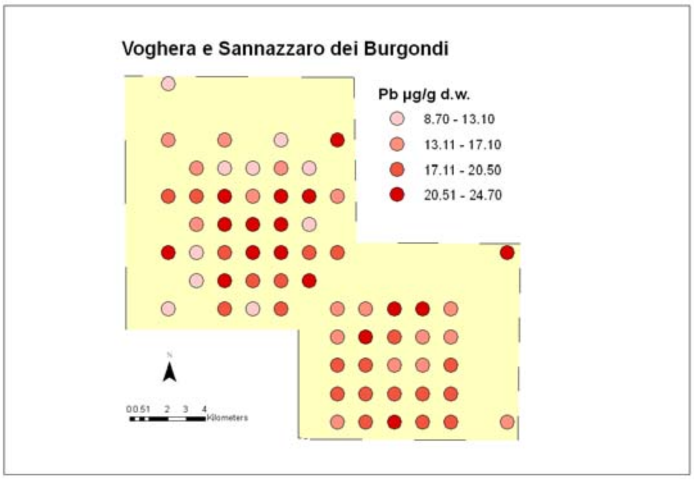


Figure 18. Concentration point symbologies of Pb in the area of Voghera and Sannazzaro dei Burgondi

Polluted area

AM2 (Secondary Point 4)

AM3 (Tertiary Point Corte Olona 51)

The analyses pointed out apparently anomalous concentration levels of some elements. Therefore, a further soil sampling was necessary with subsequent analytical control.
As previously described, anomalous concentration levels were observed in soil of the Monitoring Action 2 (SP 4) for nearly all the trace elements and dioxins. The Tertiary Point Corte Olona 51 was only reconsidered for the highest levels of chrome and nickel.
The survey was carried out over an area of one hectare, collecting 5 samples per area and working as previously described.
Table 13 reports the concentration levels of the first survey, both for soils and moss, and the levels obtained widening the survey area.
The terrestrial coordinates and the indications concerning the sampling points are:

SP04A: lat. 5019930 long. 522553.
Point B (central) about 50 m north;
Point D about 50 m west from B;
Point C about 50 m north from B;
Point E about 50 m east from B.

COR51A (central): lat. 4998930 long. 525553.
Point E about 50 m south;
Point B about 50 m west;
Point D about 50 m north;
Point C about 50 m east.

The concentrations of the elements in the point Corteolona 51 confirm what was observed in the previous survey. The chrome and nickel levels are high but of natural origin.
The 5 subsequent samplings of the SP4 area confirm the levels found in the previous sampling campaign, even if to a lesser extent.
However, high levels remain. Note that 10 months passed from the first to the second sampling, with leaching and mixing processes. The agricultural practices could have influenced the decrease of the initial levels.
A detailed analysis is necessary to evaluate the size of the contaminated area with soil samples, as well as those further down, to observe if element migration towards deeper layers occurred.

Principal Component Analysis (PCA)

The Principal Component Analysis was applied to evaluate the possible connections between the element content in the surface layers and the sampling points for the Monitoring Action AM2 (Aceto *et al.,* 2003; Grammatica *et al., 2006*).

Table 14 reports the levels in relation to the three components, while figure 19 shows the sampling point distribution.

In component 1 we can observe high "weights" of the chrome and nickel, which are of natural origin. The same is valid for copper and zinc, but to a lesser extent.

Component 2 gives a significant "weight" to the nutrients carbon and nitrogen, and to hydrogen.

Component 3 shows high values of mercury and cadmium, that are of anthropic origin as moss and not always local. Lead has recent origins, due to its use as an anti-knock element in fuels, but they are not stressed in this study.

All the sampling points are grouped in the range +2 and -2. It is assumed that the concentration values are quite homogeneous. This observation is supported by about 50% of the points falling within +1 and -1.

Stations 11 and 5 are represented in the upper part of the figure, concerning component 1. They present high levels of carbon, nitrogen and hydrogen but low levels of chrome, nickel and copper, having been less influenced by the sediments of the River Po. In the quadrant within +1 and +2, concerning component 3, there is a group of stations with higher levels of chrome, nickel and copper. These points are prevalently located in the areas most influenced by the historical sediments of the River Po.

In the quadrant within -2 and -1, the levels of nickel, chrome and copper are lower against high levels of the nutrients (carbon, nitrogen) and hydrogen.

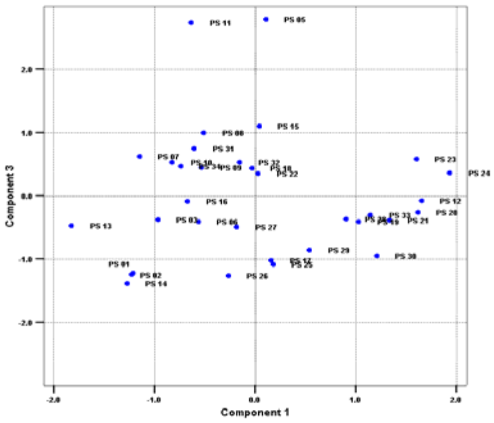


Figure 19. Graphical representation of components 1 and 3

Table 14. Levels of the considered elements for the three components

Element	Component 1	Component 2	Component 3
C	0.236	0.848	-0.159
N	-0.034	0.825	0.287
H	0.309	0.798	0.032
Cd	0.051	0.073	0.797
Cr	0.922	0.115	-0.125
Cu	0.801	0.329	0.219
Hg	-0.102	0.142	0.599
Ni	0.930	0.031	-0.148
Pb	0.056	-0.124	0.748
Zn	0.688	0.375	0.502

Dioxins

The dioxins analysis was carried out on soil samples collected as previously described. For AM1, 14 soil samples were collected in the surface and deep layers. The soil samples for action AM2 were grouped on the basis of the soil use forming 9 samples which represent 9 areas.
The individual soil samples for the 6 industrial areas were united obtaining 19 samples.
Figures 20 and 21 point out the sample groups of the area representing the Secondary Points (9 groups) and the Tertiary Points (19 groups).
For action SAMA there had been 9 samples, three for each area considering the different layers (0-5; 0-15 e 15-30 cm).
The samples for the sediment core samples were 8 as a whole. In total, 59 soil and sediment samples were analysed.

Materials and methods
The dioxins and furans analysis (PCDD/Fs) was carried out using gas chromatography coupled with high resolution mass spectrometry (HRGC-HRMS) on the basis of the official method USEPA 1613.
An internal standard mixture (16 isomers of PCDD/Fs 2,3,7,8 substituted labelled with $^{13}C_{12}$) was added to the samples upon extraction.
The extraction was made by Soxhlet for 48 hours using 300 ml of n-hexane/acetone (220/30). The extract obtained first underwent a strongly acid treatment with 98% sulphuric acid adsorbed on inert phase (Extrelut), then it was purified on an automatic system (Power-Prep P6, Fluid Management Systems (FMS) Inc., Watertown, MA, USA). This system first of all provides the passage of the sample on an acidified silica/neutral silica column, then on a basic alumina column and finally on active carbon. The obtained samples were concentrated at a small volume and subjected to an instrumental analysis.
A 60 m BP-DXN column with a diameter of 0.25 mm (SGE, Australia) mounted on a column HP-6890 gas chromatograph was used for the isomeric separation. The mass spectrometer used is the Autospec Ultima (Micromass, Manchester, UK), operating with electronic impact (34 eV) at a resolution of >10000. Two ions were registered both for the isomers to be quantified and the internal standards in order to control the typical isotopic ratio of the chlorine cluster inside these compounds: M^{+} - M^{+2} for the tetra-chlorinated classes and M^{+2} - M^{+4} for the penta-, exa-, hepta- and octa-chlorinated classes.
The isotopic dilution method was used coupled with the response factor method for the quantitative determination of PCDD and PCDF. For the identification of the various classes or isomers, reference was made to the retention times and the isotopic ratio, calculated on the basis of the ratio among the areas surveyed on the two registered ions belonging to the same compound. This ratio had to correspond to the theoretical isotopic ratio in a variability range within 15%. As a further parameter besides those aforementioned, analyses were executed to control the quality of reference materials selected among those used during previous international practices of intercalibration (Bert Van Bavel), to which the laboratory regularly participates to control all the process.
Finally, the results were expressed in Equivalent TCDD according to the indications of the WHO-TEQ (Van den Berg et al., 1998).

Results
Appendix C reports the concentration levels of the congeners for the three Monitoring Actions (AM1, AM2 e AM3).

AM1 Principal Point surface layers

The concentrations of PCDD/Fs, expressed according the WHO-TEQ agreement (World-Health-Organization; TCDD-Equivalent) for the surface lands (sampling depth of 0-10 cm a 0-25 cm), are reported in table 15. The results are within 0.52 and 1.16 pg/g with an average level of 0.97 pg/g; they correspond to the lowest part of the base levels of the surface continental values (Umlauf *et al.*, 2004). The northern areas of the Province of Pavia show higher levels.

The highest WHO-TEQ concentration level (1.6 pg/g) was observed in Primary Point 1, where chlorinated pesticides are used in agriculture. This can suggest their possible contribution to global contamination due to the PCDD/Fs traces that they contain as impurities. However, the distribution of the various isomers does not differ from that found in the other points, thus discrediting this hypothesis.

The congeners distribution over the seven sites was quite similar and is dominated by dioxins and furans at a higher chlorination degree. PP6 is exclusively dominated by octa-dioxins (OCDD), thus representing an exception.

AM1 Primary Point deep layer

As it was expected, the PCDD/Fs levels in WHO-TEQ at a depth of 70 and 100 cm were lower than the surface levels, and they were between 0.088 and 0.41 pg/g (average 0.20 pg/g). The concentration levels were largely of about 10% of the levels observed in the surface soils. Concentration differences were not noted between the northern and southern areas.

AM2 Secondary Points

The PCDD/Fs levels expressed in WHO-TEQ were within 0.52 and 11 pg/g (average level 2.1 pg/g) and are reported in table 16 (figure 20).

Secondary Point D, grouping soil of Secondary Points 4, 10, 11 and 15 (figure 20), is known for its high levels of some trace elements in soil and moss. In this area the concentration is of 11 pg/g, expressed in WHO-TEQ PCDD/Fs. This level exceeds the limits of Legislative Decree 152 of 2006, wherein the level for public and residential green areas is of 10 pg/g. The other samples point out low levels within 0.52 and 1.4 pg/g, which correspond to low continental base levels (Umlauf *et al.*, 2004). A slight trend towards higher levels is also observed for AM2 in the areas north of the Province of Pavia with respect to the southern areas. The congener distribution is similar in all the sites and is dominated by dioxins and furans with higher levels of chlorination.

Note that the highest level (11 pg/g WHO-TEQ) observed north-east of the province and resulting from the analysis of the mixture of soils collected in four Secondary Points is also accompanied by a higher level of trace elements.

Assuming that three points 10, 11 and 15 have a concentration of 1 pg/g each, the concentration level of point SP4 could be of 40 pg/g WHO-TEQ.

Further analyses will be carried out to inspect the origin of such a phenomenon with a higher spatial resolution.

AM3 Tertiary Points

The PCDD/Fs levels expressed in WHO-TEQ are within 0.78 e 4.6 pg/g (average level 1.3 pg/g) and are reported in table 17 (figure 21).

Only one area presented high PCDD/Fs levels in WHO-TEQ, but they were significantly below the limit imposed by Legislative Decree 152. It is north-west of the province and corresponds to Par A (Parona A) (figure 21), with a level of 4,6 pg/g.

As in the entire province, the remaining areas showed low levels within 0.78 and 1.8pg/g, and also AM3 points out a trend towards higher levels in the northern areas. Congener distribution over all the areas is similar and dominated by dioxins and furans with a higher chlorination degree. An exception is represented by PAR A, COR B and in part PIEV A, where there are principally hepta- and octa-dioxins (HpCDD, OCDD).

A comparison with the survey of Trezzo D’Adda (Cenci *et al.,* 2003), an agricultural, urban and industrialized area, whose PCDD/Fs levels expressed in WHO-TEQ are within 0.54 and 19 pg/g, pointed out how the levels observed in all the area of Pavia are significantly lower, apart from area SP4.

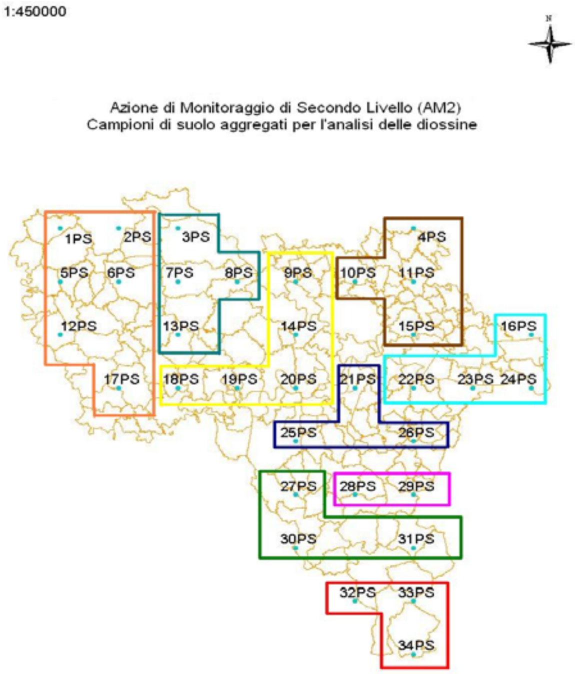


Figure 20. Division of the areas in AM2 for the collection and grouping of the soil samples

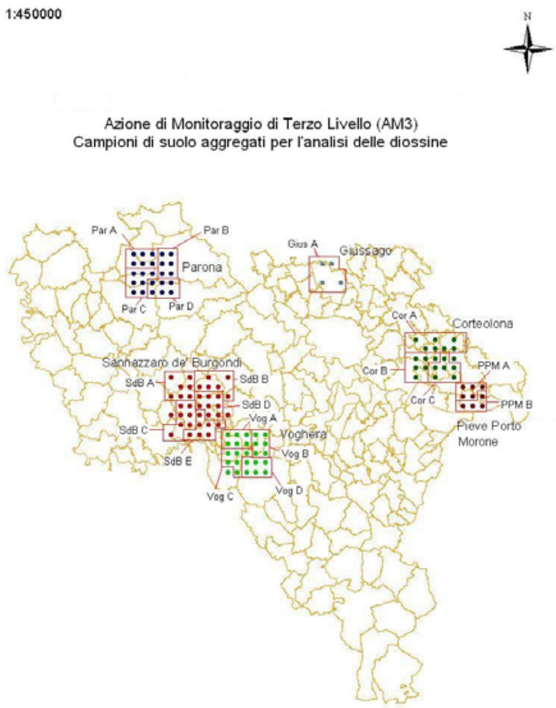


Figure 21. Division of the areas in AM3 for the collection and grouping of the soil samples

Bacteria

As described above, the analyses on all the collected soil samples concerning fertility were prepared by the Istituto CRA-ISNP (Consiglio per la Ricerca e la Sperimentazione in Agricoltura, Istituto Sperimentale Nutrizione delle Piante di Roma), on the basis of the contract number 380926 F1SC.
The soil samples of the Monitoring Action 1 (AM1) were 70 in all. They were identified in the 7 nodes of the LUCAS network and involved two depths: (0-30) cm and (70-100) cm.
For the Monitoring Action AM2, the LUCAS network identified 34 nodes in the grid. The samples were collected at a depth between 0 and 30 cm.
Action AM3 involved six sites with high anthropogenic pressure and identified 116 points. As in AM2, all the soil samples were collected at a depth within 0 and 30 cm.

Preface
The biological fertility of a soil is a very complex concept and it is determined on the basis of several biological indicators. Normally, all the parameters directly expressing the soil biological activity are used.
It should be considered that the activity of the microbial biomass of a soil is in direct relation to the quantity of organic substance, which is the energy source for its survival. Furthermore, the activity of the microbial biomass is also related to the cycles of the nutritional elements. It modulates them increasing or decreasing their availability for the plan absorption.
The parameters used as indicators in this project are presented in table 18.

Analytical methods
The organic matter (O.M.) content was indirectly estimated determining the total concentration of organic carbon (Corg) by means of the analytical method of Springer and Klee (1954). The obtained value was then multiplied by the Van Bemmelen coefficient (1.724), which is based on the assumption that the soil organic matter contains about 58% of organic carbon.
The respiration of each soil sample was measured according to the method described by Isermeyer (1952). The CO2 evolution measure was extended to the achievement of stable levels for each sample group (21 days, basal respiration) and is expressed in ppm [(mg C-CO2/ kg soil)/day].
The FE method (fumigation-extraction method of Vanace et al. (1987)) is among the most used to assess the microbial biomass. The fumigation carried out with chloroform kills the microbial cells provoking cell lysis and the release of cytoplasm in the soil permitting the cell material extraction. The obtained extracts are assessed for total organic carbon of the biomass by means of quick oxidation of dichromate.
The combination of the measures of the microbial biomass and its activity provides the measure of the microbial biomass specific activity per time unit (qCO2) expressed in h-1 (Anderson et Domsch, 1993). This is an indicator of the system state. It varies depending on the conditions and is potentially suitable for identifying carbon cycle alterations. In fact, the environmental stress forces the soil microbial biomass to use more energy for its maintenance than for its growth. This condition is represented by higher levels of qCO2, because an increased amount of C assimilated by the biomass is respired as CO2 and a reduced effectiveness in converting C in new C of the biomass is observed.
The mineralization quotient (qM) expresses the capacity percentage of the soil microorganisms to mineralize the weakest fraction of organic matter during the respiration incubation period (Dommergues, 1960).

Monitoring Action 1 (AM1) results

The results of the parameters used to determine the biological fertility are documented. They are related to the 7 Primary Points (PP), both for the surface (table 19) and deep (table 20) layers. There are five columns reporting the results for the analyzed samples (letters from α to ε) and a column with the average level. A class of fertility was assigned to each Primary Point on the basis of the results among the following classes:

Fertility class	*I*	*II*	*III*	*IV*	*V*
	fatigue alarm	stress pre-alarm	medium	good	high

Monitoring Action 2 (AM2) results

Table 21 documents the results of the biological fertility determination in the 34 sampling secondary points. Also in this case, a class of fertility was assigned to each point.

Monitoring Action 3 (AM3) results

The following tables 22-25 report the results of the determination of the biological fertility of the 116 sampling Tertiary Points. These points are divided in municipalities: Pieve Porto Morone (9), Corteolona (19), Parona (25), Giussago (4), Voghera (24), Sannazzaro dè Burgundi (35).
Also in this case, a class of fertility was assigned to each point.

Results processing for the three Monitoring Actions

Our aim is to prove that the information concerning the biological fertility, which are represented by the group of selected parameters, change with the variation of the sampling level.
This is why the study area was divided into subsets (figure 22) having the individual Primary Points (PP) as a centre. The average level and the standard deviation were assessed for the three sampling levels:

- considering the individual values of the Primary Points (PP);
- considering the values of the Primary and Secondary Points (PP + SP);
- considering the values of the Primary, Secondary and Tertiary Points (PP + SP + TP).

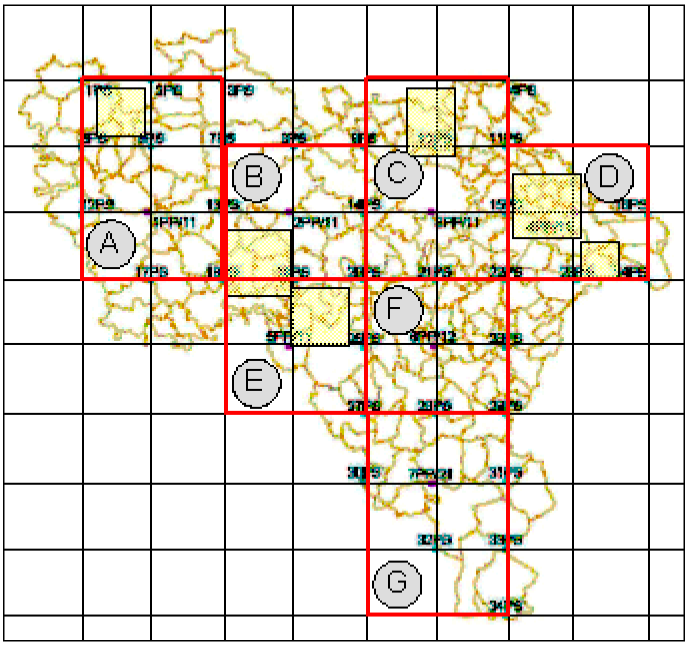
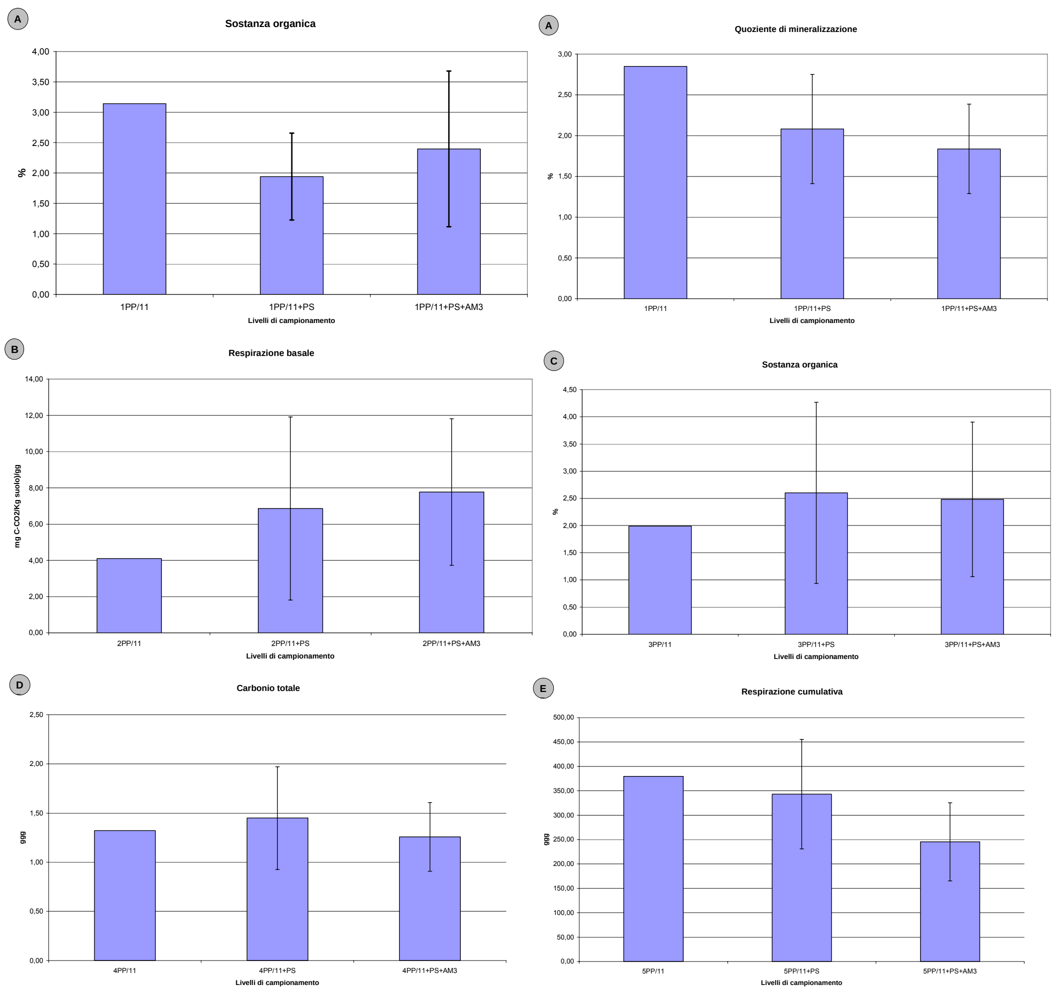


Figure 22. Division into sub-areas of the Pavia province territory. The alphabet letters indicate the sub-areas where PP, SP and TP fall.

The sub-groups comprise the following soil samples:
A: 1PP/11, 5 SP, 6 SP, 7 SP, 12 SP, 13 SP, 17 SP, 18 SP, 1 SP, 2 SP, 3 SP, par 11, par 2, par 13 , par 14, par15, par21, par22, par23, par24, par25, par31, par32, par33, par34, par35, par41, par42, par43, par44, par45, par51, par52, par53, par54, par55.
B: 2PP/11, 7 SP, 8 SP, 9 SP, 13 SP, 14 SP, 18 SP, 19 SP, 20 SP, San 11, San 13, San 5, San 17, San 22, San 24, San 23, San 25, San 26, San 31, San 32, San 33, San 34, San 5, San 36, San 37, San 42, San 43, San 44, San 45, San 46, San 52, San 53, San 54, San 55, San 56.
C: 3PP/11, 9 SP, 10 SP, 11 SP, 14 SP, 15 SP, 20 SP, 21 SP, 22 SP, 4 SP, Giuss 11, Giuss 12, Giuss 31, Giuss 33.
D: 4PP/11, 11 SP, 15 SP, 16 SP, 22 SP, 23 SP, 24 SP, cort 11, cort 13, cort 15, cort 22, cort 23, cort 24, cort 25, cort 31, cort 32, cort 33, cort 34, cort 41, cort 42, cort 43, cort 44, cort 45, cort 51, cort 53, cort 55, Pieve 11, Pieve 12, Pieve 13, Pieve 21, Pieve 22, Pieve 23, Pieve 31, Pieve 32, Pieve 33.
E: 5PP/11, , 8 SP, 19 SP, 20 SP, 25 SP, 27 SP, San 62, San 63, San 64, San 65, San 66, San 71, San 73, San 74, San 75, Vog 11, Vog 12, Vog 13, Vog 14, Vog 15, Vog 21, Vog 22, Vog 23, Vog 24, Vog 25, Vog 31, Vog 32, Vog 33, Vog 34, Vog 35, Vog 41, Vog 42, Vog 43, Vog 44, Vog 45, Vog 52, Vog 53, Vog 54, Vog 55.
F: 6PP/12, 20 SP, 21 SP, 22 SP, 25 SP, 26 SP, 27 SP, 28 SP, 29 SP.
G: 7PP/21, 27 SP, 28 SP, 29 SP, 30 SP, 31 SP, 32 SP, 34 SP.

Figure 23 reports some diagrams concerning the average levels with their standard deviations of the parameters that show a more evident change in the fertility level, as well as in the data precision, of each sub-area depending on the sampling level



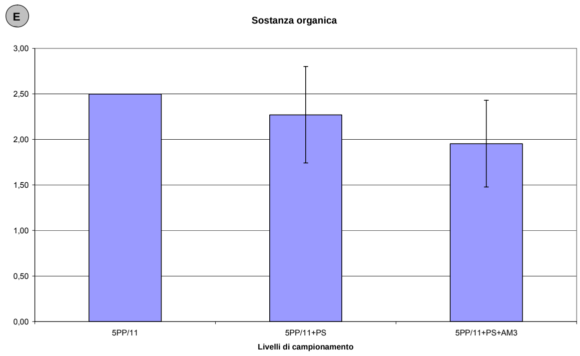
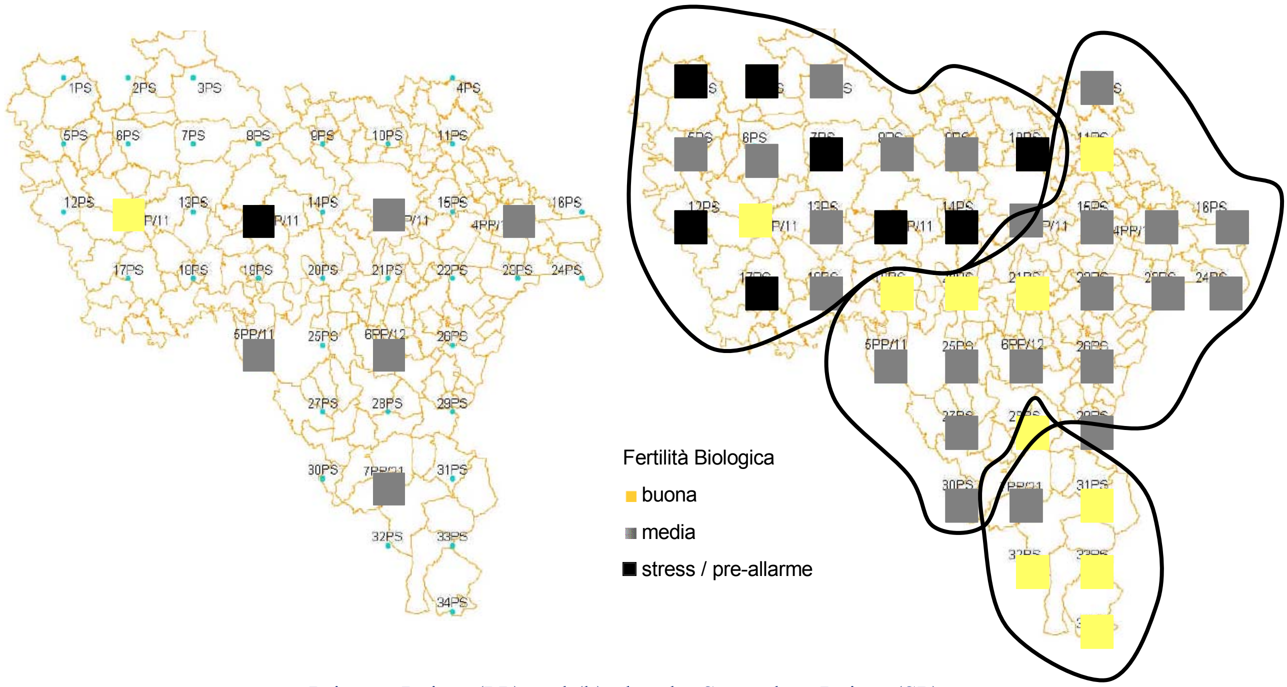


Figure 23. Average levels and standard deviations of some considered parameters

Final considerations

Figure 24 represents the biological fertility in the territory of the Province of Pavia only considering the monitoring Primary Points (a). Clearly this kind of sampling is not reliable, largely insufficient and too superficial for the elaboration of a final evaluation of the soil biological fertility. However, a situation appears which will be confirmed with the next monitoring level (b).



Primary Points (PP) and (b) also the Secondary Points (SP).

As observed in Figure 1, the whole province presents a medium-high fertility level. However, this state is more concentrated in the central zone (medium situation) and in the southernmost part (positive situation) of the territory. On the contrary, in the north-west zone the values of the analyzed parameters show a condition of slight stress in the soil biological domain.

The studied and analyzed soil samples of the six areas of the Monitoring Action 3 showed a situation of biological fertility in the monitored areas which was medium (Giussago and Voghera), medium-high (Pieve Porto Morone) and good (Corteolona). These monitoring levels were already observed over the central and south areas of the province of Pavia. The only exception is the area of Sannazzaro de Burgundi, where an existing stress condition was observed, maybe due to the presence of a refinery operating since the ‘60s. In this area there is also a pesticide factory. This stress condition is also confirmed by some soil samples of the area of Parona (the nearest points to 7SP).

The main difficulty in determining such biological parameters is the high variability of the data even moving few centimetres on the field. Therefore, the application of very detailed sampling methods brings a higher precision of the biological fertility evaluation.
Furthermore, the statistical evaluation was aimed at indicating the importance of the sampling modes in the study of the biological fertility of the soil, with the use of meshes having different precision levels. This did not occur in all the sub-areas into which the province was divided. For example, in the case of sub-area A, a first assessment gave a "good" biological fertility result derived from the determinations concerning the sub-samples of the Primary Points (table 19). However, with the analysis of the soil samples of the secondary (table 21) and tertiary (table 22-25) points as a whole, that biological fertility appeared to be of "medium" level.

Pedological survey

The pedological survey was assigned to ERSAF (Ente Regionale per i Servizi all'Agricoltura e alle Foreste), with the contract number 380515.
This investigation involved the 7 Primary Points and the 34 Secondary Points previously identified by LUCAS network. The description is in the chapter on soil sampling methods.
The charts concerning the pedological description of the 77 PP are in appendix D.

Description and identification of the pedological types
Materials and methods
Some pedological profiles were opened by means of a mechanical shovel at the seven sites of the level I network (Primary Points). This operation exposed a vertical soil wall 2 metres deep (in absence of physical obstacles as hard rock or flowing layers) and 1.5 metres wide (figure 25).
The identified horizons were described and sampled to carry out the laboratory chemical and physical analyses.
The soil character was described according to standard the method adopted by the Servizio regionale del Suolo (ERSAF, 2000). Also, the consistency between the criteria used and the ISO regulation on this subject (ISO, 1998) was verified.

Figure 25. Excavations for the description of the pedological profile (site of the level I network)

The following analyses were carried out in a laboratory according to the official methods for the analysis of Italian soils (Rep. It., 1997):
- apparent texture (6 fractions);
- pH in H_2O and pH in KCl;

- total and active $CaCO_3$ (if pH in KCl > 6,5);
- organic carbon;
- cation exchange capacity and exchangeable cations (Ca, Mg, K, Na) through extraction in barium chloride (if pH in KCl >6,5) or in ammonium acetate (if pH in KCl ≤6,5); overall acidity in ammonium acetate (se pH in KCl ≤6,5); basic saturation ratio.

Finally, soils were classified according to the taxonomic system World Reference Base (FAO, 1998) and the Soil Taxonomy system (USDA, 2003).
Appendix E reports the description of 7 pedological profiles.

In the 34 sites of the level II network the soil identification was carried out by sampling (figure 26) obtained with a manual Edelman drill, at a depth of at least 1.5 metres. The inspection stopped at lower depth only in presence of physical obstacles such as hard rocks or extreme stones content.
The Guide to soil description adopted by ERSAF (ERSAF, 2000) was used also to describe soils observed with drilling.

Figure 26. Drilling (site of the level II network)

Pedological correlation
Each soil identified in the sampling sites of the monitoring actions of level I and II was then traced back to a pedological typology (STU – Soil Typology Units) of the Lombardia soil type Catalogue (ERSAF, 2004).
The correlation criteria were principally based on the taxonomy (essentially the WRB) and the genetic characters (pedogenetic processes and sequence of the horizons). Secondly, the typical pedolandscape and the functional features were also compared; among which the chemical (pH and organic carbon content), physical (texture and rubble content) and hydrological (presence of gley characters and of permanent saturation conditions) characters.
On the whole, the profiles and the drillings represented 23 soil typologies among the 85 of the Pavia province territory (out of the 322 STUs of the regional catalogue of the Lombardy soil types). These 23 STUs account for 61% of the whole province surface.

In the following, the STUs of the regional catalogue are reported for the profiles of the level I network related to such soils along with the significant differences in their features and functional behaviours.

- Profile P1/11 - Humi-Anthraquic Gleysols (Endoeutric)

Related STU: 187 (Dystri-Umbrihumic Cambisols)
The soil has similar characters to STU 187. It differs from the latter for some modal values: it has a finer texture (silt-loam) and well defined shallower gley characters. Both their layers are at 100 cm depth.
The profile P1 is located in a valley of the minor hydrographical network, near to an irrigation ditch, on a slightly lowered surface with respect to the general level of the plain. Furthermore, the soil evolved on finer sediments (loam) than those usually characterising this pedolandscape.
Therefore, relocation of monitoring site P1 in a more representative point around the network node could be considered.

- Profile P2/11 - Areni-Epigleyic Luvisols (Profondic, Epidystric)

Related STU: 85 (Orthidystric Luvisols)
This profile falls within the typical variability range of the STU; it has an Ap horizon with gley characters in its lower part connected to its agricultural use (rice field) and a rougher texture.

- Profile P3/11 - Hypereutri-Humic Fluvisols

Related STU: 139 - Calcari-Humic Fluvisols (Hypereutric)
This profile falls within the typical variability range of the STU; it has a finer texture without rubble, which can be frequent in some soils of the STU 139.

- Profile P4/11 - Chromi-Lamellic Luvisols (Cutanic)

Related STU: 37 (Haplic Luvisols)
This profile falls within the typical variability range of the STU; this profile is reddish and presents clay films (horizon Bt1) and aggregations (Bt2) below the first 100 cm.

- Profile P5/11 - Fluvi-Vertic Cambisols

Related STU: 121 (Haplic Calcisols) also comprising soils with apical characters.
This profile falls within the typical variability range of the STU 121 representing its soils with apical characters; it shows a less evident carbonate reorganisation than the modal soil.

- Profile P6/12 - Calcari-Fluvic Cambisols

Related STU: 382 (Calcaric Cambisols)
All the parameters of this profile correspond to the typical mode values of STU.

- Profile P7/21 - Calcaric Cambisols

Related STU: 386 (Calcari-Leptic Cambisols)
This profile falls within the typical variability range of the STU. It differs from the latter for its rougher texture due to an arenaceous substrate. However, these differences do not significantly influence the hydrological and functional behaviour of these soils. It represents the deepest soils of the STU 386 also comprising finer soils which are confined by hard rock.
All the sites of the level II network can also be related to representative STUs of the province of Pavia.
Generally, the differences are always limited and can be referred to the natural variability within the STUs. These differences are principally connected to the drainage (gley characters, extreme

hydromorphy) and the presence of more or less defined calcic horizons. In some cases the differences of certain characters with respect to the mode value are stressed by the fact that the morphological position of the site differs from the typical STU position. An example is the relation between a site located on a steep versant and a STU with a less sloped morphology.
In other cases, the site is located in pedolandscapes with a limited extension; thus, it represents soils which are less widespread than the surrounding soils. It is for example the case of sites located in minor valleys, with less developed soils, within surfaces which on average are older and characterised by a different hydrological behaviour of the pedological covers.

Pedological representativeness of the monitoring network

A monitoring network set on a fixed grid has the risk of providing information regardless of proper knowledge of the site soils. Therefore, it is necessary to accurately study and distinguish soil characterising the network to assess the actual representativeness of the grid and to be able to extend the precise observed information to surrounding areas characterised by similar soils.
The analysis of the site pedological representativeness also has the aim of permitting a complete and effective interpretation of the monitoring data. In fact, the chemical and physical characters of soil, which can be related to the pedogenetic processes, influence their behaviour and features (which can vary over time), also in case of a contamination by trace elements.
All the sites of the level I and II network of the province of Pavia can be associated to significant and common soils.
The majority of the 23 STUs related are represented by one site; however, there are some STUs which can be related to more than one site (e.g. 7 sites for the STU 386 and 5 sites for the STU 37).
Leptosols and Luvisols are "significant" STUs (in terms of area diffusion or of type peculiarity) which are not represented. In the province of Pavia, Leptosols are typical of some river environments (above all in the valleys of Sesia and Ticino). Luvisols are deeper and older, and characterise the Pleistocene terraces at the Appennini margin and on the relief of San Colombano.
With the spatial distribution analysis of the monitoring network in relation to the big morphological environments of the province, we can observe that all the principal pedolandscape are well represented (figure 27). The most represented is the "low sandy plain" (15 sites), followed by the alluvial plains (7 sites), the fluvial terraces (4 sites), the alluvial plain of Oltrepo (3 sites) and the hydromorphic medium plain (1 site). The other sites are located in environments belonging to the Appennini hill (7 sites) and mountain (4 sites) areas.
The area of the old terraces at the Appennini margin (2,9% of the province territory) is the only landscape typology which is not represented.

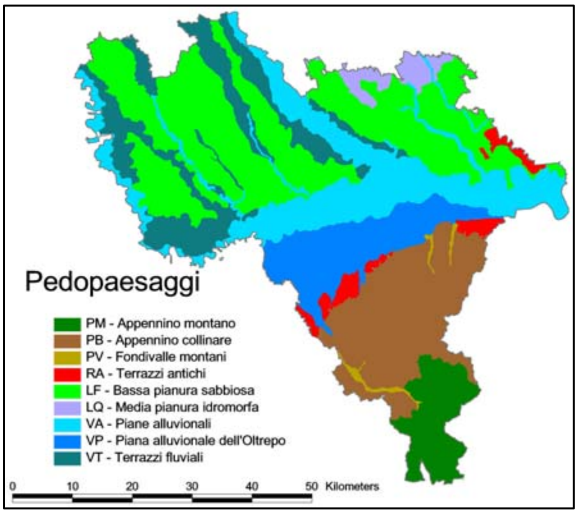


Figure 27. Pedolandscape of the province of Pavia

Geographic elaborations and functional representativeness of the monitoring sites

Data origin

The monitoring evaluation of the geographical representativeness is based on the analysis of the spatial distribution of the following soil features, referred to the surface horizon (0-30 cm):

- reaction
- texture
- total organic carbon

These parameters were derived from the geo-referenced database of the soil at a 1:250.000 scale of the region (ERSAF, 2004). The information layer of this map has every traced polygon associated to a dominant STU (Soil Typology Unit) and to one or more subordinate STUs (at most four), whose relative surface is known.

Specifically, the values of the three features were determined with the following criteria:

- reaction: the pH value (in H_2O) of the first 30 cm of soil was derived from the weighed average of the data referred to the horizons within this layer. Then, the obtained value was represented in terms of class, using the ranges reported in table 26;

Table 26. Used pH ranges

class	value	reaction
1	≤ 4.5	very acid
2	> 4.5 e ≤ 5.5	acid
3	> 5.5 e ≤ 6.6	sub-acid
4	> 6.6 e ≤ 7.3	neutral
5	> 7.3 e ≤ 7.8	sub-alkaline
6	> 7.8 e ≤ 8.4	alkaline
7	> 8.4	very alkaline

- texture class: it was defined on the basis of the weighed average of clay, silt, sand in the horizons within the first 30 cm of the soil, which identified the corresponding texture class USDA;
- organic carbon: the total carbon (in kg/m^2) of the first 30 cm of soil, without the surface organic horizons, was calculated according to the formula (Batjes, 1996):

$$T_d = \Sigma [\rho_i \cdot P_i \cdot D_i \cdot (1 - S_i)]$$

wherein:

T_d = total content of organic carbon (mg/m^2)
ρ_i = density of each *i*- layer (mg/m^3)
P_i = content of organic C of each *i*- layer (g of C/g of fine soil)
D_i = thickness of each *i*- layer (m)
S_i = volume (%) of the fragments with a diameter > 2 mm in each *i*- layer.

Geographical model

According to the criteria of the Eurogrid/INSPIRE initiative, a resolution grid of 1 km x 1 km which provides a cover of the province of Pavia made up of 3234 cells was used for the geographic representation of the parameters. The intersection between the soil chart and the grid

assigned a one-to-one value of the reaction and texture classes and of the total organic carbon content to each cell of the grid.
The "dominant class" was identified and mapped in the case of the "reaction" and "texture" parameters. This class distinguishes the biggest surface of the soil areas within the geographic space contained by each individual cell.
The effective content of organic carbon of the entire cell was calculated considering both soil comprising the cell and the non-soil areas (urbanised surfaces, water areas and barren areas). In the calculation, a null value was assigned to the latter. Therefore, the sum of the values of all the cells directly gives the estimate of the whole carbon stock in soil of the province of Pavia.
The following section on cartography represents the organic carbon data using the following classes, whose ranges are obtained by a statistic elaboration of the data of all the cells of the province:

class	CO (kg/m^2)
1	≤ 1
2	> 1 and ≤ 3.8
3	> 3.8 and ≤ 4.7
4	> 4.7 and ≤ 5.3
5	> 5.3 and ≤ 6.3
6	> 6.3

"Confidence level"
In the end, the three elaborations are accompanied by a representation of the "confidence level" which can be attributed to the so produced cartography.
The "confidence level" of the reaction and texture classes is expressed associating to each cell of the grid the percentage of the soil surface characterised by the "dominant class" assigned to that cell with respect to the total soil surface.
The incidence of the non-soil surface with respect to the total surface was considered to represent the "confidence level" of the organic carbon content of the chart. In fact, the average carbon content of the cell progressively differs from the actual soil content with the increase of non-soil areas. Thus, it results lower. The size and the spatial distribution of the non-soil areas were derived from the Destination of Use chart of the agricultural and forestal soils of Regione Lombardia (ERSAF, 2003).

Cartography

pH chart
The chart (figure 28) shows that in the province of Pavia there are soils belonging to all the reaction classes, apart from class 1 ("very acid" soils with pH $\leq$ 4,5).
The soil pH largely depends on the type of substrate and on the origin of the sediments on which the soils developed.
The western area of the plain north of the River Po is composed of fluvial sediments of alpine origin (Sesia and Ticino basins), while the easternmost area is of prealpine origin (Olona and Lambro). This sediments range from "acid" to "neutral"; in fact, the horizons of Lomellina, in the valley of the River Ticino and in the plain of Pavia up to the Lodi boundary, range mainly from "acid" to "sub-acid".
Along the valley of the River Po and in all Oltrepo there is a prevalence of deposits deriving from the Appennini basins (characterised by pH over neutral values). Here, the soil reaction ranges

from “sub alkaline” to “alkaline”, and in some zones it has values exceeding 8.5 (“very alkaline” reaction class).
Soils of “neutral” reaction are not very widespread and have a local concentration.

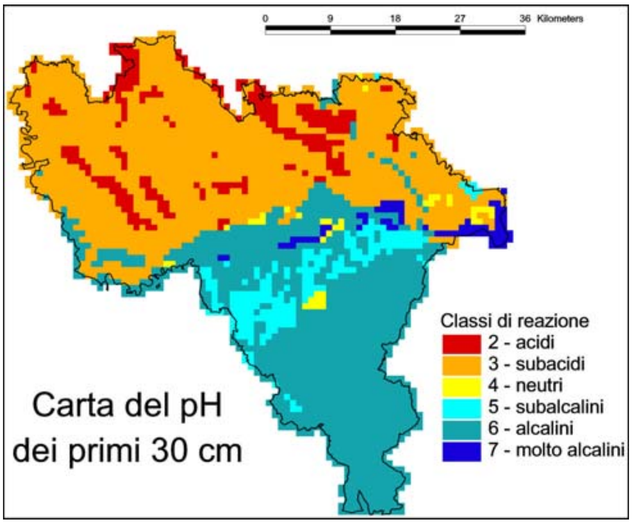


Figure 28. Chart of the pH value

The soil reaction is a relatively stable feature with low variations within small areas, as pointed out in the analysis of the “confidence level” of the pH chart (figure 29).
The greatest uncertainty is observed at the valley systems because of the natural heterogeneity of the sediments which generates a higher variability in the soil reaction. However, this local variability remains within a class of pH, with the exception of the boundary areas between the Po alluvial plain and the most acid surfaces of Lomellina and Pavese, where it can be higher.

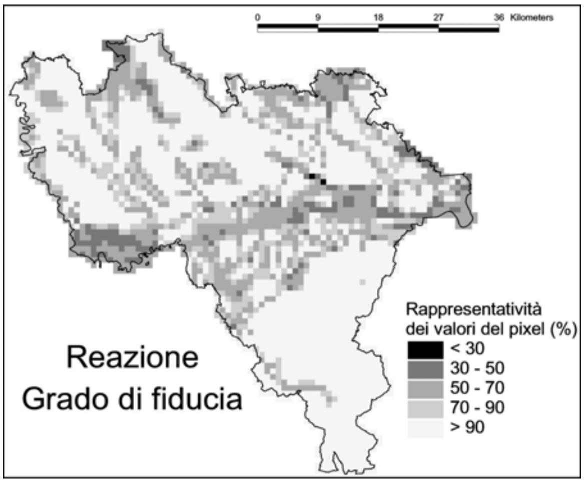


Figure 29. Chart of the confidence level of the reaction data

Texture chart
The wide range of reaction classes corresponds to an equally wide variety in the granulometric composition of the province’s soil.
In fact, all the texture classes are represented, with the exception of the “Silt” and “Sandy-clay-loam” class (figure 30). In connection to what observed for pH, the roughest textures (average clay content of less than 20%) are found north of the River Po. Here there is a prevalence of soils

ranging from Sand and Loamy-sand to Sandy-loam in Lomellina and from Loamy-sand and Sandy-loam up to Loam in Pavese land.

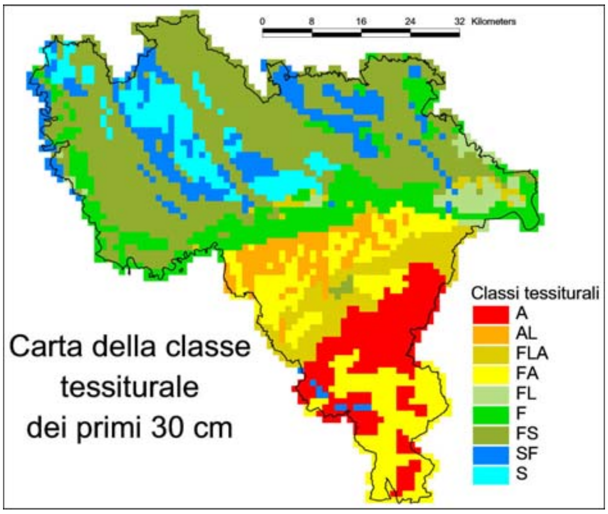


Figure 30. Chart of the texture class

South of the River Po there is the prevalence of finer textures, with an average clay content of 30% higher and a more marked silty component (silt content higher than 40%). In the northernmost part of the plain of Voghera and on the Apennine's low hills, characterised by a marly and calcareous lithology, the Silty-clay and Silty-clay-loam texture classes are the most common.

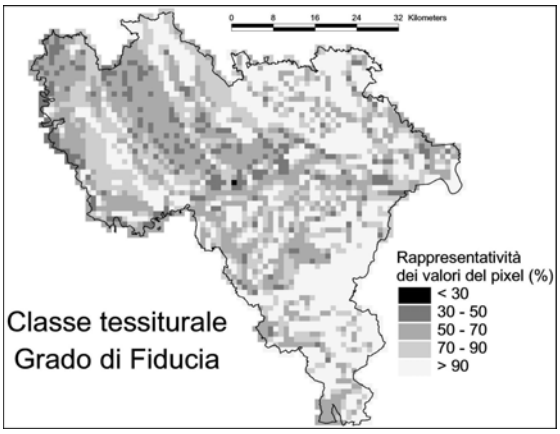


Figure 31. Chart of the confidence level of the texture data

Finally, soil characterising the Po alluvial plain show a more balanced texture in the surface horizons which on average is Loam or mostly Silt-loam in the easternmost area.
The considerations made for the reaction are also almost valid for the local variability of the soil texture. In this case, in Lomellina and in the Voghera plain a higher heterogeneity is observed, which is however within contiguous textural classes (figure 31).
Finally, note that the granulometry of the soil of the province of Pavia is characterised by a very limited presence of stones. In fact, it is locally found in the northern part of the province (above all in the valley of the Agogna stream and of the River Ticino) and in the mountainous Appenninic landscapes.

Organic carbon chart

The overall amount of organic carbon within the first 30 cm of the soil of the province of Pavia is of 14.3 million tons, corresponding to about 11% of the regional stock (Reg. Lomb. - ERSAF, ongoing project).

All in all the plain, given its spread (nearly 80% of the total), is the area of the province accounting for the highest carbon stock (figure 32). However, the soil contents are lower (4.8 kg/m^2 on average), with the lowest levels at the foot of the Apennine versants (terraces of Voghera and Stradella), on the terrace of San Colombano and in Lomellina.

On the other hand, soil of Apennine (above all the Luvisol of the low-hill zone and the Fluvisol of the thalwegs) point out a higher unitary content (on average 6.5 kg/m^2 at the hills and 6.3 kg/m^2 at the mountains).

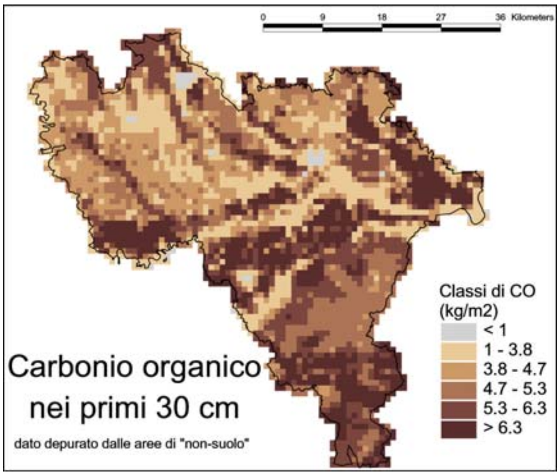


Figure 32. Chart of the organic carbon content

As previously explained to represent the "confidence level" of the organic carbon content chart, the percentage of non-soil was considered with respect to the total surface (figure 33). The areas with a higher presence of non-soil present a total organic carbon content which is quite different from the actual unit level of soil.

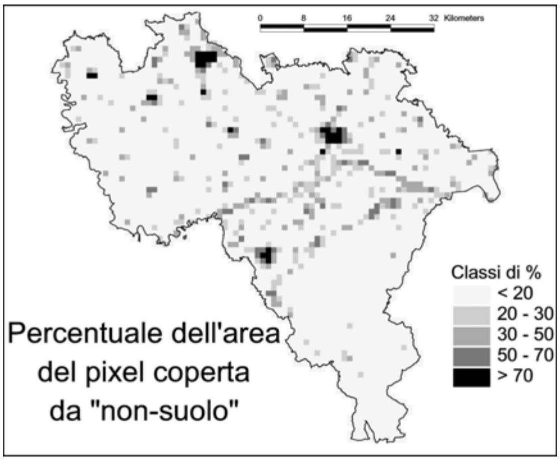


Figure 33. Chart of the percentage of pixels covered by "non-soil"

To this regard, the territory of Pavia (which has a total surface of about 296,490 ha) is comparatively less urbanized, with respect to other provinces in Lombardia. The sealed surfaces account for about 7.9% of the entire territory, against a regional average of 12%. These surfaces are concentrated inside and around the urban centres and along the principal roads of the province.

To build up this chart, also the water areas (1.2% of the province) and the barren areas (0.9%) were considered among the "non-soil" areas.
Thus, the surface which presents a pedological cover accounts for 90% of the province (DUSAF, 2003 data).

Functional representativeness of the monitoring sites

Table 27 reports the levels (reaction, texture and organic carbon content of the first 30 cm) observed in the 7 sites of the monitoring network of level I and in the 34 sites of the network of level II (only their minimum, medium and maximum levels are reported) to evaluate the representativeness of the monitoring sites concerning the examined parameters.
All in all, the monitoring networks of level I and II are sufficiently representative of soil of the province of Pavia for the examined parameters.
The reaction of the classes 1 (pH < 4.5) and 7 (pH > 8.5) is not represented. Nor does class 4 (6.7 < pH < 7.3) appear in the sites of the level I network. Moreover, in this province there are not very acidic soils (class 1), and neutral (class 4) and very alkaline (class 7) soils are not very common.
All the texture classes are represented as a whole in the sites of the level I and II networks, with the exception of the "Silt" and "Sandy-clay-loam" classes, characterising soil types which are not present in the Province of Pavia.
Moreover, the sites of level I do not present "Clay-loam" and "Clay" soils, which are common in wide areas of Oltrepo.
The average content of carbon in the sites of the level I network is of 5.6 kg/m^2, ranging from 4.6 to 6.4 kg/m^2. Instead, in the level II network the greater number of "soil-soil use" combinations produces a higher variability and the medium, minimum and maximum levels were respectively of 4.9, 1.2 e 12.6 kg/m^2.

Table 27. Levels of pH, texture and organic C for Primary Points

	site	pH (class)	texture	CO (kg/m^2)
level I Network	P1/11	2	F	6.2
	P2/11	3	SF	4.6
	P3/11	5	FS	6.3
	P4/11	3	F	6.4
	P5/11	6	FLA	6.0
	P6/12	6	FLA	4.8
	P7/21	6	FS	5.0
	mean			5.6

	value	pH (class)	texture	CO (kg/m^2)
level II Network	min	2	A	1.2
	mean			4.9
	max	6	S	12.6

The unitary carbon content derived from the regional soil inventory on a 1:250,000 scale ranges from 1.17 kg/m^2 to 33.86 kg/m^2 (the highest values, > 10 kg/m^2, are much localized and not frequent). The average value is 5.7 (± 4.42) kg/m^2.
The two sets of data are not perfectly comparable because of their differences in site number and localization, but the observed levels suggest a general correspondence.

Pedological correlation of the soil of the level II network

Soils of the level II network sites (Secondary Points) were compared to STUs of the soil regional catalogue (scale 1:250,000). All the sampled soils fall within the typical range of variability of the relative STU, and in some cases some of their parameters are different from the modal values.
In general these differences are limited and connected above all to drainage (gley characters, extreme hydromorphy) and to the presence of calcic horizons which are fairly well defined.
In some cases the differences of certain characters with respect to the mode value are stressed by the fact that the morphological position of the site differs from the typical STU position. An example is the relation between a site located on a steep versant and a STU with a less sloped morphology.
In other cases the site is located in pedolandscapes with a limited size; thus, it represents soils which are less widespread than the surrounding soils. It is for example the case of sites located in minor valleys, with less developed soils, within surfaces which on average are older and characterised by a different hydrological behaviour of the pedological covers.

Table 28 summarizes the information concerning the soil classification surveyed by means of pedological drilling in the sites of the level II network, the classification of the related STU and any difference between the soil of the site and the modal values of the STU.

Moss

Sampling
Sample of moss was collected in proximity of each of the 7 Primary Points of AM1, where soil was sampled, in the 34 points of AM2 and in the 116 points of AM3. Such a sample had a minimal weight of 30 g and was composed of several sub-samples collected in an area of about 400 m^2 in the surroundings of each sampling site.

Preparation and treatment of samples for trace element analysis
The preparation and the treatment of all the moss samples were carried out according to the method A.N.P.A. (Cenci, 1999).
The principal indications concerning the treatment of the moss samples are reported:
In the laboratory, the moss is withdrawn from the envelope and deposited on a bank with a ceramic flat surface using new or washed with High-Purity (HP) water latex gloves. The first apical 3 cm up to a fresh amount of 10-20 g are cut with plastic scissors. Thus, the greenest *caulidia* were privileged. The moss *caulidia* were put in a glass crystallizer, which was previously washed with HP water, and covered with a clock glass. The crystallizer stayed in stove for 72 hours at a temperature of 40 °C. Then, the dried moss was ground by means of a mill with an agate body and spheres (Fritsch planetary mill model Pulverisette 7). The granulometry of the ground material is lower than 125 microns. The ground moss is conserved in a polyethylene container with double plug, previously washed for the analyses.

Digestion of samples
The following instruments were used:
Microwave oven with a power of 600 W and a frequency of 2450 MHz (microwave oven CEM model MDS 2000), sample containers of TFM (Teflon). High purity HNO_3 67% (w/v) (derived from acid by distillation with acid distiller Milestone mod. Subpur), high purity H_2O_2 30% (w/v) (Merck); high purity H_2O type Milli-Q, multiple standard solutions prepared from standard solution available on the market (Merck Titrisol 1,000 g/L). In addition, 40 samples were further mineralized by microwaves in aqua regia to determine Pt and Rh.

As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb and Zn content
The uncertainty of the laboratory analytic data concerning moss was estimated for three different concentration levels. It corresponds to the formula of *Horwitz and Albert (1997)*.
Tables 29, 30 and 31 (a-f) respectively report all the values of the trace elements of the sites AM1, AM2 and AM3. *Table 32* only presents the average values of the three actions compared with the average values observed in other European and Italian areas. The lower part of *table 32* also reports in bold text some particularly high individual concentration values found in the 157 monitored areas.
The Monitoring Actions AM1 and AM2, respectively 7 and 34 sampling points, cover the entire area of the province of Pavia with a sampling density of about 70 km^2 per individual sample.

Concentration spatial distribution
A first “general” observation suggests that the concentrations of all the analysed elements in this monitoring are quite reduced and have a stable spatial distribution over all the territory.
This is principally due to the fact that the territory of the province of Pavia presents areas of mainly agricultural use, with an almost total absence of extended and significant contamination sources. *Figures 34 to 43* illustrate the spatial distribution of the concentration values of the 10 elements considered in this study.
There are few points in which the concentrations of some elements are quite high.

For example, point PP2 presents high concentration of copper (116 mg/kg) and zinc (760 mg/kg), and to a lesser extent cadmium (0.61 mg/kg) and lead (23.8 mg/kg). The cause of these high values could be the presence of a very used road, electric poles (copper and cadmium) and a factory producing plastic films (cadmium).
PP6 also presents high concentrations of copper (805 mg/kg). The reason for this high level is that the sampling site (Corvino San Quirico) is in an area of vine cultivation. This points out the moss peculiarity as a high selectivity bioindicator.
Among the Secondary Points there are few areas with high values. An example is SP4, at the north-east boundary of the provinces of Pavia and Milan. Here, the soil elements levels are particularly high (cadmium 34.6; chrome 269; chrome 264; mercury 3.2; lead 674 and zinc 4038 mg/kg). Such values suggest a contamination by polluting residues deriving from electroplating factories. Moss reflects what observed for soil. The concentrations were: cadmium 2.5; copper 40, lead 42 and zinc 359 mg/kg.
The Secondary Point 11 is 9 km south of the SP4 and shows a high value of cadmium (1.45 mg/kg) which is barely explainable.
The SP 26 is in an area cultivated with vine and thus the values of copper (366 mg/kg) and cadmium (1.13 mg/kg) are significantly high. The agricultural use of cadmium is recognised as a pesticide.
Finally, the SP17 shows high levels of cobalt (7.8), chrome (45), copper (29), manganese (1285), nickel (42) and zinc (132 mg/kg). The area is assigned to corn cultivation and it apparently does not present anthropogenic pressures.
The general situation of the six Tertiary Point areas, including important industrial plants, can be regarded as positive. An exception is represented by some individual points where the principally industrial local activities could have contributed to the increase of certain elements.
The comparison between the obtained data in the Parona inspection of 2001 with the current values underlines an almost identical situation. This suggests that human activities as a whole had the same influence over last three or four years.
The comparison with Italian experiences in urban-industrial zones, for example Trezzo D'Adda, assures the quality of the obtained data.
A consideration has to be made for chrome and nickel: the measured values are higher than the Italian and other European nation average, and the cause could be in the soil itself. The ERSAF and ARPA Pavia communications (personal communications) and this study confirm that in a part of the Pavia soils the values of these two elements are naturally between 100 and 200 mg/kg. These soil higher levels, upon capillary rise processes and/or for agricultural practices as soil tillage with the production and the dispersion of powders, could be one of the reasons for an increased concentration in the moss.

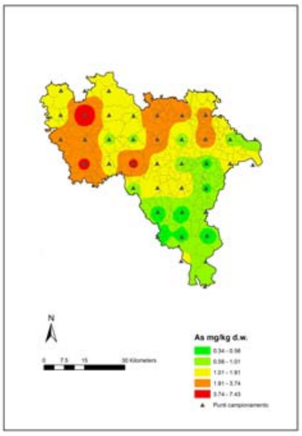


Figure 34. Concentration Distribution of As (mg/kg) in the moss

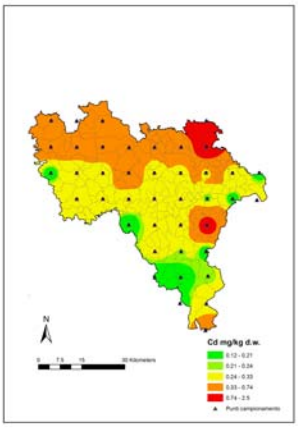


Figure 35. Concentration Distribution of Cd (mg/kg) in the moss

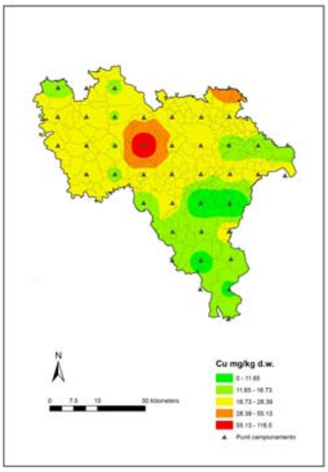


Figure 36. Concentration Distribution of Cu (mg/kg) in the moss

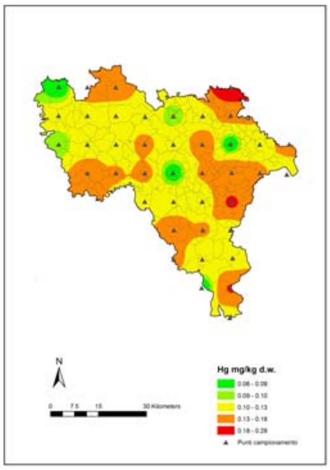


Figure 37. Concentration Distribution of Hg (mg/kg) in the moss

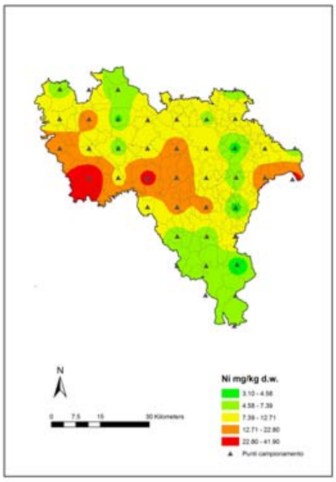


Figure 38. Concentration Distribution of Ni (mg/kg) in the moss

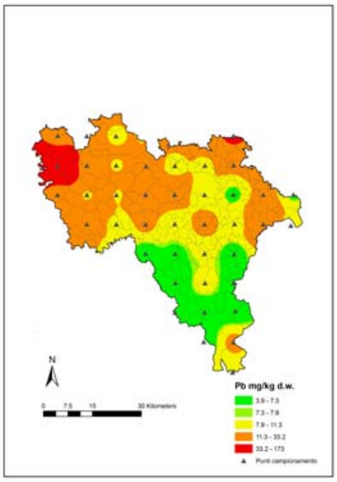


Figure 39. Concentration Distribution of Pb (mg/kg) in the moss

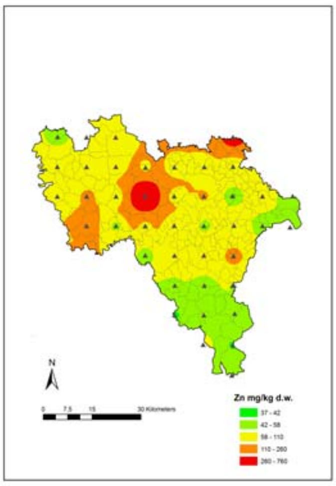


Figure 40. Concentration Distribution of Zn (mg/kg) in the moss

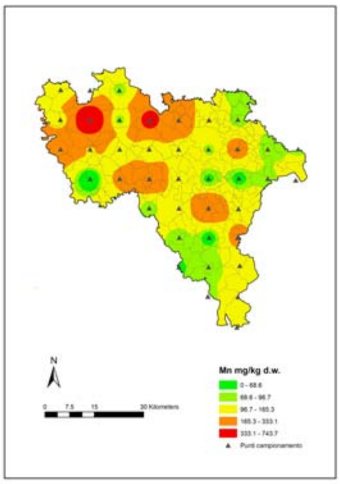
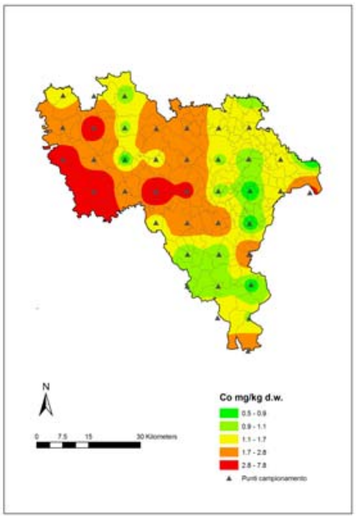


Figure 41. Concentration Distribution of Mn (mg/kg) in the moss



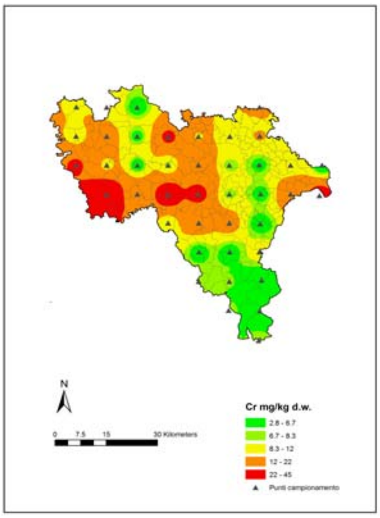


Figure 42. Concentration Distribution of Co (mg/kg) in the moss

Figure 43. Concentration Distribution of Cr (mg/kg) in the moss

Concentration spatial distribution in Tertiary Points

The spatial distribution of the element concentration in the moss is represented in figures 44-53. The four sampling points of the area of Giussago were not enough to obtain maps representing the concentration distribution. The maps concerning mercury were also not prepared in Corteolona and Pieve Porto Morone. The latter does not even have the maps for cobalt and manganese. As previously mentioned, the anthropogenic activities did not have significant influence in the concentration increase both of soil and moss. Figures 44-53 represent industrialized areas and show an almost homogeneous concentration distribution. The drops of the 10 analyzed elements in the moss are limited and can be compared to those which can be observed in areas with low anthropogenic pressure.

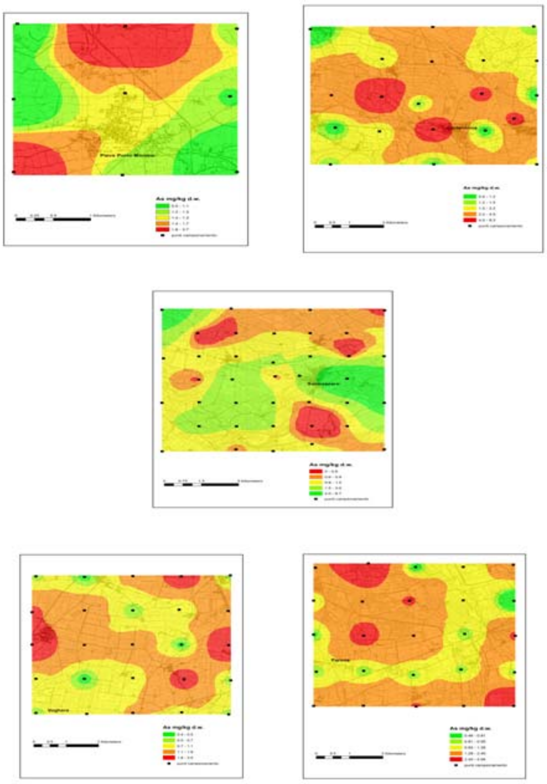


Figure 44. Concentration distribution of As (mg/kg) in the moss in the zones AM3

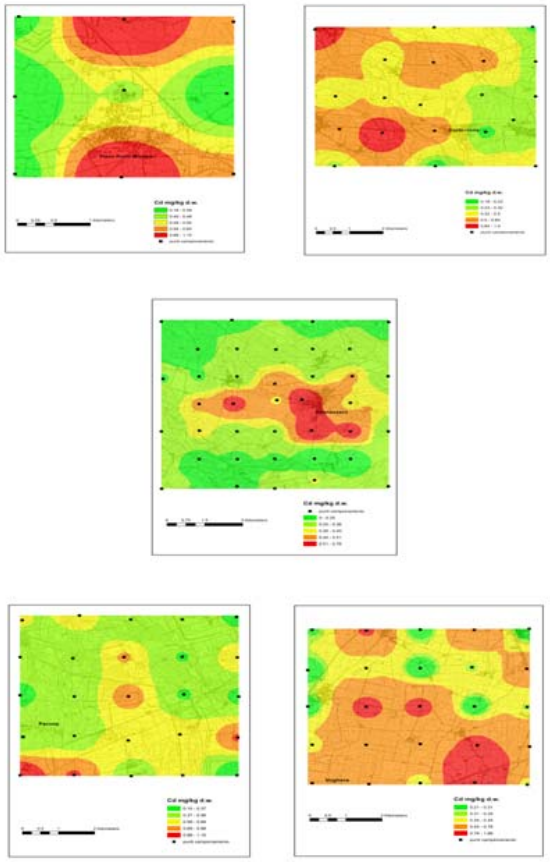


Figure 45. Concentration distribution of Cd (mg/kg) in the moss in the zones AM3

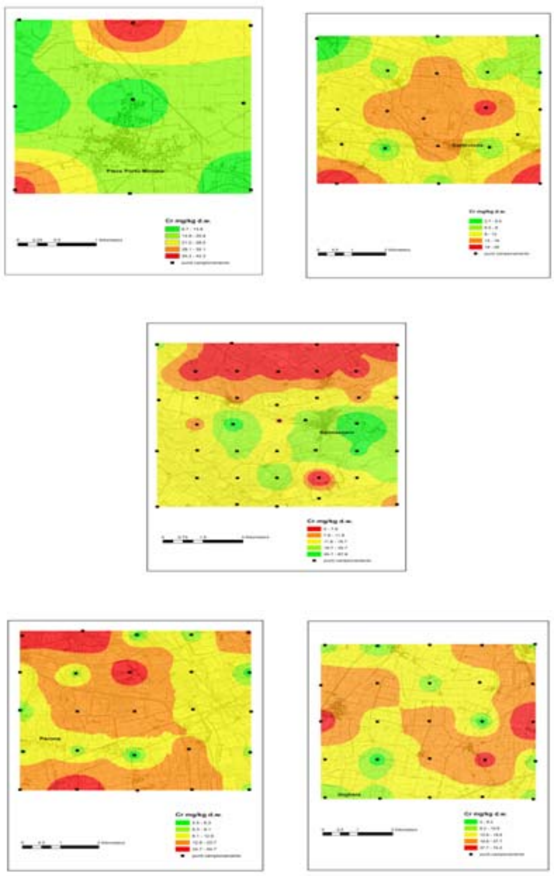


Figure 46. Concentration distribution of Cr (mg/kg) in the moss in the zones AM3

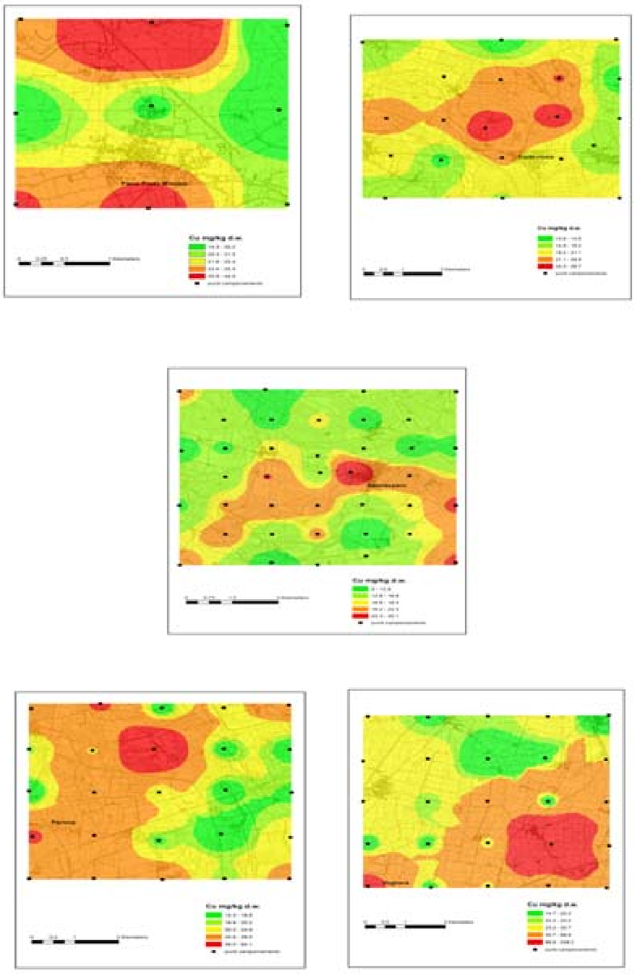


Figure 47. Concentration distribution of Cu (mg/kg) in the moss in the zones AM3

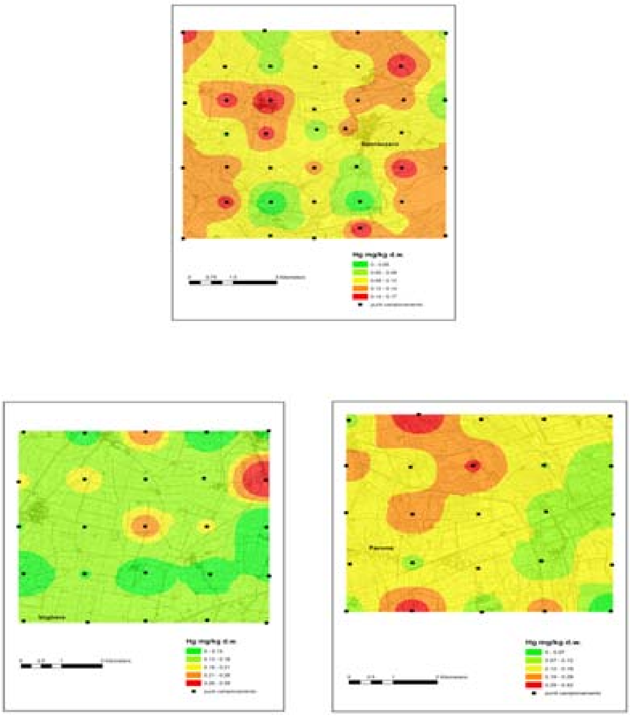


Figure 48. Concentration distribution of Hg (mg/kg) in the moss in the zones AM3

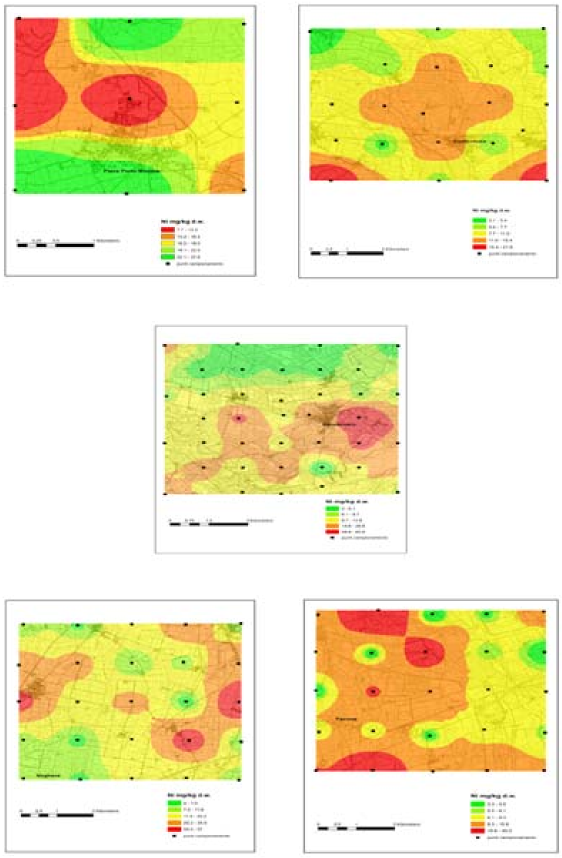


Figure 49. Concentration distribution of Ni (mg/kg) in the moss in the zones AM3

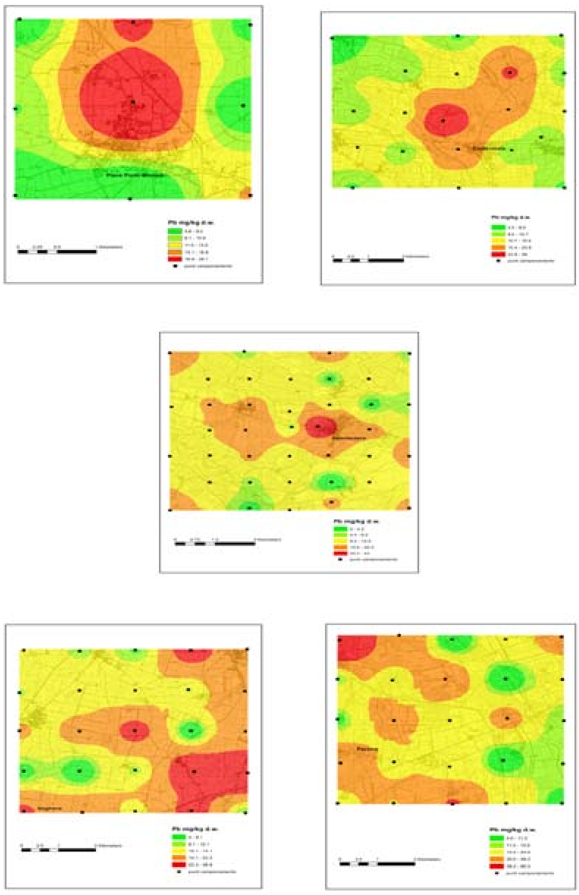


Figure 50. Concentration distribution of Pb (mg/kg) in the moss in the zones AM3

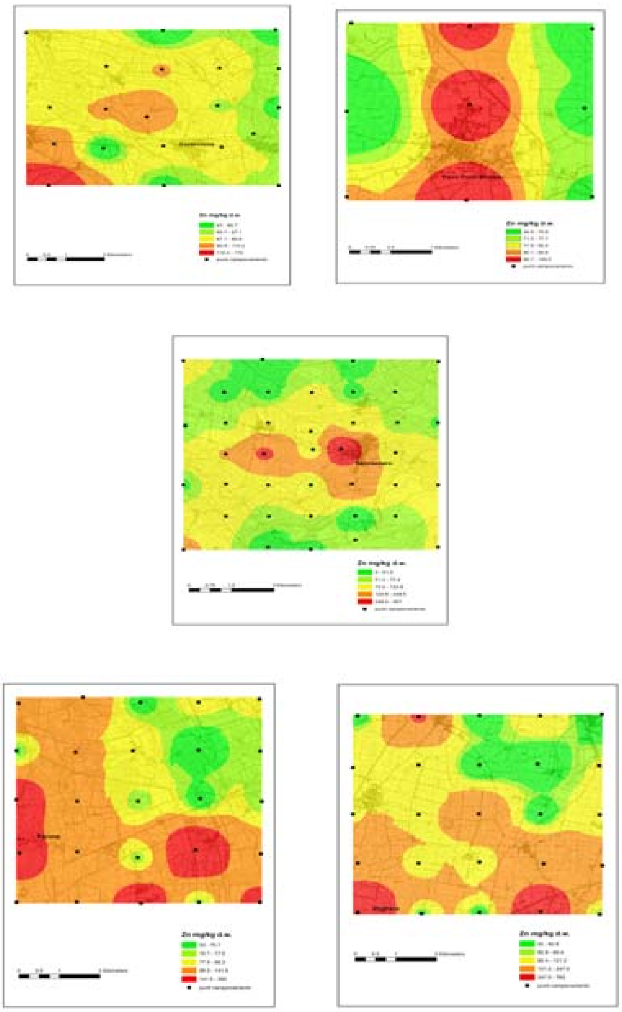


Figure 51. Concentration distribution of Zn (mg/kg) in the moss in the zones AM3

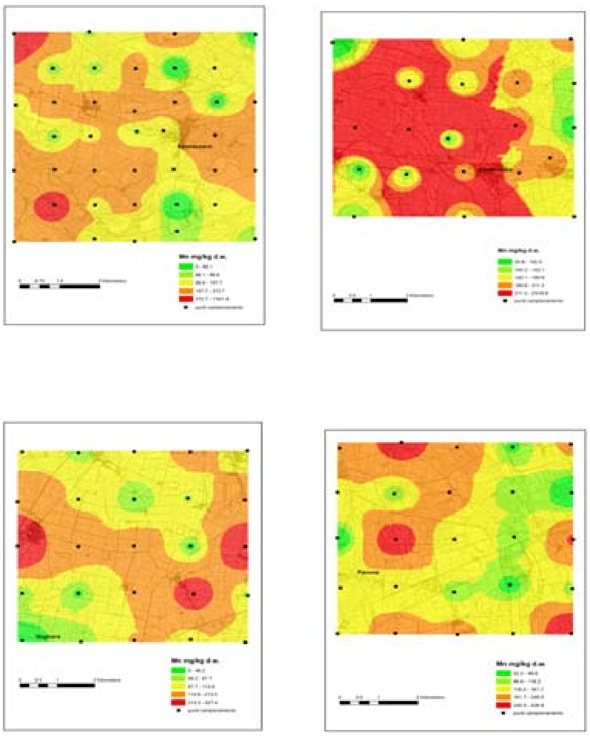


Figure 52. Concentration distribution of Mn (mg/kg) in the moss in the zones AM3

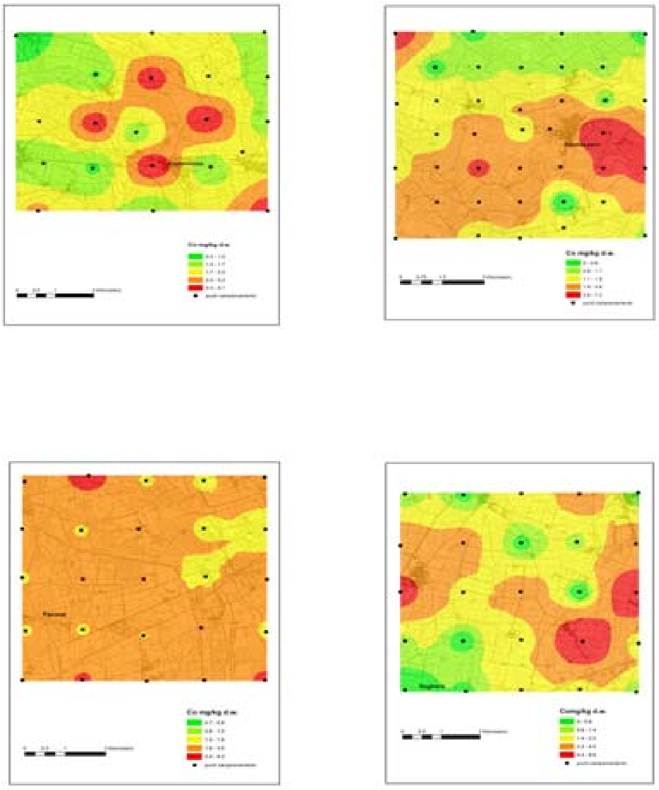


Figure 53. Concentration distribution of Co (mg/kg) in the moss in the zones AM3

Platinum and Rhodium

The environmental assessment also took in consideration the analysis of two elements which are present as an "ultra trace": platinum and rhodium. These elements are introduced in the environment mainly through catalytic mufflers, used to reduce the gaseous contaminants produced by internal combustion engines.

All in all, 40 samples of moss collected in the Monitoring Actions AM2 e AM3 were selected.

In the choice of the moss samples we tried to indicate over the entire province the areas with the highest traffic density and anthropogenic pressure, and those most natural, included some agricultural areas.

The moss concentration values are reported in table 33.

In the considered sampling points the rhodium and platinum levels are quite stable. The traffic does not seem to significantly contribute in increasing the concentrations.

Other researches carried out on areas with low anthropogenic pressure, for example Parco dei Monti Sibillini and the territory of Valle D'Aosta, show concentrations which are similar to those of this study.

Note that the drop of rhodium and platinum occurs prevalently on the road surface and its close surroundings, both directly and upon rain-wash. The experiences on the subject pointed out high values at few metres from the curb. At distances of some ten metres the concentrations are significantly lower.

Deposition rate

The deposition rate was calculated using the following formula proposed by *Rühling (1994).*

$$\text{Deposition rate} = \frac{C_{EL}}{(FE)\times(T_a)\times(F_R)}$$

Wherein:
C_{EL} = Element concentration in the moss (mg/kg)
FE = Efficiency factor of the element
T_a = Period covered by *caulidia* (years)
F_R = Rühling factor = [$\log_{10}$ (element concentration in the moss)] = [0.59+1.0 $\log_{10}$ (atmospheric deposition)] ≅ 4

The estimated average growth time of the apical 3 cm of the collected moss *caulidia* was of 4 years. Such a value matches what was suggested by *Zechmeister (1997 and 1998).*
Table 34 reports the average values of the deposition rate (g ha^{-1} y^{-1}) for the sampling points of Actions AM1 and AM2, and individually for the 6 more industrial areas (AM3) on the Pavia territory. These values were compared with Italian and international experiences which used both moss and dry and wet precipitation collectors. Such a comparison permits a more proper interpretation of the origin and the amount of the drops.
The situation observed with the values of Actions AM1 and 2 is quite encouraging: the deposition levels of all the considered elements are limited. The comparison with some Italian experiences put the data of the Province of Pavia on the same level of significantly agricultural areas as Sicily. Nations with high environmental sense such as Sweden also present very similar values.
The six most industrialized areas of the province of Pavia do not differ much from Actions AM1 and AM2. The values obtained are generally lower than those observed in Italian industrialized areas and in nations with a high level of industrialization as Germany.
Another positive result is given by the data concerning the zone of Parona obtained in this study and compared with the assessment of 2001.
First, it shows how similar some data are (Ni and Pb); other data underwent a slight drop (cadmium and zinc), while chrome and copper had a 30-40% increase in their value.
The second aspect, which is purely scientific, considers the use of the methodology. Moss proved to be reliable thanks to a correspondence of the results after 3 years, without significant changes in the inspected area.

Enrichment factor
The Enrichment factor (EF) of each metal in the moss tissues, compared with the soil *(Zoller et al. 1974; Bargagli et al. 1994)***,** was calculated using the following formula:

$$FA = (X_{moss}/Al_{moss})/(X_{soil}/Al_{soil})$$

Wherein:

X_{moss} (mg/kg concentration of the element X in moss);

Al_{moss} (mg/kg concentration of Aluminium in moss);

X_{soil} (mg/kg concentration of the element X in soil);

Al_{soil} (mg/kg concentration of Aluminium in soil).

Values of 10 or higher indicate that the drops arise from anthropic factors which are local or derive principally from transportation caused by wind. Values lower than 10 indicate that the drops can be prevalently attributed to the soil or the substrate.
The obtained results (tables 35 a-h) point out a mixed situation of industry and agriculture; the latter is more present.

All in all, about 24% of the element total has anthropic origins. It is worth noting that the origin of cadmium and mercury is only in part anthropic *(Cenci et al., 2003)* and that these two elements account for 66% of the average value increase.
The “anthropization” order of the assessed elements is the following:
Cd=Hg>Zn>Cu>Pb>Co>Ni=Co=Cr=As.
The “high” rank of copper is principally due to the predisposition to the vine cultivation of a part of the Pavia territory.

SAMA (Sewage sludges Sub-Monitoring Action)

The activity named *SAMA* (Sewage sludges Sub-Monitoring Action) was carried out in three areas which use different fertilization methodologies.
Two out of these three areas are in Bereguardo and one in Corte Olona.
The first is in Azienda Agricola Cascine Orsine. It has been used for 25 years for organic farming and no longer receives any kind of treatment apart from the irrigation water which is diverted from the close canal. At the sampling it presented a mixed meadow, as observed in figure 54. The second farm is in Cascina Nuova: mixed meadow fertilized with manure and 150 kg/ha of mineral fertilizer (15N 15P 15K). The third is in Corte Olona at Cascina Novella. The field is cultivated with corn and for 10 years has been receiving pre-treated sewage sludges (about 360 q/ha). A liquid solution of herbicide is also periodically delivered on the field.

Geographical coordinates
Figure 54 shows the areas where the soil sampling was carried out and the respective geographical coordinates.

Sampling strategy
The adopted sampling strategy derives from the studies of the French researchers (Jolivet *et al.,* 2003). It provides the creation of an area of 20 x 20 metres divided into 9 sub-squares of 6.6 metres for each area.
Litter, roots, stones and other coarse materials were removed in advance from the field before the sampling procedures.
A sub-sample was collected in each sub-square by means of a manual drill and was mixed with the remaining eight sub-samples to form an individual composite sample.
The sampling depths were: 0-5 cm; 0-15 cm and 15-30 cm.
The composite samples obtained in each area were 3, for a total of 9 samples for the three areas assessed.
The soil sample collection was carried out along with Action AM1 by specialised staff of the Soil and Waste Unit of JRC of Ispra.

The "quartering technique" was executed on each of the 9 soil samples (3 areas x 3 depths). The first quarter was used to analyse the concentration of mercury, total and organic carbon, pH and macro-elements. The second quarter was delivered to the colleagues of the Università del Sacro Cuore di Piacenza to determine the trace element concentration.
After air drying of the soil, the third sample was delivered to the Istituto Sperimentale Nutrizione delle Piante of Rome for microbiological analysis and for the evaluation of the polychlorobiphenils (PCBs). This analysis was carried out by the Istituto Superiore di Sanità of Rome. The fourth soil fraction of each of the 9 samples was placed in glass dark bottles that were subsequently covered with an aluminium sheet, inserted into plastic bags and frozen. This aliquot served to determine the dioxins and furans concentration.

Results and discussion

Pedological profile
In the three sites identified for the SAMA study (farms Cascina Nuova, Cascina Orsine and Cascina Novella), the soil survey was carried out for a first pedological classification.

Sampling was carried out by means of manual drill up to a depth of one metre. This was to enable the identification of the principal horizons or soil layers, and their description is based on the ISO no. 11259 (1998) standards. The studied soils were classified in collaboration with the Ente Regionale per i Servizi all'Agricoltura e alle Foreste della Lombardia (ERSAF) on the basis of the Soil Chart realized by ERSAF, scale 1:50,000, and the related database.

<table>
<tr><td></td><td></td></tr>
<tr><td>View of the biological area</td><td>View of the manure area</td></tr>
<tr><td></td><td>Azienda Agricola Cascine Orsine
(biological area)
latitude: 5012306
longitude: 500850

Cascina Nuova
(manure)
latitude: 5001293
longitude: 501611

Cascina Novella
(Sewage sludges)
latitude: 5010486
longitude: 529490</td></tr>
<tr><td>View of the sewage sludge area</td><td>Geographic Coordinates</td></tr>
</table>

Figure 54. View of the three areas with the corresponding terrestrial coordinates

Despite the high spatial variability characterising the examined soils in relation to the alluvial nature of the sediments where soil formed and to human intervention, it was possible to connect the studied sites to the soil types described in the Soil Chart. According to the campaign assessments, this connection is of good quality. The description of the representative soil type for each examined site is reported using abbreviations and denominations consistent with the ERSAF database and the cartographic classification elaborated by ERSAF:

- Cascina Nuova, Bereguardo, traditional treatment
  Representative soil type: "S. Varese O Sandy-loam with low or common rubble" (cartographic abbreviation: SVO).

Soils on plain fluvial terraces, which formed in fluvial deposits moderately coarse, with good drainage (Typic Dystrustepts, coarse loamy, mixed, superactive, mesic, according to the classification Soil Taxonomy)
Profile description:
- 0-30 cm: horizon Ap; principal colour greyish brown (10YR 5/2, humid); Sandy-loam, with common rubble, very small and small; non calcareous;
- 30-50 cm: horizon Bw1; principal colour brown (10YR 5/3, humid); Sandy-loam, with common rubble, very small and small; non calcareous;
- 50-80 cm: horizon Bw2; principal colour from brown to dark brown (10YR 4/3, humid); Loamy-sand, with common rubble, very small; non calcareous;
- 80-100 cm: horizon C; principal colour olive brown (2.5Y 4/3, humid); Sand, with frequent rubble, very small and small; non calcareous.

- Cascina Orsine, Bereguardo, biological treatment
  Representative soil type: "Parosacco sandy-franca" (cartographic abbreviation: SPA).
  Soils on sub-plain fluvial terraces, which formed in coarse fluvial deposits, with slow drainage (Typic Humaquepts, sandy, mixed, mesic, according to the classification Soil Taxonomy)
  Profile description:
  - 0-35 cm: horizon Ap; principal colour very dark greyish brown (2.5Y 3/2, humid); Sandy-loam, with low rubble, very small and small; non calcareous;
  - 35-50 cm: horizon Apg; principal colour dark grey (5Y 4/1, humid), with common variegations, brown-yellowish (10YR 5/4); Sandy-loam, with low rubble, very small and small; non calcareous;
  - 50-80 cm: horizon CA; principal colour greyish brown (2.5Y 5/2, humid), with common variegations, brown-yellowish (10YR 5/4); Loamy-sand, with common rubble, small; non calcareous;
  - 80-100 cm: horizon C; principal colour grey (5Y 6/1, humid), with common variegations, brown-yellowish (10YR 5/4); Sand, with low rubble, very small; non calcareous.

- Cascina Novella, Corteolona, treated with biological sludges
  Representative soil type: "Valcova Sandy-loam" (cartographic abbreviation: VAC).
  Soils on sub-plain surfaces, which formed in medium fluvial and fluvioglacial deposits, with poor drainage (Aquultic Haplustafs, fine silty, mixed, superactive, mesic, according to the classification Soil Taxonomy)
  Profile description:
  - 0-45 cm: horizon Ap; principal colour from brown to dark brown (10YR 4/3, humid), with common variegations, dark grey (10YR 4/1); Sandy-loam; non calcareous;
  - 45-90 cm: horizon Bt; principal colour yellowish brown (10YR 5/4, humid), very rich in variegations, light browny grey 2.5Y 6/2); Silt-loam; non calcareous;
  - 90-100 cm: horizon 2Cg; principal colour yellowish brown (10YR 5/4, humid), rich in variegations, grey (N 6/0); Sandy-loam; non calcareous.

Granulometry and water content
Table 36 reports the percentage data concerning the principal granulometric fractions and the water content.
In the three sites the sandy fraction was dominant, apart from the most superficial horizons of Cascina Novella, where the loamy component was predominant.

The water content was higher in the surface horizons, apart from Cascina Novella, where the highest value was found within the layer between 30 and 5 cm along with higher levels of clay and silt.
The obtained values as a whole well represent soil formed in the sediments of the sinuous plateau of the River Po.

Trace elements
The concentrations of the trace elements and of the macro-elements within the three depth levels are reported in table 37.
The concentration difference observed in all the elements among the first two farms (Cascina Orsine and Cascina Nuova) and Cascina Novella are evident. To a first approximation, this may be due to the different natural typology of soil. Note that the concentrations observed in the Cascina Novella site fall within the typical values obtained for all soil of the province of Pavia, only a part of which is treated with sewage sludges.
The soil concentration of the trace elements does not seem to be directly influenced by the different use of “fertilizers” (biological treatment, manure and mineral fertilizer, sewage sludges).

Soils of the first two farms are very similar. Note that the there is a distance of about one kilometre between these two sites, while Cascina Novella is about 30 km south of those two farms.
This is strengthened by the average concentration levels of the trace elements within the Corte Olona area, comprising a surface of 40 km^2, where Sewage sludges and manure are used and there are some industries. The levels observed are similar to those of Cascina Novella apart from Cd, whose concentration level in the latter area was a half.
The areas of the SAMA sub-project presented three different uses and treatments of the soil. The elements reported in the table present concentration levels which are similar if compared with the results obtained in soil of the entire province of Pavia. There are not significant differences among the concentration values of the three examined areas and among the values at the different depths.

Dioxins
Table 38 reports the values of the three considered areas expressed in WHO-TEQ (World-Health-Organization; Toxic-Equivalent-Quantities) (World-Health-Organization; Toxic-Equivalent-Quantities) for the PCDD/Fs obtained with the analysis of the three soil layers.
Appendix D reports the values of the dioxin congeners referred to the different soil layers collected over the three survey areas.
Values with marginal concentration differences in dioxins and furans (PCDD/Fs) were found in the biological area and the area fertilized with manure.
The vertical concentration profiles point out a constant level on the analysed soil column.
It should be specified that the principal dioxin and furan source of soil derives from atmospheric depositions.
The concentrations of the areas where sewage sludges were used as Sewage sludges are slightly higher than in the other two areas.

The influence of the sewage sludges can explain the concentration difference. The annual amount of sludges per hectare is 5 tons and involves a ploughed layer of 30 cm. Assuming a soil bulk density of 1.4 kg/dm^3 with a humidity of 20% and a dioxin concentration level of 150 pg/g in the 50% mixed sludges, the result is an annual value of 0.05 pg/g of sludges distribution. In the surveyed area the sewage sludges has been used for 15 years giving an increase of 0.75 pg/g. This level matches what was found in this study. The influence of the sewage sludges in increasing the concentration levels was reported in a number of literature cases (Langenkamp and Part, 2001;

Umlauf *et al.*, 2004). The dioxin and furan contribution upon the agricultural use of the sewage sludges accounts for 1.8% of all the sources in the UK (Duarte-Davidson *et al.,* 1997). Also in Denmark the use of the sewage sludges is considered as the lowest source (Hansen, 2000). It is worth noting that in countries like Finland, UK, Ireland, France, Denmark and Luxembourg the re-use percentage of the sewage sludges is over 60% (Magoarou, 2000).
The chemical features of these hydrophobic compounds which are not water soluble present a low bioavailability for plant life.
It is worth pointing out that the measured concentration levels are 10-20 folds lower than the tabular limits of Legislative Decree 152 of 2006 which provides a threshold value of 10 pg/g for the public and residential green areas.
Note that limit concentration values of these substances were not defined in the agricultural soils at a national level. Given that, the Istituto Superiore di Sanità expressed an opinion (note no. 051899 I.A.12 of November the 6th, 2003) literally reporting: *"Awaiting a revision of Ministerial Decree 471/99 concerning the soil reclamation in order also to include the quality standards for the agricultural soils, we think that the values presented in column A of Table 1 Annex 1 of Ministerial Decree 471/99 can also be applied at the agricultural soils themselves"*.
Legislative Decree 152 reports the same tables of Ministerial Decree 471 for heavy metals and dioxins.
Furthermore, for example, German law sets a limit of 40 pg/g in the agricultural soils. This limit is of 5 pg/g in case of meadows assigned to forage (Bund/Länder-Arbeitsgruppe DIOXINE, 2002).
We must note that Regione Emilia Romagna, upon the resolution number 285, February the 14th, 2005, of the Regional Council forbids the application of sludges on the same lands for a continuous period of more than three years. After this period, it will not be possible to distribute sludges on the lands for at least two years (Regione Emilia Romagna, 2005).

Bacteria

The analytical methods used are those previously described in relation to the Monitoring Actions AM1, 2 and 3.
The sampling campaign was carried out four times during this one-year project. The first campaign was performed during September 2004, the second in January 2005, the third in March 2005 and the fourth in July 2005.
The soil sample collections of the study were executed in three farms of the province of Pavia with different management, within an area of 20 x 20 m. The sampling consisted in 5 soil sub-samples at a depth of (0-15) cm and (15-30) cm, considering the fact that the microbial load decreases with depth, along with the reduction of organic matter. The analyses were carried out on an average sample for each depth to limit the field variability.

- Farm 1 (Cascina Orsine). It is a Farm with biological management in which there is a mixed cropping, where the last ploughing occurred in 2002. The field was not treated at all because of its biodynamic management, thus neither pesticides nor herbicides were used. It is located in the Bereguardo area.
- Farm 2 (Cascina Nuova). It is a Farm in which there is a mixed cropping on the field, and the last ploughing was in 1999. The field is fertilized with very diluted manure and slurry. Also this farm is located in the Bereguardo area.
- Farm 3 (Cascina Novella). It is a Farm in which there is field corn cropping, and the last ploughing occurred at the end of 2003. The field is

fertilized with sewage sludges previously treated with NH_3 and H_2O. The site is located in the Corteolona zone.

Results

The following pages report the results of the biological fertility parameters. The first concern the sampling over time for each farm, in order to observe the parameter variation over one year of study. Then, there is the comparison among the three farms using the average values to observe any difference on the basis of type of agricultural management adopted.

In order: tables 39, 40 and 41 show (a) the results of the fertility parameters concerning the two soil layers (0-15) cm and (15-30) cm for the four samplings (a fertility class was assigned to the last line on the bottom); (b) the values of the different organic carbon fractions in the soil samples and the corresponding moistening parameters.

Figures 55, 56 and 57 represent the course over time (a) of the organic matter values and of the total mineralization activity; (b) the values of the moistening parameters, only considering the layer of (0-30) cm.

Finally, table 42 (a) and (b) and figure 58 (a) and (b) report the average values of the results already shown in the previous tables, divided for each farm. The diagram of figure 59 and table 39 propose instead the course of the biological fertility over time, and permits the comparison among the different agricultural managements.

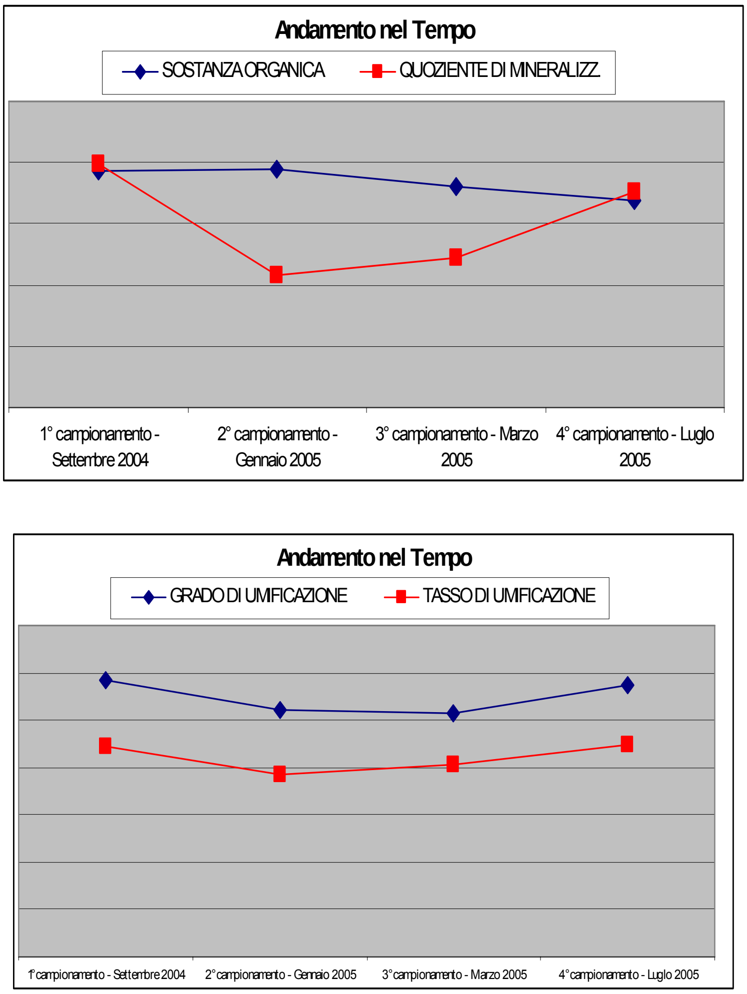
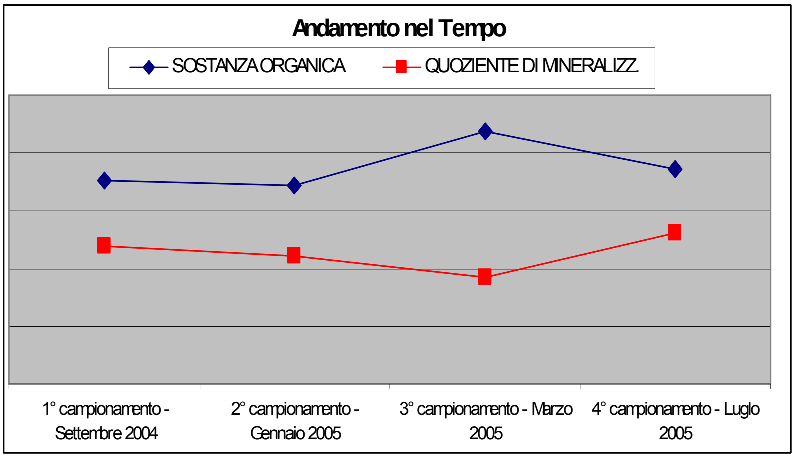


Figure 55. Course over time of some parameters



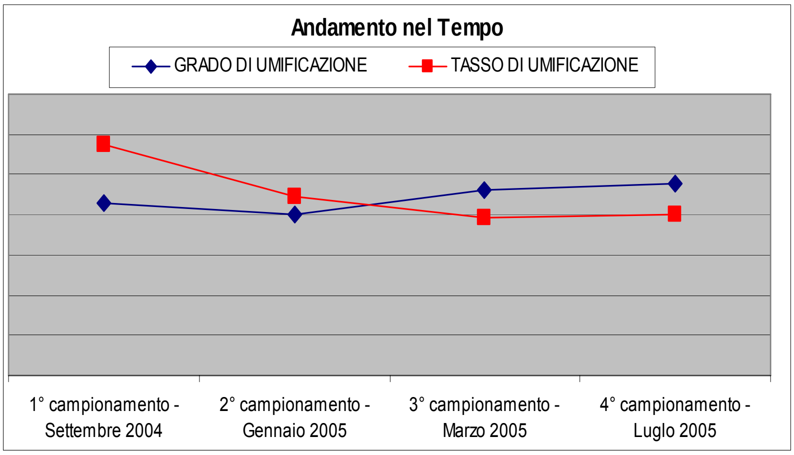
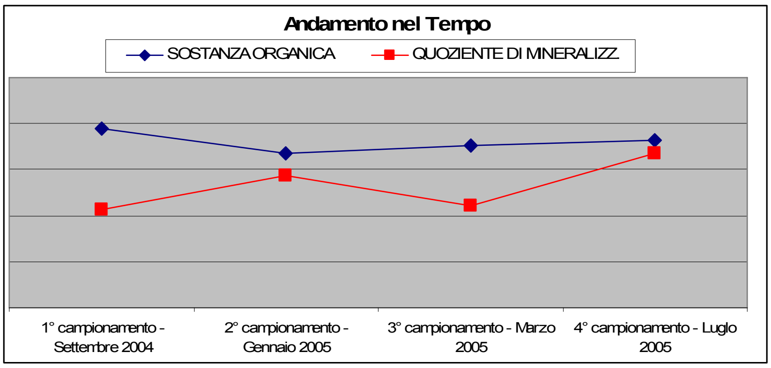


Figure 56. Course over time of some parameters



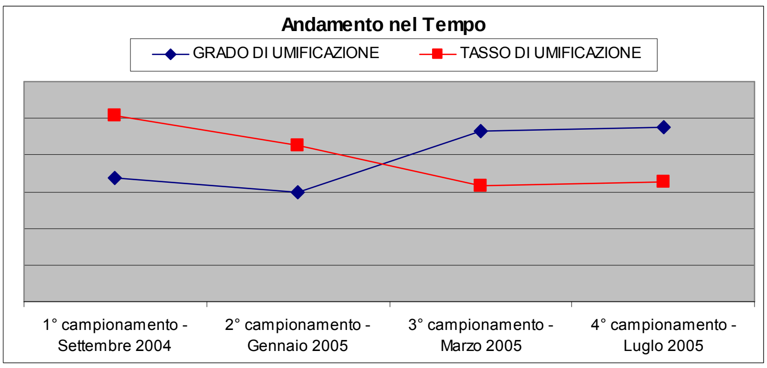


Figure 57. Course over time of some parameters

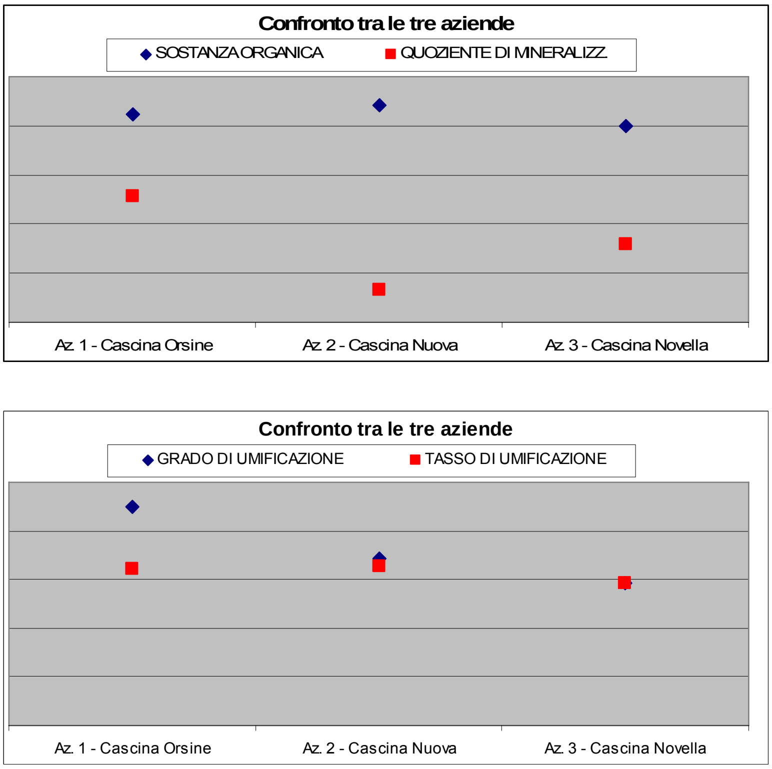


Figure 58. Comparison among some parameters in the three Farms

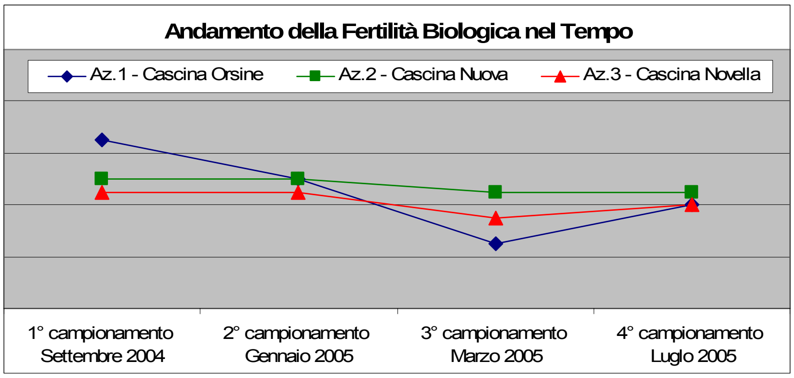


Figure 59. Course over time of the biological fertility for the three farms

Considerations

Note that the results over time of each farm concerning the organic matter parameters are generally stable, and at least more stable than the micro-organism activity. For example, Farm 1 (Cascina Orsine) shows a mineralization activity which is lower in the sampling carried out in January 2005. However, this is not significant because it falls within the seasonal variability. The other two farms present constant variations and lower variability of the same parameters.

The aim of the situation comparison among the three farms was first to point out that the average level of organic matter is largely identical despite fertilization, as well as its amount fixed in the soil as moist material. The situation concerning microbial activity is slightly different. In fact, while the microbial carbon levels are nearly the same in the three farms, the amount of mineralized organic substance shows greater variations with respect to the current total amount. In particular, Farm 2 (Cascina Nuova) and Farm 3 (Cascina Novella) present the lowest levels, probably due to the presence of a more stressed microbial community.

Such a result comes as no surprise. In fact, other analytical records proved that the effectiveness depends on the quality of the added organic matter (e.g. in the case of sludges used as a field amending). In general, the lower the mineralization of the organic matter is, the better its agronomic validity will be (Benedetti and Sebastiani, 1996; Alianiello and Benedetti, 1994). The reason is that a quick mineralization process could offer excessive amounts of nitric and ammoniac nitrogen. Furthermore, the addition of not treated sludges provokes a phenomenon called “priming effect”, which stimulates the microbial biomass mineralization of a quantity of carbon which is higher than the quantity added to the ground. This could explain the results obtained.

In conclusion, note that the biological fertility of the three farms is not different, even though their course over time is. In fact, Farm 1 (Cascina Orsine) presents a moment of evident stress at the sampling of March 2005. The cause could be that during spring, in the growing period, the microbial biomass has to compete for nutrients and organic substrate providing energy. The confirmation is the fact that this does not occur in the other farms, where the organic matter contribution was provided by fertilization (Farm 2 - Cascina Nuova) and the corn harvest (Farm 3 - Cascina Novella) in March 2005.

Sediment

On May 12th, 2005, the campaign for the sediment core sample collection was carried out in two oxbows of the Pavia zone in collaboration with the fire brigades of Milan and the administrators of the province of Pavia.

Area description

The two areas (Zelata and San Massimo), chosen by the administrators of the Province of Pavia, are both within Parco Lombardo of Valle del Ticino. They do not present any direct anthropogenic pressure, and thus are suitable for the description of the semi-quantitative courses of trace elements and organic compounds carried and deposited by the wind and rain-wash of the respective catchment basins.

The site Zelata (Chart 1) is in the Bereguardo zone. The oxbow has an area of about 8 ha. It formed around 1880-90 after the shifting of the River Ticino.
Its contour is characterised by a mixed oak wood with prevalence of Common Oak (*Quercus robur*), Hornbeam (*Carpinus betulus*), Field Maple (*Acer campestre*) and Field Elm (*Ulmus minor*). There is also a hygrophilous wood characterised above all by Black Alder (*Alnus glutinosa*), willow (*Salix alba*, *S. Caprea*, *S. eleagnos*) and poplar (*Populus alba*, *P. nigra*) (Sartori, 1990).
Regarding the fauna, a breeding community of herons has been living here for more than 30 years. It is principally made up of Grey Heron *Ardea cinerea* and secondly, by Night Heron, Little Egret *Egretta garzetta* and Purple Heron *Ardea purpurea*. It is a breeding site for the Black Kite (*Milvus migrans*) - a member of the hawk family classified as endangered by the IUCN, and also a wintering site for anatids, 700-2500, almost exclusively represented by Mallard (*Anas platyrhynchos*) (Furlanetto, 1999).
Zelata is identified as a Site of Community Importance (SCI) and Special Protection Area (SPA).
The site San Massimo (Chart 2) is in the Gropello Cairoli zone, and its water basin has a surface of 1 ha within a forest land of 200 ha.
The tree vegetation is mainly represented by Black Alder (*Alnus glutinosa*).
The water basin formed around 1950 after peat extraction interventions on a territory cultivated over a long time as meadow, rice fields and poplars. Currently it is an ornithological zone for the capture and mark of waterfowls.
The San Massimo (490 ha) area is of inestimable value from faunal and environmental points of view both for species and habitat richness. The Black Alder forestlands are the most extended in Italy and fauna counts species of particular interest at a European Community level. Among the invertebrate animals, note the presence of the Coleopters *Cerambyx cedro* and *Lucanus cervus*. Among the vertebrate animals there are the Italian Agile Frog (*Rana latastei*), an endemic amphibian of the Padana plain; Herons (Night Heron *Nycticorax nycticorax*, Little Egret *Egretta garzetta*, Grey Heron *Ardea cinerea*, Purple Heron *Ardea purpurea*, Squacco Heron *Ardeola ralloides*), representing a breeding community which has been living here for over 30 years (600 nests in 2000); and some species of Chiropterans (e.g. Greater Horseshoe Bat *Rhinolophus ferrumequinum* and Lesser Horseshoe Bat *Rhinolophus hipposideros*). In addition, in this zone there is also the presence of a mixed ornithic population, represented above all by water species, in particular Anatids (Alieri *et al.,* 1986). The area is regarded as a Site of Community Importance (SCI) and a Special Protection Area (SPA) thanks to its faunal and environmental value.

Sampling

The sediment core sample collection was carried out manually using Plexiglas tubes driven into the sediment. With this procedure undisturbed sediments can be obtained. Two core samples were collected in each area at a distance of few centimetres. The core sample length was 43.2 cm in La Zelata and 37.4 cm in San Massimo.

Then, the core samples were sectioned perpendicularly to their length into sub-samples with a thickness of 1.2 cm for the core sample collected in La Zelata and 1.1 cm for the sediment core sample collected in San Massimo.

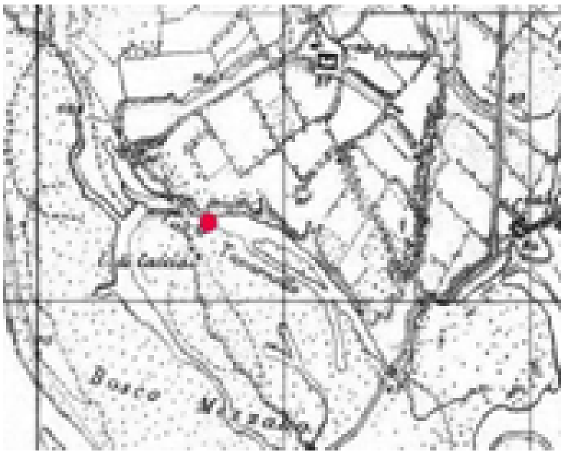
The total of sub-samples was respectively 36 (La Zelata) and 34 (San Massimo). The sample preparation and the subsequent analyses were carried as previously described for soil.

The sampled sites are defined oxbows, even if only the first has to be considered an oxbow, because its communication is strictly connected to the river. Consequently, during the flooding a part of the old sediment is carried away and significant amounts of "new" sediment are brought to the oxbow. Therefore, we can say that the oxbow is an ecosystem in continuous transformation with deposits and removals of sediments.

The ri-sedimentation occurring in the oxbow produces the mixing of recent and "old" sediments. A part of them is autochthonous, while another part is of fluvial origin. The latter is influenced by the catchment basin type and varies with the river regime during the different seasons. Thus, the oxbow is controlled both by the river and by the catchment basin.

During soft seasons, the oxbow is subjected to a limited influence from the river and tends to differentiate from it. During the low water period, some oxbows can completely dry out and receive terrestrial pioneer plants. Then, they newly turn into water environments during the river level increase. This depends on the oxbow location with respect to the river and on its communication with the river. This is pointed out by the mercury and organic carbon concentration distribution over time in the core sample collected within La Zelata (tables 43 and 44).

Lanca La Zelata: Sampling Area Description



Map 1

Photo Nr. 1

Photo Nr. 2

Photo Nr. 3

Location ID: Bereguardo – Lanca Arena

Geographic area: Provincia di Pavia – Valle del Ticino

Sampling date: 12 May 2005

Coordinates	Position format: UTM/UPS		Map Datum: WGS 84
	32T	Long.	0500543
		Lat.	5010041

Quota and inclination: 85 m; 0%

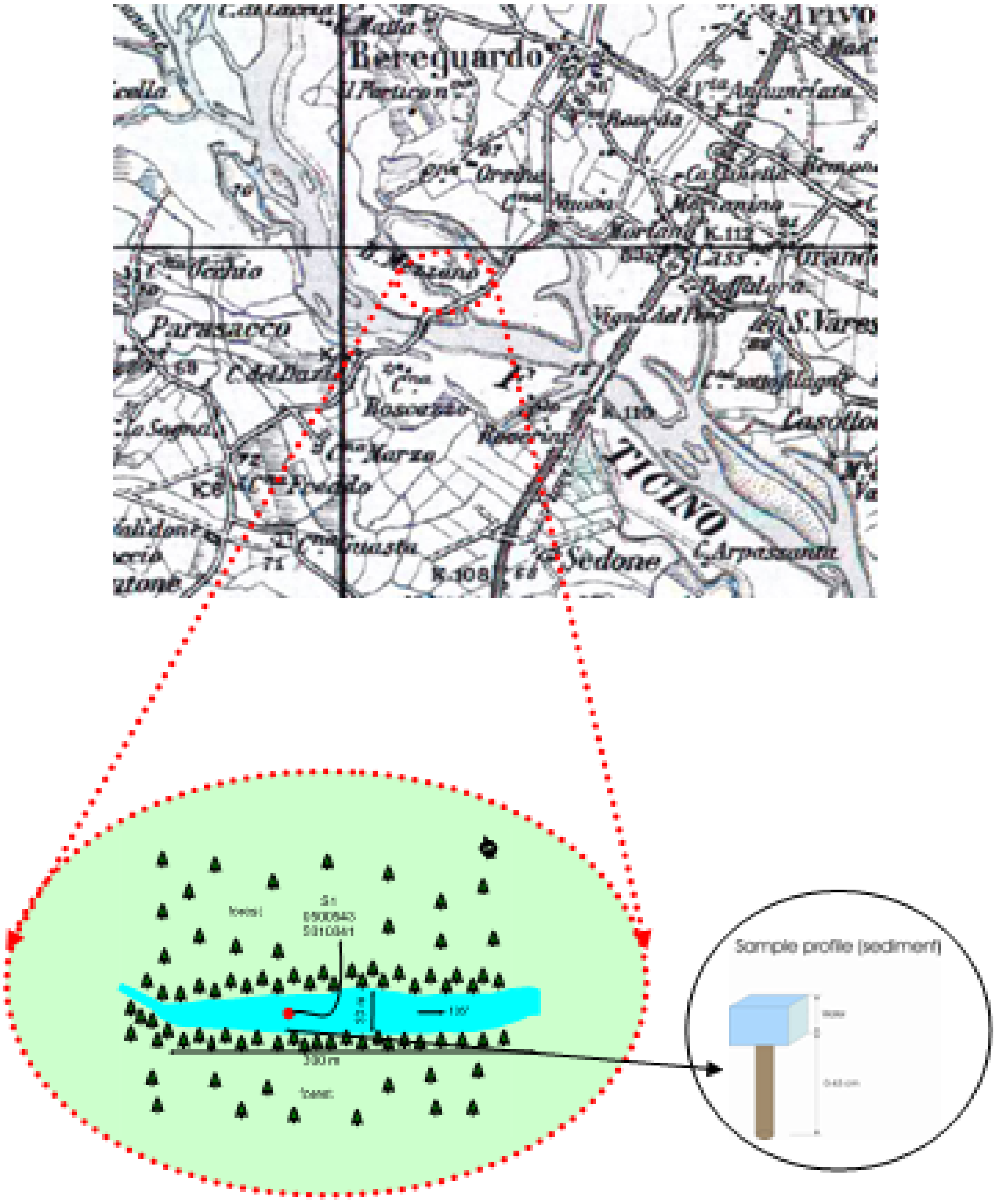
Area description: Inside farmhouse Cascina Orsine; about 1.5 km far from the farmhouse. Lanca Arena (direction 105°), fed by Ticino. Width 25÷30 m, length of principal body ~ 300 m, depth 3m. Woody shores, dense vegetation, plane ground.

Land-use: Wild wood

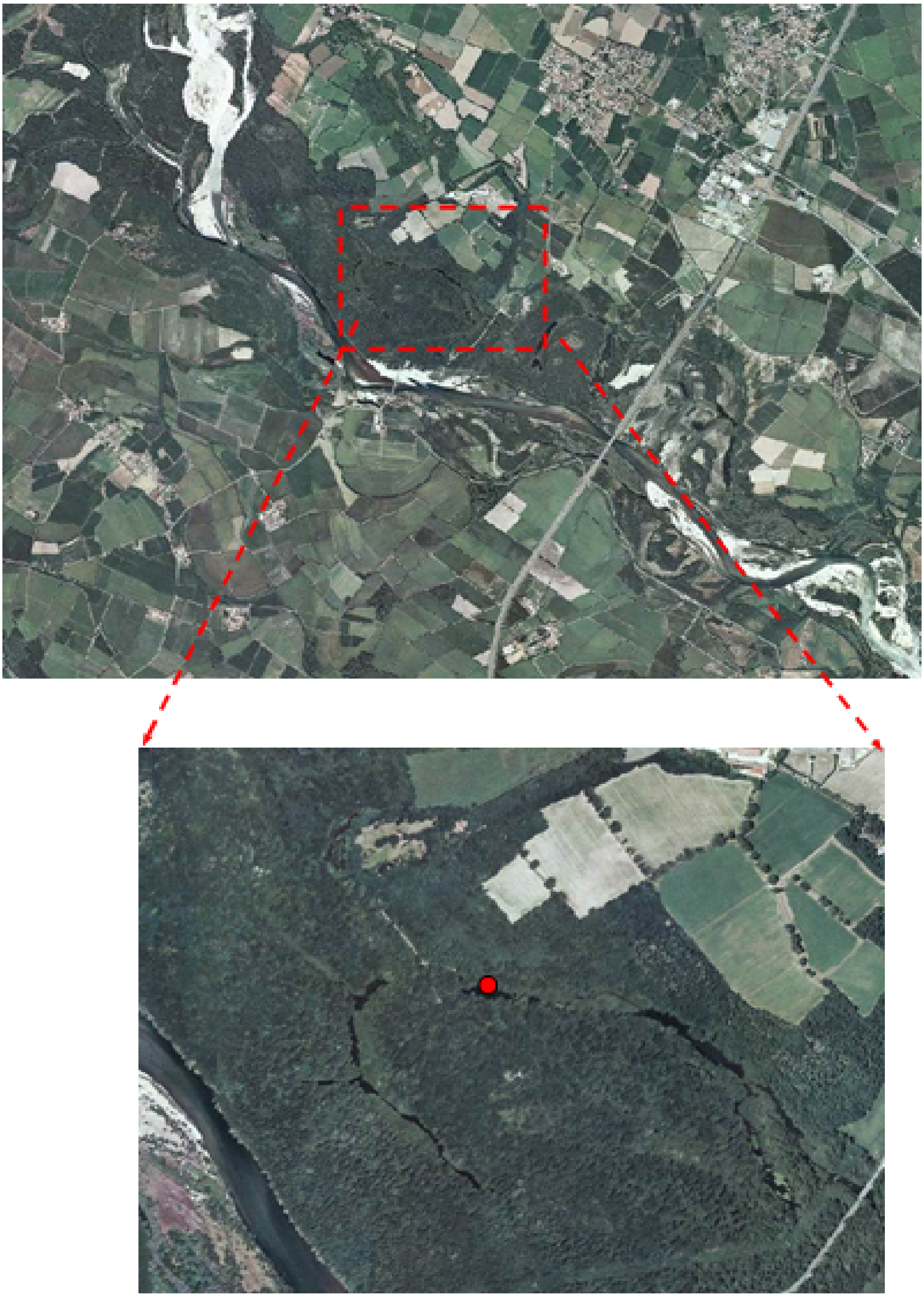
Sediment

1M 0-43 cm, undisturbed sediment sampled in the centre of the water body, and subsequently divided in 36 sections of 12 mm each.

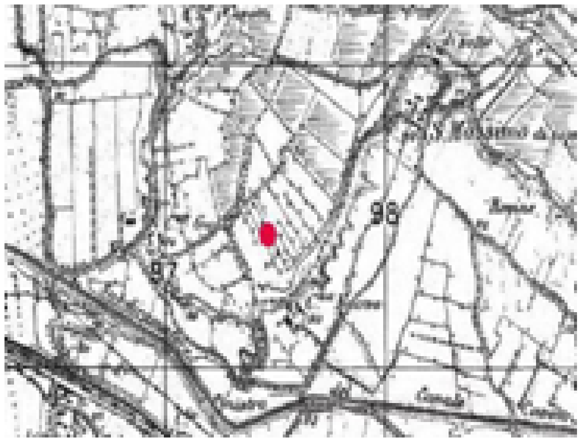
1D 0-43 cm, undisturbed sediment sampled in the centre of the water body, and subsequently divided in 18 sections of 24 mm each.



Location of sampling area "La Zelata"



S. Massimo: Sampling Area Description



Map 1

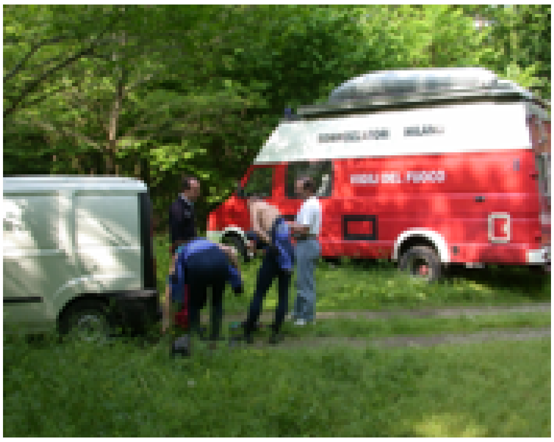


Photo Nr. 1

Photo Nr. 2

Photo Nr. 3

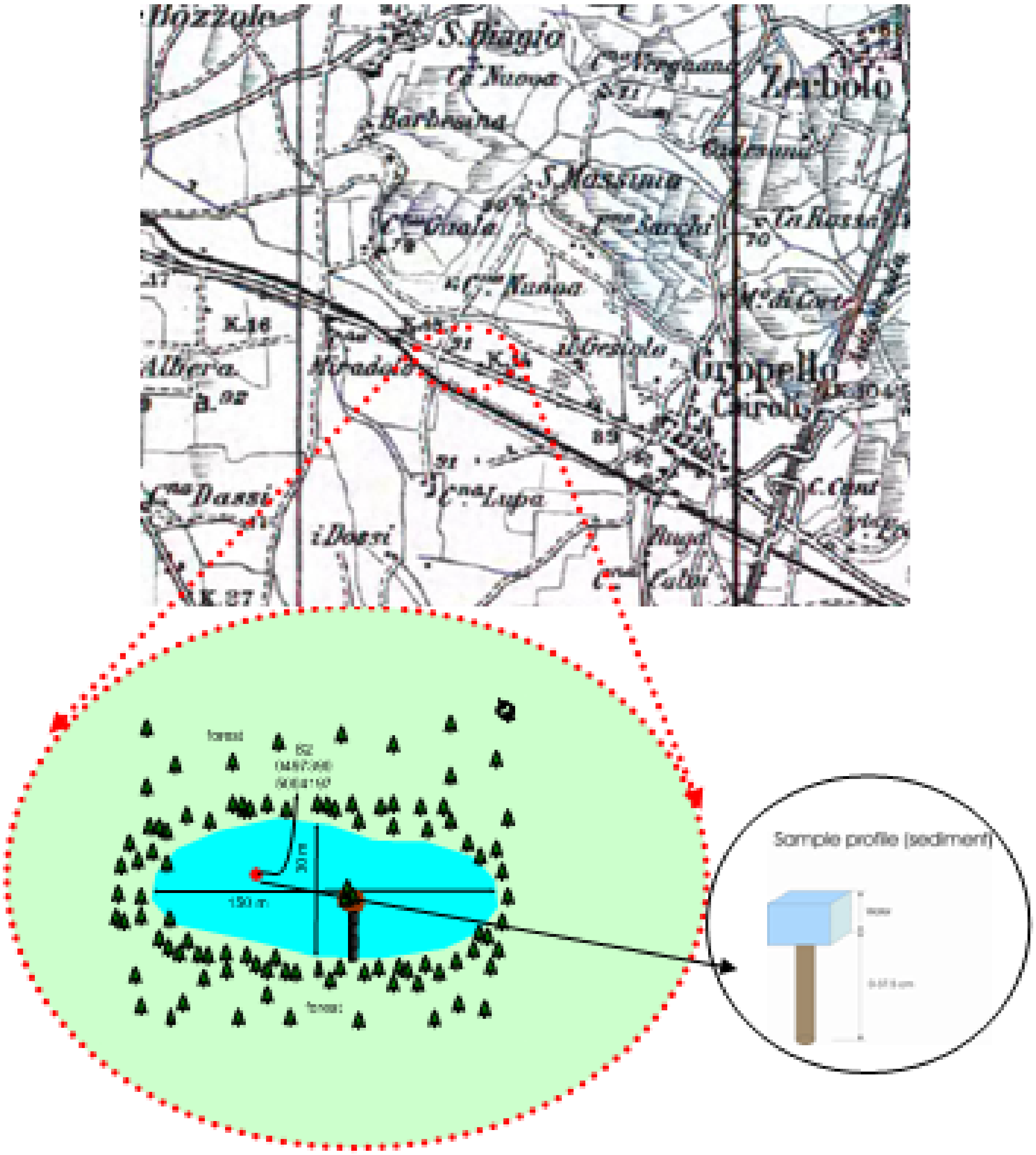
Location ID:	Groppello – Cascina S. Massimo		
Geographic area:	Provincia di Pavia – Lomellina		
Sampling date:	12 May 2005		
Coordinates	Position format: UTM/UPS		Map Datum: WGS 84
	32T	Lat.	0497390
		Long.	5004197
Quota and inclination:	72 m; 0%		
Area description:	Farmhouse Cascina S. Massimo; about 1 km from the farmhouse, inside the natural reserve. The little pond is completely covered by sediments (~ 30 cm of water). Area covered with trees, dense vegetation; lake width 50 m, length ~ 150 m, depth 25÷40 cm.		

Land-use: Wild wood

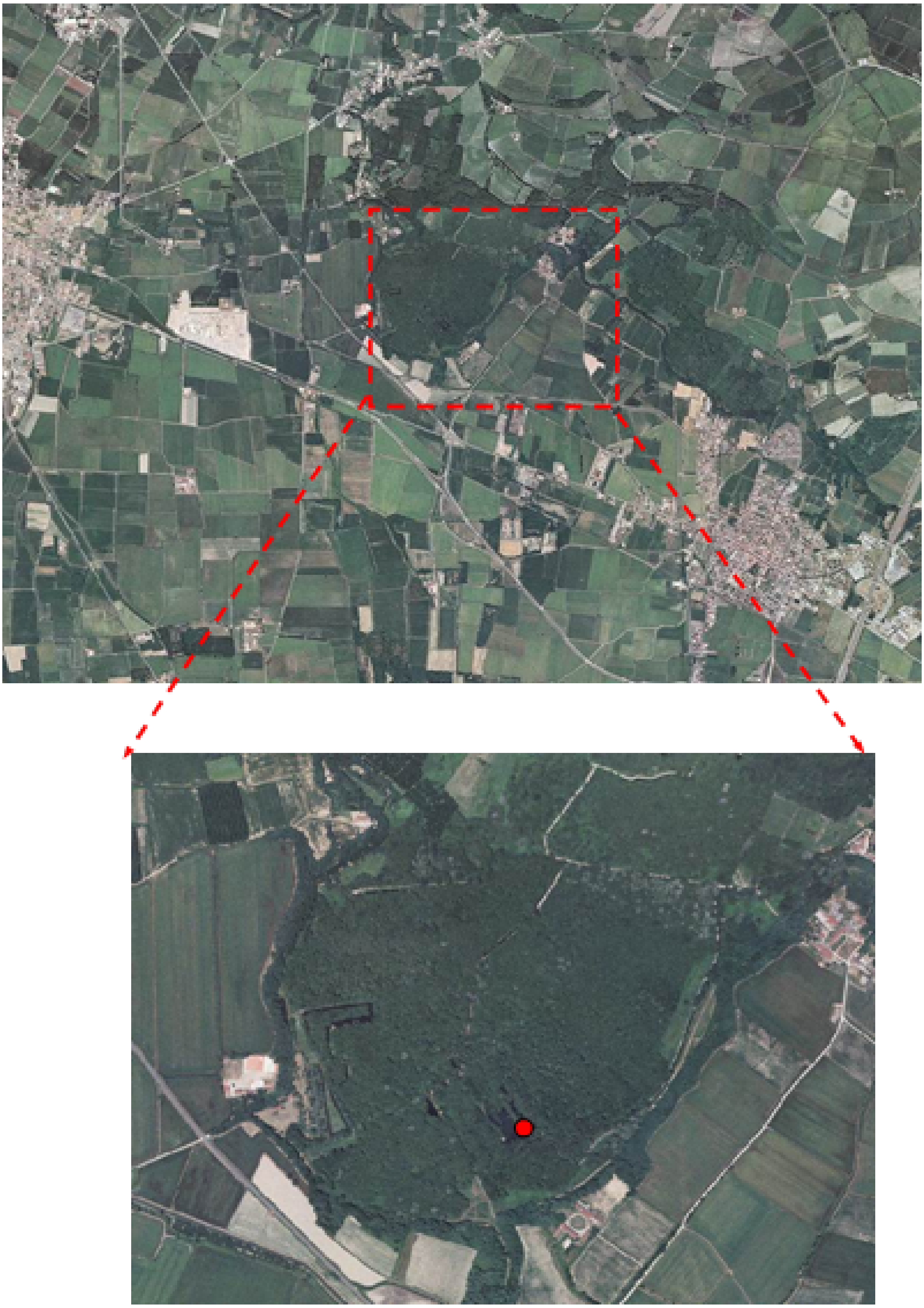
Sediment

2M 0÷37.5 cm, undisturbed sediment sampled in the centre of the pond, and subsequently divided in 34 sections of 11 mm each.

2D 0÷37.5 cm, undisturbed sediment sampled in the centre of the pond, and subsequently divided in 17 sections of 22 mm each.



Location of sampling area "S. Massimo"



Results and discussion

Figures 60 to 78 illustrate the concentration distribution over time of the assessed elements (C, N, S, P, Al, Si, Ca, K, Fe, Mg, Na, Cu, Cr, Hg, Mn, Ni, Pb, Ti and Zn) in the oxbow La Zelata. The respective values are reported in tables 43 and 44. The concentrations of macro-elements such as carbon, sulphur, phosphorus and nitrogen over time are particularly variable upon the seasonal deposit and removal of sediments, controlled by the river floods. The macro-elements, in particular silica and aluminium, but also calcium and potassium, present a time distribution which is more stable and less subject to the phenomena occurring over the year. The elements iron, sodium and magnesium have a fairly similar course, but to a lesser extent. This can be prevalently attributed to the terrigenous origin of the elements, which can hardly be modified or vary. To this regard, it is worth noting these are the principal elements composing the soil. They account for over 80% of the total oxide concentration. Therefore, this almost stable time course reflects the terrigenous origin of the sediments. The remaining trace elements, whose concentrations are significantly lower and thus more influenceable by natural and/or anthropic events, are more connected with the flood and slack periods of the river. The concentration over time does not indicate any decrease or increase trend. Only "moderate" concentration variations which occurred during the period covered by the sediment core sample collections were observed.

As expected, the concentrations reflect the values of soil within the catchment basin of the River Ticino and of other rivers of the zone, because they largely derive from them.
The San Massimo Groppello area has the typical characteristics of a lake rather than of an oxbow, even if it is of quite small size. Figures 79 to 94 show the course over time of the concentration of some elements, while tables 45 and 46 report their concentrations. Carbon and sulphur point out a decrease in the deepest layers with respect to the shallowest layers. Stable levels are observed for the macro-elements in the deepest layers up to about 25 cm in depth. The concentration increases starting from a depth of 25 cm and becomes stable at 10 cm from the most superficial layer. This course is well represented by trace elements as mercury, manganese, lead, titanium and zinc. The trace element concentrations over time can be compared to those found in other Italian lakes (*Cenci et al., 2003*). The level was stable in the deepest layer and presented values which can be considered as preindustrial contents.
At the end of the '40s and early in the '50s, a significant industrialization started both in Italy and in the rest of Europe. Such a phenomenon is pointed out by the increase in the element concentrations from a depth of 17-18 cm. The comparison between what was observed concerning mercury and the core sample collected in Lake Varese (figure 96) confirms what is described above. Another important data is observed at a depth of about 10 cm, where the concentration starts to decrease. Such a decrease is mainly due to Legge Merli n. 319, put into force in 1976.

The comparison of the mercury, lead, titanium, manganese and zinc concentration course in the core sample of San Massimo Groppello, which represents some events occurred during known time periods, with the values of mercury and ^{137}Cs of Lake Varese (Figures 95 and 96), allowed the assessment with good approximation the sedimentation rate of the core sample collected in San Massimo Groppello, which is of about 0,35 cm/year.
The sediment core sample being 37 cm, we can infer that it had formed and is able to "cover" a period of about 100 years.

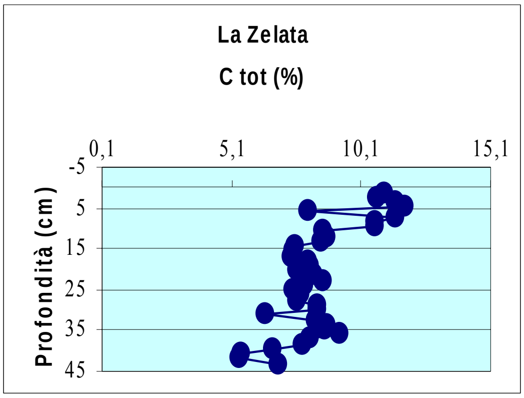


Figure 60. Concentration of C_{total}

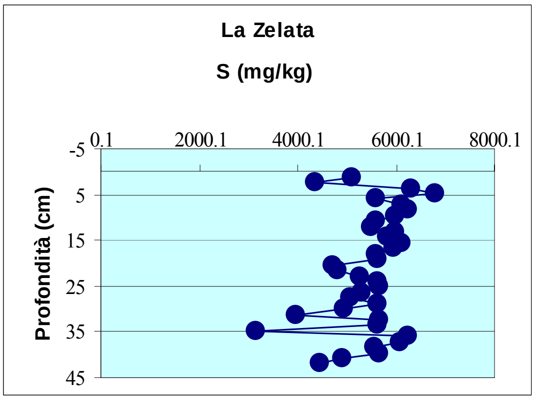


Figure 61. Concentration of S

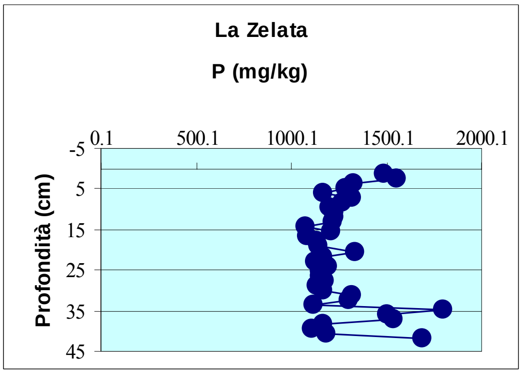


Figure 62. Concentration of P

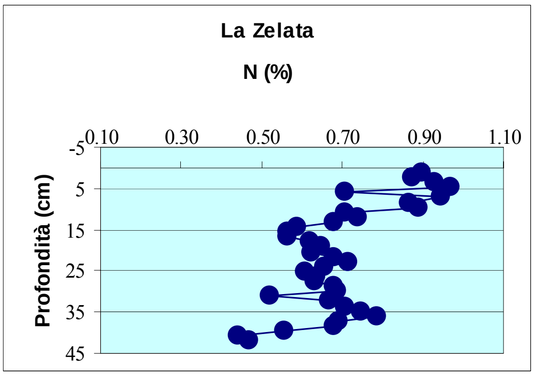


Figure 63. Concentration of N

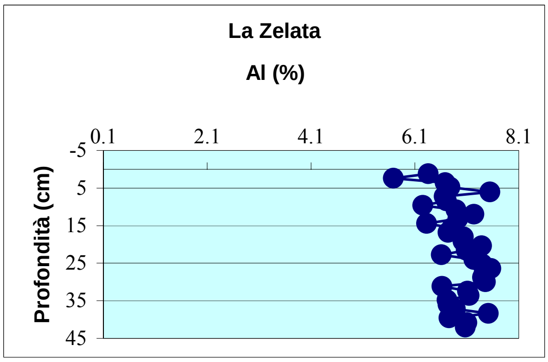


Figure 64. Concentration of Si

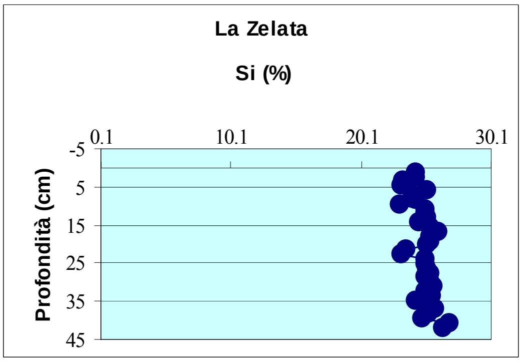


Figure 65. Concentration of Al

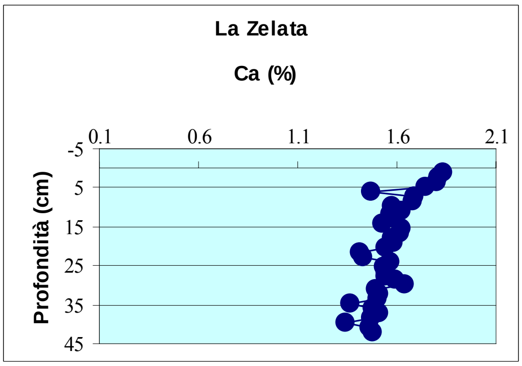


Figure 66. Concentration of Ca

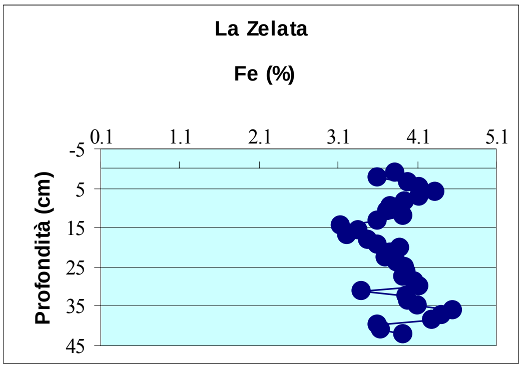


Figure 67. Concentration of Fe

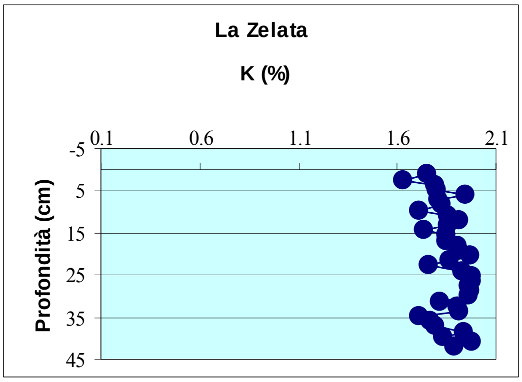


Figure 68. Concentration of K

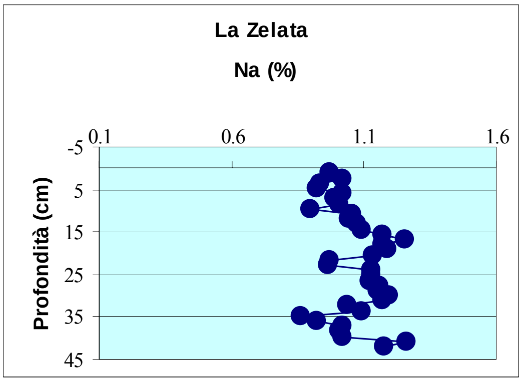


Figure 69. Concentration of Na

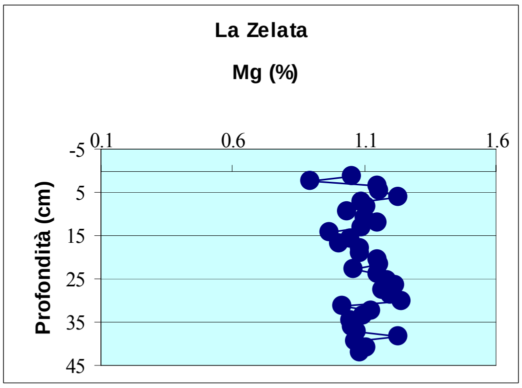


Figure 70. Concentration of Mg

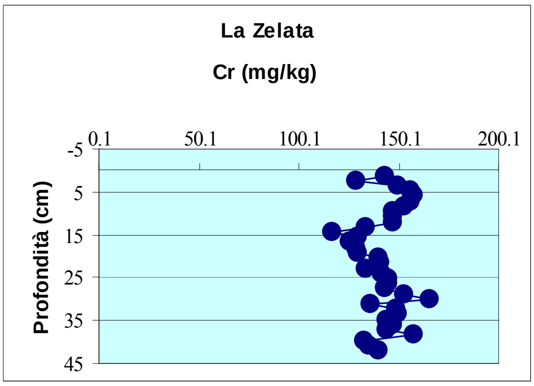


Figure 71. Concentration of Cr

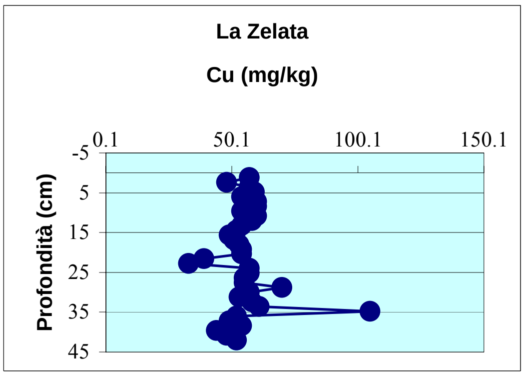


Figure 72. Concentration of Cu

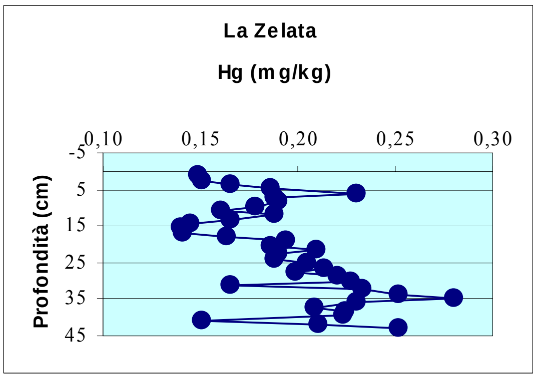


Figure 73. Concentration of Hg

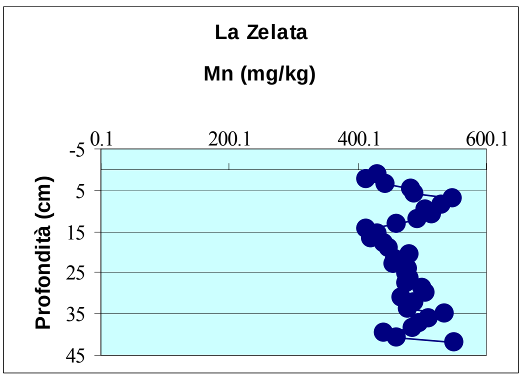


Figure 74. Concentration of Mn

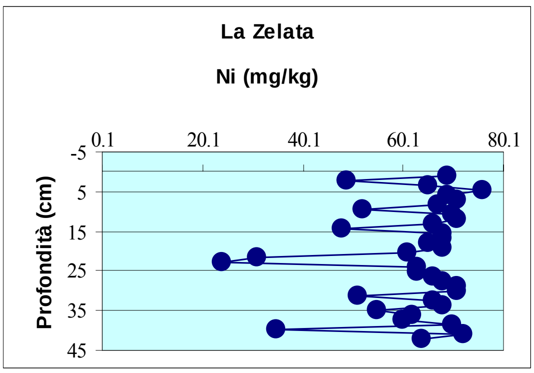


Figure 75. Concentration of Ni

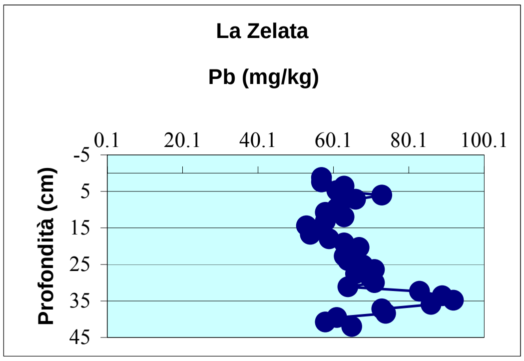


Figure 76. Concentration of Pb

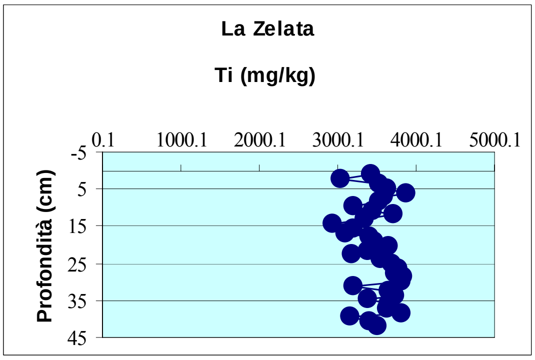


Figure 77. Concentration of Ti

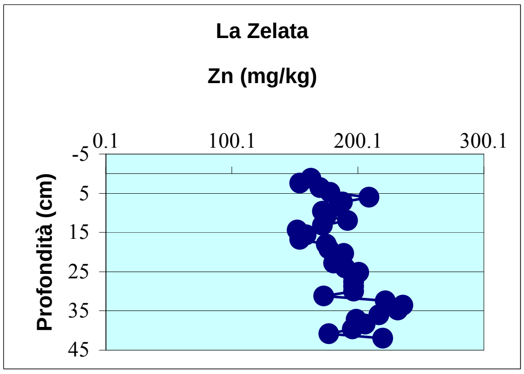


Figure 78. Concentration of Zn

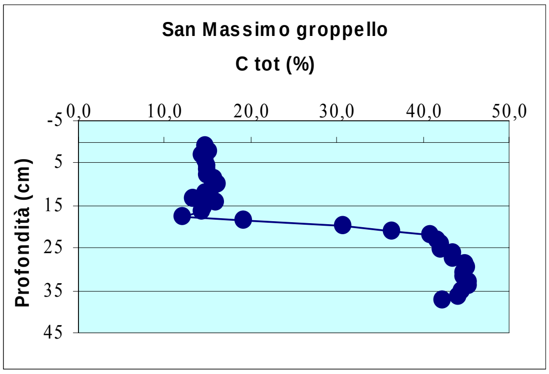


Figure 79. Concentration of total C

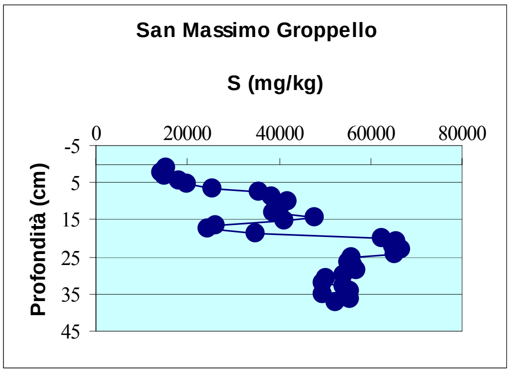


Figure 80. Concentration of S

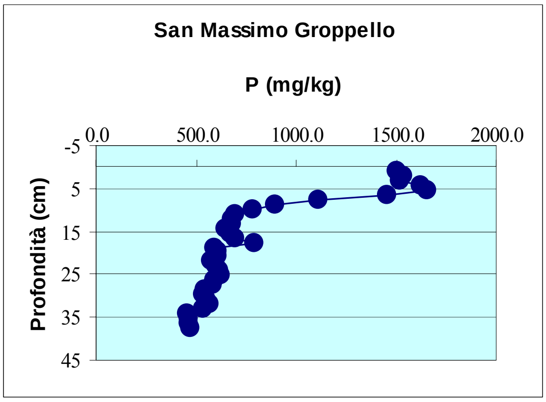


Figure 81 Concentration of P

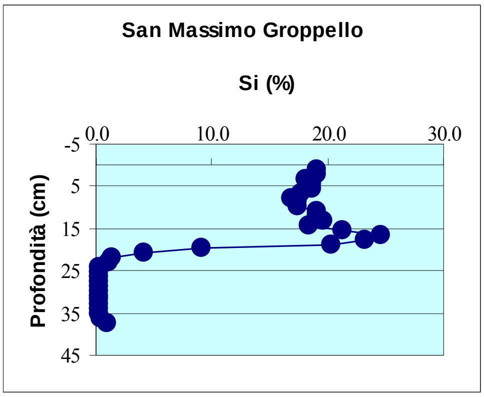


Figure 82. Concentration of Si

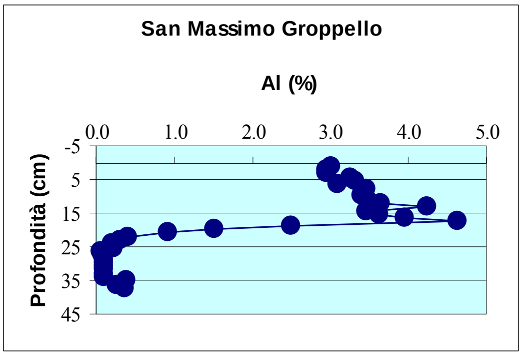


Figure 83. Concentration of Al

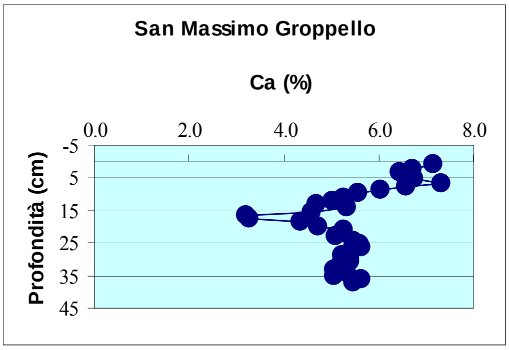


Figure 84. Concentration of Ca

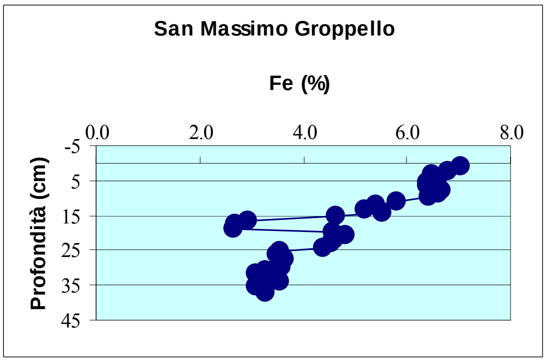


Figure 85. Concentration of Fe

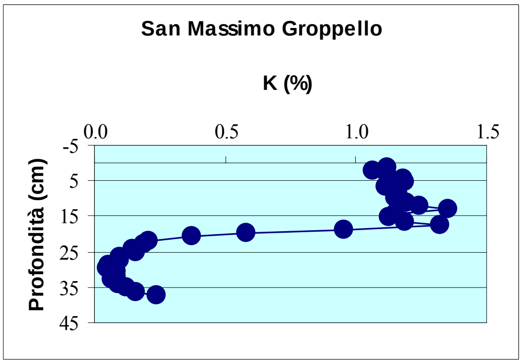


Figure 86. Concentration of K

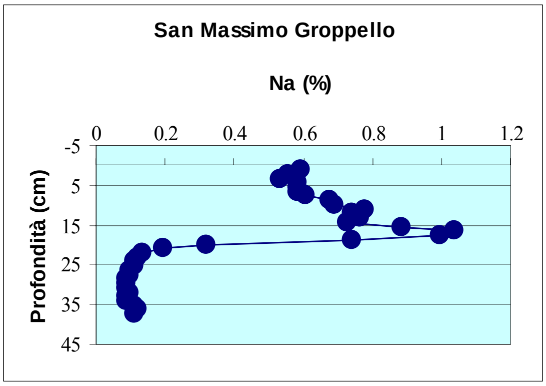


Figure 87. Concentration of Na

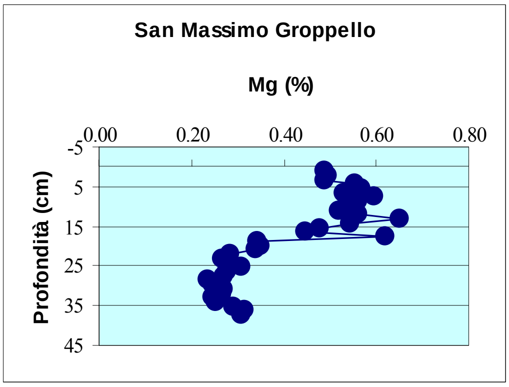


Figure 88. Concentration of Mg

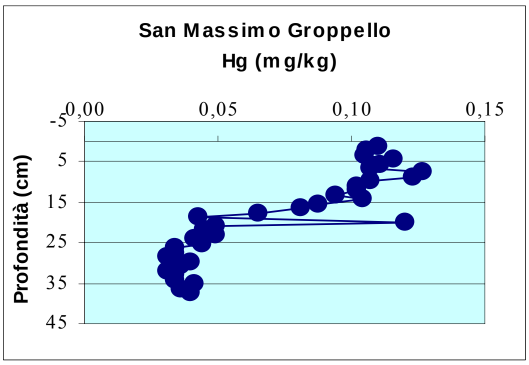


Figure 89. Concentration of Cr

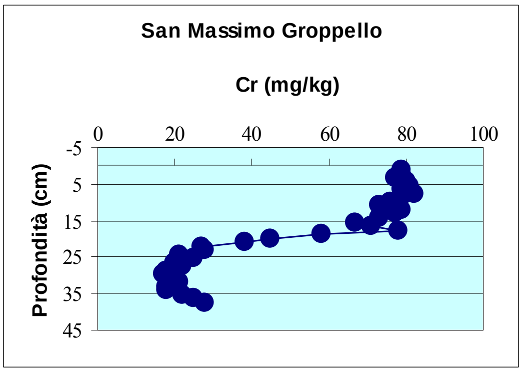


Figure 90. Concentration of Hg

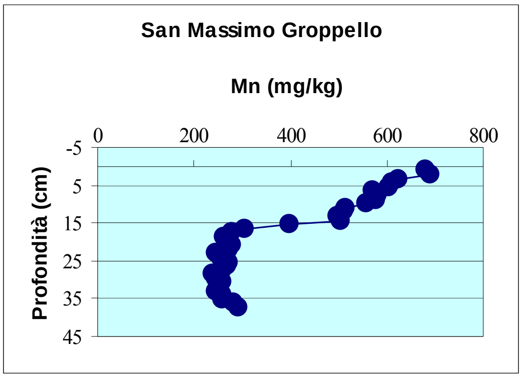


Figure 91. Concentration of Mn

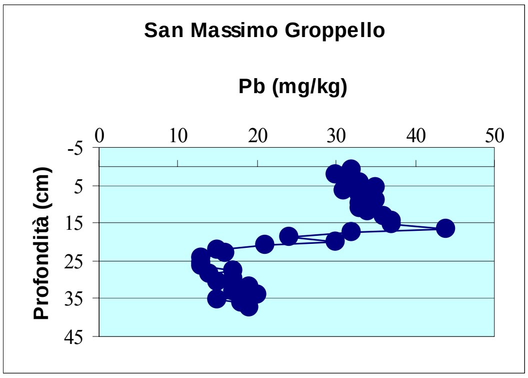


Figure 92. Concentration of Pb

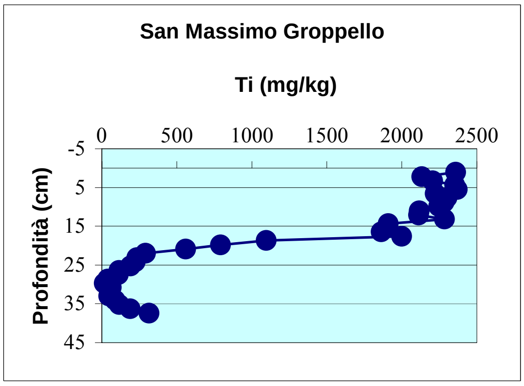


Figure 93. Concentration of Ti

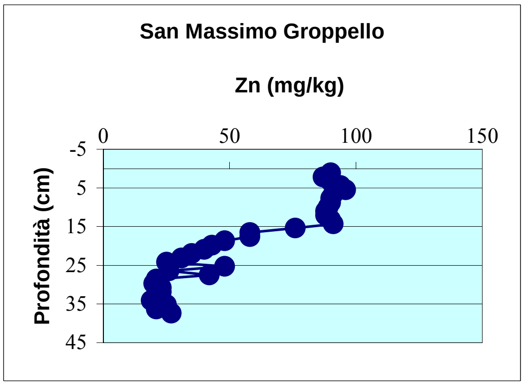


Figure 94. Concentration of Zn

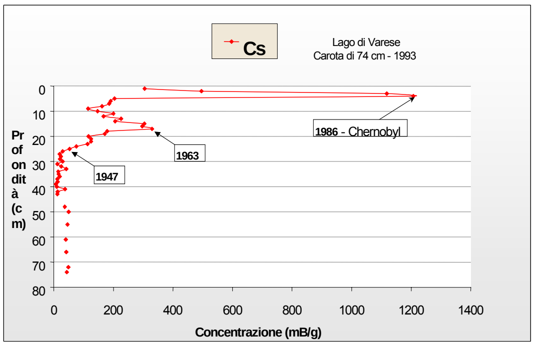


Figure 95. Concentration course of 137 Cs in the sediment core sample collected in the Varese lake (Cenci *et al*., 2003)

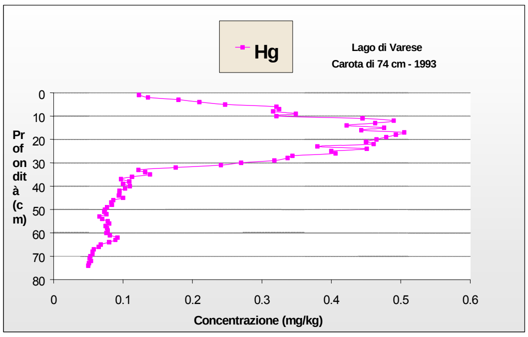


Figure 96. Concentration course of Hg in the sediment core sample collected in the Varese lake (Cenci *et al*., 2003)

Dioxins and furans

Tables 47 and 48 report the concentration levels of dioxins and furans in the sediment core samples respectively collected in La Zelata and San Massimo Groppello, expressed in WHO-TEQ (World-Health-Organization; Toxic-Equivalent-Quantities).

The concentration levels of the core sample collected in La Zelata are stable along the entire profile of the core sample itself. However, they are higher than the values of the core sample collected in San Massimo Groppello. This difference in concentration can be explained by the greater size of the catchment basin of La Zelata, which collects and settles a larger amount of organic and terrigenous matter.

The lower levels of PCDD/Fs (San Massimo Groppello) witness a small catchment basin and a small body of water which collects the atmospheric precipitation containing dioxins and furans.

Surprisingly, the deepest layer points out a significantly higher concentration level. This is quite difficult to explain and more targeted surveys would be necessary along with a historic knowledge of the area of S. Massimo Groppello.

Conclusions

The concentrations of the elements in the sediment core sample collected in La Zelata reflect the values of soil within the River Ticino basin. The variations over time are prevalently due to the flood and slack periods of the river which regulate the sedimentation and sediment removal processes. The trace element course of the San Massimo Groppello core sample confirms the beginning of a more significant industrialization occurred in the late '40s. Both the "bottom" values and concentrations in the more recent sediments are quite low, reflecting the activities carried out during the last few decades.

These low values match what was found in the soil and moss study and do not point out significant trace element introductions in the environment due to human activities or accidents occurred during the last few decades.

The values observed for dioxins and furans are low and stable over time. An exception is represented by the value found in the deep layers of the San Massimo Groppello core sample.

Sanitary risk

(The soil quality of the Province of Pavia in connection with sanitary risk)

The "Risk Assessment" is defined in scientific terms as the "systematic process for the evaluation of all the significant risk factors intervening in an exposition situation caused by the presence of dangers". In practice, the Risk Assessment evaluates the consequences on human health of a potentially harmful event, and more precisely the probability that these consequences will occur. According to its nature, the evaluation process provides the degree of importance of potential risks examined for a specific case, and has to be compared on a univocal reference basis.
The Risk (R), which is a definition originally derived from the industrial safety procedures, is intended as the conjunction of the probability that a harmful event (P) will occur, and the extent of the damage provoked by this event (D):

$$R = P \times D$$

The damage caused by the accidental event (D) can in turn be provided by the product of a danger factor (Fp), depending on the entity of the possible damage, by a contact factor (Fe) which is a function of the exposition duration:

$$D = Fp \times Fe$$

The danger factor is given by the pollutant toxicity (T [mg/kg d]-1); the contact factor is expressed as a function of the effective exposition (E [mg/kg d]). Thus, the risk (R) is calculated in general with the following formula:

$$R = E \times T$$

Wherein: E ([mg/kg d]) represents the daily chronic intake of the contaminant and T ([mg/kg d]-1) represents its toxicity. The result, R, is then compared with the individual and cumulative criteria of acceptability of the sanitary risk, to decide whether the existing conditions can cause harmful health effects or not.

On the basis of these principles, in this document a risk evaluation in connection with the quality state of the province of Pavia was carried out through the "Acceptable Daily Intake" (A.D.I.) criterion. The A.D.I. is established by certain international bodies on the basis of toxicological criteria. In this document we have used those proposed by the Joint FAO/WHO Export Committee on Food Additives (JECFA).
We made the precautionary assumption that there could be an exposition to the substances observed in soil of the province of Pavia of a particularly sensitive human target: "a child".
According to the care principle, which leads us to consider the risk in the Worst Case scenario, the ingestion of contaminated soil by a child is assumed as the exposition route. This data is compared to the A.D.I. for this specific substance.
As reported in the document "Criteri metodologici per l'applicazione dell'analisi assoluta di rischio ai siti contaminati", elaborated by APAT, ARPAs, ISS, ISPESL and ICRAM (June 2005), it is assumed that a child could ingest 200 mg/day of soil (containing the researched substances).
Therefore, we present in the following some tables reporting the concentrations of substances which could be assimilated by a child ingesting 200 mg of soil per day. The results are compared with the A.D.I. reported in the scientific literature concerning the individual substances considered.

Still on the basis of the “Worst Case” scenario, the maximum concentration observed for every individual substance researched in the entire provincial area is taken as the representative value (Table 49).

Conclusions

The concentrations observed for the parameters researched in the surface soils of the province of Pavia showed a nickel content which is higher with respect to what was stated by Legislative Decree 152 of 2006, concerning the contaminated soil reclamation, the housing/recreational/public green destination of use and the hypothetical exposition to the soil due to ingestion by a child. However, they did not point out a sanitary risk even under the worst conditions (Worst Case).

Note that only the execution of a risk evaluation with respect to the “soil ingestion” exposition was considered as suitable, as the analytical data refers to the surface soil layer. Therefore, this exposition possibility appears as the most likely and conservative.

Final Conclusions

2004 was the "year zero" for the soil of Pavia.
It set a milestone in the environmental monitoring field and provided a complete register of bio-physical-chemical information concerning the soil of the province of Pavia.
The soil was monitored using standard methodologies for site identification, and for sample collection, treatment and analysis. Different aspects of soil were taken into consideration: for example chemical aspects, such as the trace elements, dioxins and furans, organic carbon. Physical aspects such as the texture, water content, soil profile. Biological aspects such as bacteria and their products. Vegetal bioindicators were used for a wider reading aimed at evaluating the quality and thus the health state of soil and this made way for the assessment the soil depositions of trace elements and their origin.
The concentration levels of trace elements, dioxins and furans are similar to those found in areas with low anthropogenic pressure. Human activities such as agriculture and industry did not increase their levels.
Concerning the soil fertility, an impoverishment of the nutrients was not observed, and the values of the organic substance are positive. An exception is represented by Secondary Point 4, where the concentrations of trace elements, dioxins and furans are high. This was also confirmed by the second survey. An appropriate extension of the study was carried out to evaluate the expansion and the level of the contaminated area, and these data are now available.
Concerning the soil "goodness" and the evaluation of the pre-industrial level, the latter is difficult to assess. Instead, the terrigenous contribution due to the "historic" sediments carried by the River Po, which had an influence on soils and their content in metal elements, is evident. Such an aspect is shown by chrome and nickel. In fact, their concentrations slightly exceed the national limits of Legislative Decree 152 in rare cases and in the close surroundings of the river bed.
The observations obtained with the study of bacteria suggest that certain intensive and monocropping agricultural practices, mainly localised in the northern area of the province, are potentially harmful for soil health and fertility. In fact, they did point out some stress factors. Such an aspect should be further assessed using a higher number of bioindicators.

The soil drops of trace elements, both of anthropic and natural origin, were assessed by the use of moss as bioindicators. They do not significantly increase the concentration levels in soil. The comparison of these drops with the results obtained in other studies shows that they are similar to those of agricultural areas. Also, they are significantly lower than in urbanized areas with industrial and agricultural activities.

Another considered aspect concerns the agricultural use of Sewage sludges. The increase in the trace element concentration in soil of the areas treated with sludges is almost absent and difficult to assess, because the levels of the surveyed area are similar to those observed in the wider area, which is partially treated with sludges. The dioxin and furan levels are modest and a direct influence of the use of sewage sludges in increasing their concentration in the soil was not pointed out. The analysis of bacteria shows an almost identical state over the three considered areas. All in all, the biological fertility can be considered as positive.

In conclusion, we point out three observations of primary importance. The first concerns the evaluation of the sanitary risk: the results obtained considering a possible exposition upon child soil ingestion did not suggest a potential sanitary risk even in the worst case.
Secondly, we want to focus the attention on the importance of the monitoring, on how it was planned and on the results obtained. These aspects laid a solid basis for future developments and surveys.

The last observation concerns the soil quality and health. All in all, they appear to be positive and suggest that in past and present times the territory was and is largely respected and well managed.

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TABLES

Data Tables
of this Publication

Table 3. Primary Points (AM1), average levels of pH and concentrations of C, N (%), S and P (mg/kg) within first and fourth soil layers

AM1	Thickness cm	pH unit	C %	Ctot %	N %	S mg/kg	P mg/kg
PP1	0-10	5	1,78	1,43	0,15	495	696
PP1	80-100	5,8	0,36	0,19	0,02	60	765
PP2	0-25	5,29	1,15	0,95	0,11	1109	871
PP2	80-100	5,5	0,2	0,17	0,03	<60	707
PP3	0-10	5,6	1,26	0,99	0,13	267	996
PP3	80-100	6,25	0,18	0,14	0,02	<60	656
PP4	0-25	6,3	1,35	1,18	0,18	283	1543
PP4	75-100	6,34	0,98	0,16	0,14	62	4537
PP5	0-10	7,38	3,39	1,1	0,15	282	730
PP5	80-100	7,56	3,23	0,61	0,08	119	516
PP6	0-15	7,49	2,32	1,04	0,15	272	674
PP6	80-100	7,66	2,22	0,31	0,05	76	540
PP7	0-10	7,71	4,55	1,32	0,15	455	781
PP7	70-100	7,66	2,97	0,23	0,03	121	556

Table 4. Primary Points (AM1), average levels of Si, Al, Ca, K, Fe, Mg, Na (%) and Ti (mg/kg) concentrations within the first and fourth soil layers

AM1	Thickness cm	Si %	Al %	Ca %	K %	Fe %	Mg %	Na %	Ti mg/kg
PP1	0-10	25,5	8,9	1,7	1,5	6,3	1,3	1,1	5210
PP1	80-100	25,5	8,9	2,5	1,5	5,6	2	1,4	6030
PP2	0-25	31,8	7,3	1,2	2	1,5	0,8	1,9	2460
PP2	80-100	29,6	8,9	1,1	2,2	2,6	1	1,6	3130
PP3	0-10	29,7	7,9	1,5	2,3	3,2	1,4	1,8	3380
PP3	80-100	31,1	6,9	1,4	2,2	2,1	1	2	2600
PP4	0-25	33,1	6,4	1,2	1,8	2,1	0,7	1,4	3670
PP4	75-100	31,9	7,3	1,2	1,8	2,5	0,9	7	2610
PP5	0-10	22,3	7,7	7	2,1	3,8	2,6	0,5	3420
PP5	80-100	21,6	7,4	8,1	2	3,7	2,5	0,5	3350
PP6	0-15	25,9	7,8	4,2	2,1	3,8	1,5	0,9	3900
PP6	80-100	24,2	7,2	7,0	1,8	3,6	1,4	0,8	3660
PP7	0-10	22,7	4,3	11,3	1,4	2,9	1,3	0,7	1930
PP7	70-100	23,9	4,4	10,9	1,5	2,8	1,1	0,8	1960

Table 5. Primary Points (AM1), average levels of As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb and Zn (mg/kg) concentrations in soils of the first layer compared with values described in "*Decreto Legislativo" Nr.152 of 2006* and with criteria of Regione Lombardia

Site	**As** mg/kg	**Cd** mg/kg	**Co** mg/kg	**Cr** mg/kg	**Cu** mg/kg	**Hg** mg/kg	**Mn** mg/kg	**Ni** mg/kg	**Pb** mg/kg	**Zn** mg/kg
PP1 (0-10 cm)	56,8	0,29	18,2	111	30	0,06	1318	57	23,6	90
PP1 (80-100 cm)	14,7	0,06	14,8	115	23,5	0,01	733	59	5,9	60
PP2 (0-25 cm)	3,2	0,13	4,4	28	16,4	0,04	199	17	15,5	47
PP2 (80-100 cm)	9,7	0,05	8,1	33	11	0,01	588	23	7,6	44
PP3 (80-100 cm)	6,1	0,05	5,7	31	9,7	0,23	310	19	6,3	33
PP4 (0-25 cm)	12,2	0,26	8,5	48	24,1	0,04	476	28	18,8	100
PP4 (75-100 cm)	13,1	0,07	8,1	51	15,7	0,02	517	35	8,5	42
PP5 (80-10 cm)	9,4	0,29	16	163	115	0,05	605	123	18,1	98
PP5 (80-100 cm)	9,1	0,19	17,2	166	45,2	0,04	657	128	14,5	89
PP6 (0-15 cm)	12,1	0,13	14,4	102	150	0,04	675	78	15,1	96
PP6 (80-100 cm)	11,7	0,11	14,2	106	48,9	0,04	669	77	12	80
PP7(0-15 cm)	6	0,18	9,7	124	11,6	0,03	395	67	9,6	57
PP7 (80-100 cm)	5,8	0,12	10,5	127	11,7	0,03	409	72	8,3	54

The uncertainty of the analytical data for soil was estimated for three different concentration levels. It is in agreement with the formula of Horwitz and Albert (1997). The average uncertainty levels for the elements were obtained with this formula.

Table 6. Secondary Points (AM2), average levels of C, N (%) and trace elements (mg/kg) concentrations of soils, within the layer 0-30 cm

Site	C %	Corg %	N %	Al %	As mg/kg	Cd mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Hg mg/kg	Mn mg/kg	Ni mg/kg	Pb mg/kg	Zn mg/kg
ps 01	1,15	0,95	0,11	4,7	8	0,09	8,3	38	9,8	0,05	335	19	11,5	45
ps 02	0,94	0,86	0,09	3,2	4,5	0,14	5,1	30	11,5	0,05	162	17	12,9	38
ps 03	1,06	0,98	0,11	5,2	9	0,1	6,9	40	14,1	0,07	378	2	18,6	60
ps 04*	*4,28*	*4,1*	*0,42*	4,8	32,5	34,6	12,8	269	264	3,15	1577	56	674	4038
ps 05	1,29	1,33	0,12	4	3,7	0,41	8,6	89	41,6	0,34	222	46	32,8	114
ps 06	0,81	0,69	0,08	5,8	9	0,17	8,2	47	20,1	0,05	519	26	12,7	78
ps 07	0,94	0,73	0,09	2,8	6,9	0,07	4	25	9,7	0,07	306	16	45,9	41
ps 08	1,68	1,35	0,16	3,3	10,2	0,35	7	62	19,5	0,06	286	25	28,7	100
ps 09	0,71	0,57	0,08	5,3	17,8	0,19	9,9	42	21,7	0,05	427	28	22,5	74
ps 10	0,65	0,5	0,08	5,5	24,3	0,14	9,2	36	16,3	0,07	619	22	16,5	67
ps 11	2,81	2,68	0,31	4,7	15,5	0,44	9,8	51	33	0,14	655	34	32,1	119
ps 12	0,89	0,67	0,09	6,8	8,7	0,26	20,7	162	42,5	0,05	894	163	19,6	98
ps 13	2,62	1,91	0,27	1,7	3,1	0,08	2,9	20	15,8	0,19	121	14	8,7	55
ps 14	0,8	0,62	0,08	2,5	4,6	0,09	4,6	33	7,9	0,03	466	16	9,8	33
ps 15	1,02	0,94	0,12	7,6	23	0,14	14,1	64	34,9	0,06	652	43	20,6	104
ps 16	0,85	0,77	0,11	5,2	7,7	0,13	8,3	66	18,8	0,06	577	34	23,9	51
ps 17	0,86	0,78	0,1	3,1	2,4	0,08	7,5	133	17,4	0,04	177	87	19,3	59
ps 18 (san 51)	1,38	1,01	0,15	6,2	9,6	0,26	12,7	107	23,6	0,09	1502	66	21,7	86
ps 19 (san 57)	1,94	1,43	0,19	4,7	7,2	0,28	18,1	179	31,4	0,05	428	145	19	89
ps 20	1,35	0,61	0,07	4,8	7,9	0,23	16,9	205	36,3	0,06	653	146	21,9	88
ps 21	2,99	1,23	0,18	11,5	8,1	0,2	19,7	172	47,2	0,05	927	135	19,5	109
ps 22	1,19	0,84	0,16	7	7	0,24	18,7	97	34,9	0,08	840	51	25,4	89
ps 23	1,74	1,2	0,19	12,1	9,9	0,34	20,6	191	50,4	0,08	834	125	24,6	131
ps 24	2,5	0,91	0,16	6,7	11,5	0,29	22	225	46,8	0,1	774	176	24,6	104
ps 25	4,41	2,64	0,28	5,10	9,7	0,18	13,2	187	20,9	0,09	522	133	16,1	64
ps 26	4,21	0,8	0,13	9,3	3	0,29	9,51	88	33,8	0,03	386	28	9,3	92
ps 27	4,32	0,88	0,14	5,3	6,2	0,21	13,3	88	33,5	0,14	909	71	14,5	77
ps 28	3,17	0,8	0,16	8,5	8,1	0,25	16,8	152	39,9	0,06	793	113	17,8	102
ps 29	2,96	0,64	0,14	12,7	4,8	0,14	17,1	84	57,5	0,05	1291	58	13,2	106
ps 30	4,26	0,85	0,13	6,4	5,1	0,25	18,4	183	34,4	0,05	866	140	16,1	102
ps 31	3,76	3,56	0,24	9,2	7,2	0,45	14,2	73	27,6	0,08	956	38	29,3	95
ps 32	2,17	1,66	0,25	11,8	12,2	0,15	14,4	88	39	0,07	471	47	24,7	100
ps 33	3,03	0,97	0,13	11,8	6,4	0,21	20,1	117	51,6	0,07	1416	120	19,4	112
ps 34	3,17	2,41	0,24	10,5	8	0,29	12,6	68	26,5	0,08	510	34	27	82
media	2,11		0,15	6,50	8,8	0,22	12,6	98	29,4	0,08	633	68	21	84
min	0,65	0,5	0,08	1,7	2,4	0,07	2,9	20	7,9	0,03	121	14	9	33
max	4,42	4,1	0,42	12,7	24,3	0,45	22	225	57,5	0,34	1502	176	46	131
dev std				3,1	5	0,1	5,5	60	13	0,06	345	52	8	25
U (%)				9	12	20	11	8	10	23	6	8	10	8

* levels excluded from the average

Table 7. AM3, area of Sannazzaro dei Burgondi, soil data in layer 0-30 cm

Site	C %	Corg %	N %	Al %	As mg/kg	Cd mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Hg mg/kg	Mn mg/kg	Ni mg/kg	Pb mg/kg	Zn mg/kg
san 11	0,93	0,73	0,09	3,5	4,2	0,09	5,7	43	11,7	0,03	231	19	14,9	41
san 13	1,35	1,19	0,12	3,3	4,1	0,12	4,5	31	11	0,04	175	16	16	42
san 15	1,22	1,12	0,11	3	2,8	0,17	3,8	26	10,3	0,06	225	15	13,1	47
san 17	1,22	1,19	0,11	3,9	5,5	0,21	6,4	49	26	0,08	440	22	24,7	84
san 22	1,05	0,93	0,1	2,9	4,7	0,11	5,2	26	11,6	0,03	208	18	14,4	45
san 23	0,72	0,69	0,07	5,7	2,9	0,05	4,3	28	8,8	0,02	235	16	8,9	34
san 24	0,6	0,45	0,06	5,7	13,6	0,09	10,4	46	18,7	0,04	587	32	11,4	52
san 25	1,99	1,79	0,2	3,5	3,1	0,2	5	39	17,5	0,04	219	18	16,2	50
san 26	0,55	0,48	0,06	2,6	3,7	0,08	4,4	21	8,4	0,03	541	15	10,9	42
san 31	0,99	0,82	0,11	6,1	8,4	0,18	10,5	59	18,4	0,05	320	36	19,8	70
san 32	0,78	0,73	0,08	3,8	6,8	0,21	9,3	69	19,7	0,02	264	42	18,2	73
san 33	1,26	1,16	0,13	3,8	4,4	0,15	6,2	42	17	0,08	207	25	21	60
san 34	1,25	1,15	0,13	4	3,9	0,13	7,1	54	17,3	0,21	177	32	15,9	59
san 35	1,19	0,92	0,12	5	3,8	0,12	7,9	70	19,5	0,1	240	45	23	65
san 36	1,91	1,55	0,19	3,6	5,	0,19	6,4	4	19,4	0,08	218	25	22,8	59
san 37	1,69	1,03	0,16	5,4	7	0,16	8,4	53	21	0,09	338	33	15,6	58
san 42	0,85	0,66	0,09	8	8,6	0,12	13,1	75	1	0,03	683	36	15,8	68
san 43	0,77	0,56	0,08	4,5	5	0,19	9,6	61	13,3	0,03	313	33	15	58
san 44	1,16	0,78	0,13	4,2	6,7	0,09	6,2	44	15,1	0,19	348	25	20,6	52
san 45	0,96	0,69	0,1	5,6	10,1	0,28	9,5	54	29,7	0,05	666	35	23	72
san 46	1,98	1,21	0,16	8	16	0,28	26,4	262	45,5	0,06	904	214	23,6	110
san 51 (18 ps)	1,38	nd	0,15	6,2	9,6	0,26	12,7	107	23,6	0,09	1502	6	21,7	86
san 52	0,69	0,49	0,07	3,3	6,8	0,1	9,8	106	14	0,02	508	61	9,9	56
san 53	0,49	0,04	0,06	4,9	4,5	0,1	8,8	55	10,8	0,02	338	28	12,6	49
san 54	1,02	0,82	0,11	5,7	4,6	0,16	10,1	67	19,1	0,05	319	36	18,1	62
san 55	2,05	1,22	0,15	5,6	8,9	0,24	18,6	191	35,3	0,09	711	144	20,9	94
san 56	1,89	0,82	0,12	6,3	10,3	0,24	21,5	210	38,9	0,09	816	169	22,1	97
san 57 (19 ps)	1,94	nd	0,19	4,7	7,2	0,28	18,1	179	31,4	0,05	428	145	19	89
san 62	0,68	0,65	0,07	5,2	12,1	0,34	11,3	82	16,8	0,03	607	48	13	63
san 63	1,13	0,88	0,12	6,8	5,9	0,23	15,5	178	30,2	0,07	347	112	21,3	92
san 64	1	0,72	0,1	7,3	11	0,21	24,1	230	39,1	0,04	786	183	20,2	97
san 65	1,58	1,08	0,14	5,4	6,5	0,3	18,7	191	31,7	0,06	392	153	18,5	82
san 66	1,52	0,69	0,09	6,4	8,4	0,26	18,6	180	44,9	0,12	757	146	24,4	107
san 71	0,8	0,57	0,09	5,8	15,4	0,13	12,9	75	19,4	0,03	1110	45	13	66
san 73	1,48	0,51	0,08	9,7	10,1	0,2	25,9	261	44,6	0,14	875	214	17,5	99
san 74	1,03	0,67	0,09	5,7	6	0,18	15,8	192	25,9	0,05	461	127	12,8	75
san 75	1,61	0,89	0,11	5,3	8	0,27	19,4	195	38,2	0,16	758	155	19,7	86
san 77 (vog 11)	1,6	0,5	0,07	3,7	8,7	0,25	15,5	174	31,3	0,03	551	128	14,5	72
media				5,1	7,2	0,18	11,8	102	23	0,06	495	71	17,5	69
min	0,49	0,04	0,06	2,6	2,8	0,05	3,8	21	8,4	0,02	175	15	8,9	34
max	2,05	1,79	0,2	9,7	16	0,34	26,4	262	45,5	0,21	1502	214	24,7	110
dev std				1,6	3,3	0,07	6,3	74	10,8	0,05	295	63	4,3	20
U (%)				9	12	21	11	8	10	24	6	8	10	8

Table 8. AM3, Parona, soil data in layer 0-30 cm

Site	C %	Corg %	N %	Al %	As mg/kg	Cd mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Hg mg/kg	Mn mg/kg	Ni mg/kg	Pb mg/kg	Zn mg/kg
par 11	0,93	0,81	0,08	3,4	6,2	0,2	4,6	27	15,7	0,09	183	16	17,2	44
par 12	1,04	0,89	0,11	8	13,5	0,23	10,2	57	18,5	0,13	710	30	22	119
par 13	2,03	1,94	0,19	7,7	12,3	0,15	10,8	58	18,6	0,08	399	30	28,3	74
par 14	1,2	1,15	0,12	5	7,6	0,15	6,8	62	16,9	0,09	355	22	22	69
par 15	1,65	1,37	0,18	5,2	10,5	0,18	7,9	42	27,6	0,19	592	24	38,3	78
par 21	0,84	0,81	0,08	3,4	5,6	0,2	5,1	33	25,2	0,11	446	23	24,9	79
par 22	1,72	1,77	0,15	3,2	4,3	0,14	4,6	25	12,8	0,04	201	15	18,5	47
par 23	1,22	0,96	0,12	4,7	5,4	0,86	8,5	94	40,3	0,61	292	51	38,5	123
par 24	2,39	1,15	0,21	6,8	9,3	0,24	10,5	59	22,4	0,07	335	31	23,4	75
par 25	1,04	0,95	0,1	4,6	4,8	0,12	6,1	34	15,8	0,04	256	19	16,7	52
par 31	1,12	0,85	0,11	3,5	5,3	0,25	4,8	29	19,6	0,12	435	19	21,6	62
par 32	1,49	1,26	0,13	2,8	3,8	0,18	4	23	10,7	0,05	192	13	12,4	36
par 33	1,1	0,89	0,11	3,7	4,9	0,13	5,1	48	14,1	0,05	245	20	14,5	59
par 34	0,93	0,67	0,09	3,6	8,1	0,33	6,3	49	23,4	0,32	278	31	26,4	108
par 35	2,56	2,49	0,23	6,1	6,9	0,27	8,6	50	29	0,06	310	27	27,1	81
par 41	1,01	0,87	0,09	2,9	6,8	0,17	4,5	24	13,2	0,15	392	17	22,7	52
par 42	2,01	1,64	0,16	2,2	5,3	0,13	3,9	21	11,5	0,1	188	13	20,6	35
par 43	1,16	0,75	0,08	4,7	6,7	0,14	6,1	41	11,4	0,08	283	21	15,9	53
par 44	0,97	0,87	0,09	3,8	4,3	0,4	6	66	25,4	0,37	234	40	26,9	103
par 45	1,15	0,96	0,12	6,5	11,7	0,14	9,4	48	27	0,04	323	28	21,9	65
par 51	1,16	1,12	0,11	3,5	4,9	0,41	6,4	59	26,2	0,29	258	31	30,2	84
par 52	0,73	0,62	0,07	3,5	7,2	0,21	7,1	52	22,4	0,08	357	37	17,7	71
par 53	0,72	0,68	0,07	3,2	5,6	0,07	4,9	25	9,3	0,03	350	14	13,4	39
par 54	0,83	0,63	0,08	5,3	10	0,62	11,6	107	45,4	0,64	313	63	39	126
par 55	0,94	0,76	0,08	4,9	8,7	0,16	7,7	46	17,1	0,04	353	26	16,2	63
media				4,5	7,2	0,24	6,9	47	20,8	0,15	331	27	23	72
min	0,72	0,62	0,07	2,2	3,8	0,07	3,9	22	9,3	0,03	183	13	12,4	35
max	2,56	2,49	0,23	8	13,5	0,86	11,6	107	45,4	0,64	710	63	39	126
dev std				1,5	2,7	0,17	2,3	21	8,9	0,17	123	11	7,5	27
U (%)				10	12	20	12	9	10	21	7	10	10	8

Table 9. AM3, Giussago, soil data in layer 0-30 cm

Site	C %	Corg %	N %	Al %	As mg/kg	Cd mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Hg mg/kg	Mn mg/kg	Ni mg/kg	Pb mg/kg	Zn mg/kg
gius 11	1,70	1,57	0,17	2,5	11,6	0,18	3,5	18	10,1	0,09	183	11	13,2	43
gius 12	1,46	1,27	0,16	5,1	14,6	0,33	8,7	38	29,8	0,11	261	22	37,7	91
gius 31	1,26	1,02	0,13	4,3	21,6	0,25	7,1	30	14,3	0,07	346	18	19,2	63
gius 33	0,91	0,73	0,1	3,7	13,8	0,19	5,4	29	23,9	0,08	260	15	24,4	71
media				3,9	15,4	0,24	6,2	29	19,5	0,09	262	16	23,6	67
min	0,91	0,73	0,1	2,5	11,6	0,18	3,5	18	10,1	0,07	183	11	13,2	43
max	1,7	1,57	0,17	5,i	21,6	0,33	8,7	38	29,8	0,11	346	22	37,7	91
dev std				1,1	4,3	0,07	2,3	8	9	0,01	67	4,6	10,4	20
U (%)				10	11	20	12	10	10	23	7	10	10	8

Table 10. AM3, Corteolona, soil data in layer 0-30 cm

Site	C %	Corg %	N %	Al %	As mg/kg	Cd mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Hg mg/kg	Mn mg/kg	Ni mg/kg	Pb mg/kg	Zn mg/kg
cor 11	1,5	1,23	0,16	5,2	16,3	0,41	7,6	47	20,4	0,14	735	22	19,5	99
cor 13	1,12	1,09	0,12	5,2	15,5	0,22	9,1	46	18,6	0,08	494	25	21,1	65
cor 15	0,87	0,74	0,1	5,5	11,6	0,11	11,2	67	18,5	0,04	445	39	15,3	51
cor 22	0,84	0,71	0,09	4,4	16,7	0,14	7,4	34	17,5	0,08	312	21	22,4	60
cor 23	1,49	1,21	0,16	7,1	18,3	0,23	20,2	90	28,9	0,08	428	54	38,3	123
cor 24	0,65	0,6	0,07	4,7	11	0,11	8,9	56	19,4	0,04	598	42	20	64
cor 25	0,94	0,86	0,12	6,2	18,3	0,25	13,	61	18,6	0,05	865	33	23	66
cor 31	0,88	0,87	0,09	5,8	15,9	0,12	7,4	38	13,9	0,03	388	19	16,1	54
cor 32	1,3	1,11	0,15	6,1	28,7	0,51	10,5	48	27,7	0,13	1335	30	25,2	105
cor 33	1,8	1,59	0,21	5,9	14,4	0,73	13,9	96	94	0,24	711	51	43	225
cor 34	1,23	1,15	0,14	5,4	10,9	0,16	9,9	58	21,8	0,06	417	33	20,4	65
cor 35 (PP4)	nd	nd	nd	6,4	12,2	0,26	8,5	48	24,1	0,04	476	28	18,8	100
cor 41	0,89	0,74	0,11	4,6	19,2	0,17	8,8	35	19,7	0,06	424	24	23,9	64
cor 42	0,86	0,73	0,11	5,5	21,4	0,21	8,2	35	20,3	0,07	315	22	21,4	68
cor 43	1,12	1,06	0,14	6,2	16,7	0,26	12,1	52	31,8	0,08	528	35	20,5	88
cor 44	1,26	1,06	0,17	3,4	9,6	0,22	5,7	26	52,5	0,11	365	16	21,4	95
cor 45	1,25	1,18	0,13	4,5	12,9	0,2	7,1	35	24,7	0,09	555	20	24,4	74
cor 51	2,61	0,91	0,12	8,4	12,2	0,21	24,5	251	47,4	0,07	896	200	20,8	97
cor 53	0,96	0,78	0,1	4,3	11	0,15	6,8	31	16,7	0,04	291	20	13,6	54
cor 55	0,9	0,68	0,1	6	8,43	0,18	14,7	157	25,7	0,04	381	105	17,2	74
media				5,5	15,1	0,24	10,8	66	28	0,08	548	42	22,3	84
min	0,65	0,6	0,07	3,4	8,4	0,11	5,7	26	14	0,03	291	16	13,6	51
max	2,61	1,59	0,21	8,4	28,7	0,73	24,5	251	94	0,24	1335	200	43	225
dev std				1,1	4,76	0,15	4,7	53	18	0,05	255	42	7	39
U (%)				9	11	20	11	9	10	23	6	9	10	8

Table 11. AM3, Pieve Porto Morone, soil data in layer 0-30 cm

Site	C %	Corg %	N %	Al %	As mg/kg	Cd mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Hg mg/kg	Mn mg/kg	Ni mg/kg	Pb mg/kg	Zn mg/kg
piev 11	0,88	0,71	0,09	4,2	22,5	0,74	nd	55	41,8	0,23	nd	30	29,2	141
piev 12	0,75	0,6	0,07	5,3	12,4	0,18	nd	104	21,8	0,06	nd	72	18,2	70
piev 13	1,32	0,95	0,13	5,8	12,5	0,29	nd	173	36,3	0,04	nd	143	20,1	83
piev 21	0,96	0,76	0,1	6,9	14,3	0,28	nd	176	33,2	0,05	nd	150	15,7	89
piev 22	1,21	1,08	0,12	4,6	8,6	0,22	nd	127	23,5	0,09	nd	96	24,6	63
piev 23	1,01	0,8	0,1	5,7	11	0,3	nd	165	33,6	0,05	nd	142	19	82
piev 31	1,42	1,03	0,14	6,1	10,7	0,28	nd	185	35,7	0,04	nd	160	24,8	85
piev 32	1,67	0,79	0,1	3,8	8,1	0,17	nd	134	24,7	0,06	nd	112	15,5	66
piev 33	1,42	0,75	0,08	5,5	9,8	0,4	nd	200	35,6	0,1	nd	154	16,7	94
media				5,3	12,2	0,32	nd	147	31,8	0,08	nd	118	20	86
min	0,75	0,6	0,07	3,8	8,2	0,17	nd	55	21,8	0,04	nd	30	16	63
max	1,67	1,08	0,14	6,9	22,5	0,74	nd	200	41,8	0,23	nd	160	29	141
dev std				0,5	4,3	0,17	nd	46	6,8	0,06	nd	44	5	23
U (%)				9	11	19	nd	8	10	23	nd	8	10	8

Table 12. AM3, Voghera, soil data in layer 0-30 cm

Site	C %	Corg %	N %	Al %	As mg/kg	Cd mg/kg	Co mg/kg	Cr mg/kg	Cu mg/kg	Hg mg/kg	Mn mg/kg	Ni mg/kg	Pb mg/kg	Zn mg/kg
vog 11 (san 77)	1,6	0,5	0,07	3,7	8,76	0,25	15,5	174	31,3	0,03	551	128	14,5	72
vog 12	1,72	0,41	0,06	5,8	10,3	0,23	16,4	206	24,1	0,03	613	137	13,6	69
vog 13	1,98	0,8	0,11	5	13,4	0,35	20	194	72	0,05	732	162	21,7	95
vog 14	2,02	0,88	0,12	63	13,3	0,41	18,8	184	42	0,06	731	146	21,3	106
vog 15	3,88	0,71	0,09	5,2	8,5	0,26	14,5	140	32,8	0,06	738	108	13,8	78
vog 21	2,34	0,98	0,12	6,8	11,5	0,33	16,2	194	33,1	nd	631	129	16,5	85
vog 22	2,56	0,92	0,15	9,6	17	0,37	24,3	250	49,1	0,05	847	201	24,2	119
vog 23	3,56	1,14	0,17	8,6	9,2	0,4	17,3	157	48,9	0,05	757	122	17,7	120
vog 24	3,21	0,74	0,11	6	9,2	0,29	16,4	166	37,3	0,06	801	128	16,9	92
vog 25	3,5	0,84	0,12	6,8	9,5	0,33	15,5	150	36,9	0,05	769	109	16	90
vog 31	2,25	0,98	0,13	5,1	10,4	0,36	15,4	141	39,1	0,04	716	112	18,7	99
vog 32	2,87	1,15	0,18	9,7	18,5	0,4	17,7	170	43,7	0,04	772	125	20,5	110
vog 33	3,31	0,85	0,11	5,7	8,8	0,61	16,1	160	33,3	0,04	719	126	15,4	87
vog 34	3,34	0,82	0,12	7,3	8,2	0,33	15,7	155	38,4	0,05	758	114	17,1	93
vog 35	3,23	0,7	0,11	7,1	9,8	0,34	16,8	154	58,3	0,05	766	122	18,5	98
vog 41	2,94	1,12	0,17	9,8	11,5	0,35	18,3	173	75	0,05	713	134	19,8	118
vog 42	2,62	1,37	0,18	12	14,8	0,34	19,1	190	45,6	0,04	746	148	20,2	118
vog 43	3,24	1,05	0,16	12,1	10,2	0,36	17,9	174	48,3	0,04	722	129	17,4	120
vog 44	2,84	0,92	0,13	6,2	8,8	0,34	15,5	138	188	0,05	823	108	19,8	120
vog 45	3,98	1,05	0,17	8,8	10,5	0,34	16,4	140	67,9	0,08	750	110	17,8	123
vog 51 (PP2)	nd	nd	nd	7,3	3,2	0,13	4,4	28	16,4	0,04	199	17	15,5	47
vog 52	1,63	1,89	0,13	7,6	nd	0,27	17,7	131	36,5	0,04	1052	110	17,4	81
vog 53	2,2	0,9	0,14	7,6	9,8	0,34	17,6	152	40,6	0,04	935	116	22,5	101
vog 54	3,1	0,81	0,1	3,8	9,5	0,32	12,8	154	118	0,09	778	108	19,4	89
vog 55	3,11	0,98	0,14	6,8	7,9	0,31	15,2	145	57,3	0,06	722	102	18,5	94
media				7,2	10,5	0,33	16,5	161	52,6	0,05	734	122	18,2	97
min	1,6	0,41	0,07	3,7	3,2	0,13	4,41	28	16,4	0,03	199	17	13,6	47
max	3,98	1,89	0,18	12,1	18,5	0,61	24,3	250	188,1	0,09	1052	201	24,2	123
dev std				2,2	3,1	0,08	3,3	38	34,8	0,01	147	31	2,7	19
U (%)				9	11	19	10	7	9	25	6	8	10	8

Table 13. Concentration of trace elements in soil, in locations SP4 and COR 51

	Al %	As *mg/kg*	Cd *mg/kg*	Cr *mg/kg*	Cu *mg/kg*	Hg *mg/kg*	Ni *mg/kg*	Pb *mg/kg*	Zn *mg/kg*
PS4	4,8	32,5	34,6	269	264	3,15	56	674	4038
PS4B	5,6	24,6	8,2	138	113	0,86	56	255	1620
PS4A	5,5	30,9	12,5	179	159	1,33	61	387	2290
PS4C	5,6	26,3	8,4	138	114	0,92	57	244	1580
PS4D	4,7	21,7	4,9	102	75	0,61	53	150	990
PS4E	6	25,7	9,5	147	118	0,96	55	283	1860
Moss	0,2	1,52	2,51	13,2	38,9	0,29	6,9	42,2	359
COR 51	8,3	12,2	0,21	251	47	0,07	200	20,8	97
COR51A	5,5	8,9	0,2	186	32,2	0,06	150	15,5	80,9
COR51B	5,5	8,7	0,1	173	27,5	0,04	131	12,4	65,8
COR51C	6,3	8,9	0,14	199	33,2	0,05	157	15,3	78,3
COR51D	4,7	7,6	0,13	167	24,4	0,04	126	12,7	62,3
COR51E	8,6	12,5	0,19	248	45,6	0,09	200	22,8	103
Moss	0,6	1,4	0,3	24,7	15,6	0,1	21,6	7,7	174

Table 15. WHO-TEQ levels for dioxins of AM1

AM1	Valori di WHO-TEQ per PCDD/Fs
PP	pg/g
PP1 sup	1,6
PP1 prof	nd
PP2 sup	1,1
PP2 prof	0,11
PP3 sup	0,99
PP3 prog	0,088
PP4 sup	1,1
PP4 prof	0,11
PP5 sup	0,89
PP5 prof	0,41
PP6 sup	0,65
PP6 prof	0,25
PP7 sup	0,52
PP7 prof	0,22

Table 16. WHO-TEQ levels for dioxins of AM2

Site	Sampling points	WHO-TEQ values for PCDD/Fs
		pg/g
A	1, 2, 5, 6, 12, 17	1,4
B	3, 7, 8, 13	1,2
C	9, 14, 18, 19, 20	1,1
D	4, 10, 11, 15	11
E	21, 25, 26	1,2
F	16, 22, 23, 24	0,90
G	28, 29	0,53
H	27, 30, 31	1,1
I	32, 33, 34	0,52

Table 17. WHO-TEQ levels for dioxins of AM3 areas

Areas	WHO-TEQ values for PCDD/Fs	Areas	WHO-TEQ values for PCDD/Fs
sigla	pg/g	sigla	pg/g
Par A	4,6	SndB A	0,88
Par B	1,4	SndB B	1,2
Par C	1,5	SndB C	0,83
Par D	1,8	SndB D	1,1
Gius A	1,3	SndB E	0,91
Cor A	1,3	Vog A	0,82
Cor B	1,7	Vog B	0,88
Cor C	1,1	Vog C	0,78
PPM A	1,8	Vog D	0,84
PPM B	1,1		

Table 18. Measured parameters for all soil samples of the three Monitoring Actions

Used parameters	Abbreviation	Units
Organic matter (Sostanza organica)	S.O.	%
Basal respiration (Respirazione basale)	Cbas	ppm
Cumulative respiration (Respirazione cumulativa)	Ccum	ppm
Microbial carbon (Carbonio microbico)	Cmic	ppm
Metabolic quotient (Quoziente metabolico)	qCO2	(10-2) h-1
Mineralization quotient (Quoziente di mineralizzazione)	qM	%

Table 19. Primary Points (AM1) - surface layer

1PP/11 fertilita' biologica **BUONA**			α	β	γ	δ	ε	**media**
SOSTANZA ORGANICA	SO	%	3,10	3,21	3,14	3,11	3,15	3,14
CARBONIO TOTALE	Corg	%	1,80	1,86	1,82	1,81	1,83	1,82
CARBONIO MICROBICO	Cmic	ppm	181,6	149,6	177,3	186,9	225,7	184,2
RESPIRAZ. BASALE	Cbas	ppm	9,2	8,5	12,5	8,4	9,6	9,6
RESPIRAZ. CUMUL.	Ccum	ppm	439,2	424,4	623,5	589,9	519,3	519,3
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,211	0,237	0,293	0,187	0,178	0,221
QUOZIENTE DI MINERALIZZ.	qM	%	2,44	2,28	3,43	3,27	2,84	2,85

2PP/11 fertilità biologica **PREALLARME**			α	β	γ	δ	ε	**media**
SOSTANZA ORGANICA	SO	%	1,95	2,00	2,01	1,87	1,96	1,96
CARBONIO TOTALE	Corg	%	1,13	1,16	1,16	1,09	1,14	1,14
CARBONIO MICROBICO	Cmic	ppm	35,8	100,9	132,6	78,8	123,5	94,3
RESPIRAZ. BASALE	Cbas	ppm	3,2	3,2	5,9	4,1	4,1	4,1
RESPIRAZ. CUMUL.	Ccum	ppm	211,1	225,0	237,7	222,0	223,9	223,9
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,376	0,131	0,185	0,216	0,138	0,209
QUOZIENTE DI MINERALIZZ.	qM	%	1,86	1,94	2,04	2,04	1,97	1,97

3PP/11 fertilita' biologica **MEDIA**			α	β	γ	δ	ε	**media**
SOSTANZA ORGANICA	SO	%	1,93	2,16	1,85	2,01	1,99	1,99
CARBONIO TOTALE	Corg	%	1,12	1,25	1,08	1,17	1,16	1,16
CARBONIO MICROBICO	Cmic	ppm	160,2	81,6	102,2	152,3	130,0	125,2
RESPIRAZ. BASALE	Cbas	ppm	4,4	5,0	6,6	6,1	5,5	5,5
RESPIRAZ. CUMUL.	Ccum	ppm	246,6	277,6	313,0	232,1	276,1	269,1
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,114	0,256	0,270	0,166	0,177	0,197
QUOZIENTE DI MINERALIZZ.	qM	%	2,20	2,21	2,91	1,99	2,39	2,34

4PP/11 fertilita' biologica **MEDIA**			α	β	γ	δ	ε	**media**
SOSTANZA ORGANICA	SO	%	2,38	2,39	2,18	2,16	2,28	2,28
CARBONIO TOTALE	Corg	%	1,38	1,39	1,27	1,25	1,32	1,32
CARBONIO MICROBICO	Cmic	ppm	142,2	216,2	199,3	78,6	84,9	144,2
RESPIRAZ. BASALE	Cbas	ppm	7,4	6,6	5,5	5,8	6,3	6,3
RESPIRAZ. CUMUL.	Ccum	ppm	311,9	312,7	294,3	291,4	302,6	302,6
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,216	0,127	0,116	0,308	0,311	0,215
QUOZIENTE DI MINERALIZZ.	qM	%	2,26	2,25	2,32	2,32	2,29	2,29

5PP/11 fertilita' biologica **MEDIA**			α	β	γ	δ	ε	**media**
SOSTANZA ORGANICA	SO	%	2,44	2,62	2,42	2,50	2,50	2,50
CARBONIO TOTALE	Corg	%	1,42	1,52	1,40	1,45	1,45	1,45
CARBONIO MICROBICO	Cmic	ppm	185,8	109,1	451,2	215,0	324,8	257,2
RESPIRAZ. BASALE	Cbas	ppm	6,4	7,1	5,4	8,3	6,8	6,8
RESPIRAZ. CUMUL.	Ccum	ppm	316,6	348,4	417,8	427,0	388,3	379,6
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,144	0,271	0,050	0,162	0,087	0,143
QUOZIENTE DI MINERALIZZ.	qM	%	2,23	2,29	2,98	2,94	2,68	2,62

6PP/12 fertilita' biologica **MEDIA**			α	β	γ	δ	ε	**media**
SOSTANZA ORGANICA	SO	%	2,55	2,67	2,37	2,60	2,55	2,55
CARBONIO TOTALE	Corg	%	1,48	1,55	1,37	1,51	1,48	1,48
CARBONIO MICROBICO	Cmic	ppm	109,1	161,2	201,9	244,2	71,4	157,6
RESPIRAZ. BASALE	Cbas	ppm	9,5	11,0	7,2	7,1	8,7	8,7
RESPIRAZ. CUMUL.	Ccum	ppm	434,4	428,5	308,5	293,8	366,3	366,3
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,362	0,285	0,149	0,121	0,508	0,285
QUOZIENTE DI MINERALIZZ.	qM	%	2,94	2,77	2,24	1,95	2,48	2,48

7PP/21 fertilita' biologica **MEDIA**			α	β	γ	δ	ε	**media**
SOSTANZA ORGANICA	SO	%	2,20	2,41	1,71	1,79	2,03	2,03
CARBONIO TOTALE	Corg	%	1,28	1,40	0,99	1,04	1,18	1,18
CARBONIO MICROBICO	Cmic	ppm	319,6	254,7	339,3	298,4	262,4	294,9
RESPIRAZ. BASALE	Cbas	ppm	10,0	9,7	8,3	8,4	9,1	9,1
RESPIRAZ. CUMUL.	Ccum	ppm	514,1	569,6	359,9	365,8	464,5	454,8
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,131	0,159	0,102	0,117	0,144	0,130
QUOZIENTE DI MINERALIZZ.	qM	%	4,02	4,08	3,62	3,53	3,95	3,84

Table 20. Primary Points (AM1) - deep layer

1PP/11			α	β	γ	δ	ε	media
SOSTANZA ORGANICA	SO	%	0,56	0,54	0,37	0,26	0,43	0,43
CARBONIO TOTALE	Corg	%	0,33	0,31	0,21	0,15	0,25	0,25
CARBONIO MICROBICO	Cmic	ppm	19,6	19,5	17,0	2,5	17,8	15,3
RESPIRAZ. BASALE	Cbas	ppm	2,7	2,6	2,6	2,4	2,1	2,5
RESPIRAZ. CUMUL.	Ccum	ppm	43,9	34,0	49,0	37,3	31,6	39,2
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,562	0,566	0,628	3,971	0,501	1,246
QUOZIENTE DI MINERALIZZ.	qM	%	1,35	1,09	2,29	2,44	1,26	1,69

2PP/11			α	β	γ	δ	ε	media
SOSTANZA ORGANICA	SO	%	0,68	0,67	0,63	0,56	0,64	0,64
CARBONIO TOTALE	Corg	%	0,40	0,39	0,37	0,33	0,37	0,37
CARBONIO MICROBICO	Cmic	ppm	19,5	11,6	38,1	29,3	30,0	25,7
RESPIRAZ. BASALE	Cbas	ppm	4,4	2,6	2,1	2,0	5,9	3,4
RESPIRAZ. CUMUL.	Ccum	ppm	36,2	38,9	56,7	34,0	89,4	51,0
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,941	0,950	0,234	0,278	0,825	0,646
QUOZIENTE DI MINERALIZZ.	qM	%	0,91	1,01	1,55	1,04	2,42	1,39

3PP/11			α	β	γ	δ	ε	media
SOSTANZA ORGANICA	SO	%	0,30	0,34	0,32	0,16	0,43	0,31
CARBONIO TOTALE	Corg	%	0,17	0,20	0,18	0,09	0,25	0,18
CARBONIO MICROBICO	Cmic	ppm	11,5	37,3	11,6	7,0	58,1	25,1
RESPIRAZ. BASALE	Cbas	ppm	2,2	1,7	1,8	2,0	1,9	1,9
RESPIRAZ. CUMUL.	Ccum	ppm	39,7	38,9	44,1	56,7	47,2	45,3
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,794	0,185	0,637	1,165	0,136	0,584
QUOZIENTE DI MINERALIZZ.	qM	%	2,30	1,98	2,39	6,27	1,88	2,96

4PP/11			α	β	γ	δ	ε	media
SOSTANZA ORGANICA	SO	%	0,37	0,26	0,30	0,34	0,32	0,32
CARBONIO TOTALE	Corg	%	0,21	0,15	0,17	0,20	0,18	0,18
CARBONIO MICROBICO	Cmic	ppm	34,2	37,3	24,0	31,3	22,3	29,8
RESPIRAZ. BASALE	Cbas	ppm	5,9	4,5	5,9	4,5	8,0	5,7
RESPIRAZ. CUMUL.	Ccum	ppm	111,3	156,1	172,8	129,9	134,7	141,0
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,724	0,498	1,032	0,593	1,485	0,866
QUOZIENTE DI MINERALIZZ.	qM	%	5,21	10,21	10,02	6,62	7,28	7,87

5PP/11			α	β	γ	δ	ε	media
SOSTANZA ORGANICA	SO	%	1,26	1,25	1,40	1,43	1,33	1,33
CARBONIO TOTALE	Corg	%	0,73	0,72	0,81	0,83	0,77	0,77
CARBONIO MICROBICO	Cmic	ppm	25,3	4,3	30,0	38,1	52,3	30,0
RESPIRAZ. BASALE	Cbas	ppm	6,9	6,6	5,9	7,7	8,0	7,0
RESPIRAZ. CUMUL.	Ccum	ppm	172,8	187,2	175,4	188,0	129,9	170,7
QUOZIENTE METABOLICO	qCO2	h^{-1}	1,133	6,412	0,825	0,836	0,633	1,968
QUOZIENTE DI MINERALIZZ.	qM	%	2,36	2,59	2,16	2,27	1,68	2,21

6PP/12			α	β	γ	δ	ε	media
SOSTANZA ORGANICA	SO	%	0,56	0,54	0,61	0,54	0,44	0,54
CARBONIO TOTALE	Corg	%	0,33	0,31	0,36	0,31	0,26	0,31
CARBONIO MICROBICO	Cmic	ppm	31,3	29,3	21,0	29,3	15,4	25,3
RESPIRAZ. BASALE	Cbas	ppm	4,4	2,7	4,8	4,5	5,9	4,5
RESPIRAZ. CUMUL.	Ccum	ppm	185,2	44,1	89,4	156,6	188,0	132,7
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,593	0,376	0,944	0,632	1,606	0,830
QUOZIENTE DI MINERALIZZ.	qM	%	5,68	1,41	2,51	4,99	7,36	4,39

7PP/21			α	β	γ	δ	ε	media
SOSTANZA ORGANICA	SO	%	0,61	0,54	0,44	0,41	0,68	0,54
CARBONIO TOTALE	Corg	%	0,36	0,31	0,26	0,24	0,40	0,31
CARBONIO MICROBICO	Cmic	ppm	47,9	26,3	31,3	29,3	12,4	29,4
RESPIRAZ. BASALE	Cbas	ppm	4,5	4,8	4,4	4,4	4,4	4,5
RESPIRAZ. CUMUL.	Ccum	ppm	134,7	89,4	111,3	156,1	138,0	125,9
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,387	0,753	0,593	0,623	1,482	0,768
QUOZIENTE DI MINERALIZZ.	qM	%	3,78	2,85	4,36	6,53	3,49	4,20

(at 100 cm depth, fertility classes cannot be assigned)

Table 21. Secondary Points (AM2) results

			1 PS	2 PS	3 PS	4 PS	5 PS	6 PS
fertilità biologica			**preallarme**	**preallarme**	**media**	**media**	**media**	**media**
SOSTANZA ORGANICA	SO	%	1,71	1,33	1,44	6,62	2,93	1,32
CARBONIO TOTALE	Corg	%	0,99	0,77	0,83	3,84	1,70	0,77
CARBONIO MICROBICO	Cmic	ppm	69,7	69,8	125,4	140,2	39,0	79,5
RESPIRAZ. BASALE	Cbas	ppm	4,4	4,5	4,9	11,3	7,0	6,2
RESPIRAZ. CUMUL.	Ccum	ppm	200,8	154,9	227,6	448,6	296,8	258,4
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,263	0,269	0,162	0,337	0,748	0,327
QUOZIENTE DI MINERALIZZ.	qM	%	2,03	2,01	2,73	1,17	1,75	3,37

			7 PS	8 PS	9 PS	10 PS	11 PS	12 PS
fertilità biologica			**preallarme**	**media**	**media**	**preallarme**	**buona**	**preallarme**
SOSTANZA ORGANICA	SO	%	1,32	2,44	1,20	1,31	4,34	1,79
CARBONIO TOTALE	Corg	%	0,76	1,42	0,69	0,76	2,52	1,04
CARBONIO MICROBICO	Cmic	ppm	24,3	156,4	58,7	43,0	382,6	39,2
RESPIRAZ. BASALE	Cbas	ppm	1,9	5,2	2,1	5,6	12,8	5,3
RESPIRAZ. CUMUL.	Ccum	ppm	99,5	270,5	150,1	170,6	591,5	163,9
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,324	0,137	0,146	0,546	0,139	0,567
QUOZIENTE DI MINERALIZZ.	qM	%	1,30	1,91	2,16	2,25	2,35	1,58

			13 PS	14 PS	15 PS	16 PS	17 PS	18 PS
fertilità biologica			**media**	**preallarme**	**media**	**media**	**preallarme**	**media**
SOSTANZA ORGANICA	SO	%	2,75	2,04	1,92	1,52	1,29	2,33
CARBONIO TOTALE	Corg	%	1,60	1,18	1,12	0,88	0,75	1,35
CARBONIO MICROBICO	Cmic	ppm	181,2	62,5	131,8	76,9	58,9	110,0
RESPIRAZ. BASALE	Cbas	ppm	7,0	4,0	9,2	6,3	2,2	7,4
RESPIRAZ. CUMUL.	Ccum	ppm	279,4	125,5	374,9	210,7	93,7	308,1
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,161	0,268	0,291	0,338	0,156	0,282
QUOZIENTE DI MINERALIZZ.	qM	%	1,75	1,06	3,36	2,39	1,25	2,28

			19 PS	20 PS	21 PS	22 PS	23 PS	24 PS
fertilità biologica			**buona**	**buona**	**buona**	**media**	**media**	**media**
SOSTANZA ORGANICA	SO	%	3,15	1,63	2,65	2,32	2,80	2,31
CARBONIO TOTALE	Corg	%	1,83	0,95	1,53	1,35	1,62	1,34
CARBONIO MICROBICO	Cmic	ppm	175,3	222,2	208,7	128,5	197,6	96,6
RESPIRAZ. BASALE	Cbas	ppm	16,4	13,6	9,1	5,7	12,8	11,8
RESPIRAZ. CUMUL.	Ccum	ppm	499,4	425,9	348,8	197,7	397,9	411,8
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,391	0,255	0,181	0,185	0,269	0,507
QUOZIENTE DI MINERALIZZ.	qM	%	2,73	4,50	2,27	1,47	2,45	3,08

			25 PS	26 PS	27 PS	28 PS	29 PS	30 PS
fertilità biologica			**media**	**media**	**media**	**alta**	**media**	**media**
SOSTANZA ORGANICA	SO	%	2,12	1,94	1,89	4,73	1,64	2,07
CARBONIO TOTALE	Corg	%	1,23	1,12	1,10	2,74	0,95	1,20
CARBONIO MICROBICO	Cmic	ppm	179,1	111,4	102,5	394,9	104,1	203,8
RESPIRAZ. BASALE	Cbas	ppm	5,9	13,6	6,4	33,0	7,3	7,6
RESPIRAZ. CUMUL.	Ccum	ppm	216,6	575,2	228,4	1090,8	246,7	319,8
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,138	0,508	0,258	0,348	0,292	0,155
QUOZIENTE DI MINERALIZZ.	qM	%	1,76	5,14	2,08	3,98	2,60	2,67

			31 PS	32 PS	33 PS	34 PS
fertilità biologica			**alta**	**buona**	**buona**	**buona**
SOSTANZA ORGANICA	SO	%	5,92	3,71	2,36	5,99
CARBONIO TOTALE	Corg	%	3,44	2,15	1,37	3,47
CARBONIO MICROBICO	Cmic	ppm	404,7	430,8	71,0	292,1
RESPIRAZ. BASALE	Cbas	ppm	43,6	11,4	19,2	37,2
RESPIRAZ. CUMUL.	Ccum	ppm	1557,6	605,0	569,5	1228,1
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,449	0,110	1,127	0,531
QUOZIENTE DI MINERALIZZ.	qM	%	4,53	2,81	4,16	3,54

Table 22. Tertiary Points (AM3) - Pieve Porto Morone (9 samples) and Corteolona (19 samples) results

PIEVE PORTO MORONE			Pieve 11	Pieve 12	Pieve 13	Pieve 21	Pieve 22
SOSTANZA ORGANICA	SO	%	1,98	1,48	2,19	2,06	2,50
CARBONIO TOTALE	Corg	%	1,15	0,86	1,27	1,20	1,45
CARBONIO MICROBICO	Cmic	ppm	41,1	52,7	222,6	188,3	149,6
RESPIRAZ. BASALE	Cbas	ppm	7,5	7,0	12,1	9,7	12,3
RESPIRAZ. CUMUL.	Ccum	ppm	243,8	212,6	358,9	330,4	351,5
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,765	0,556	0,227	0,214	0,342
QUOZIENTE DI MINERALIZZ.	qM	%	2,13	2,48	2,82	2,76	2,42
Fertilità Biologica			**preallarme**	**preallarme**	**buona**	**media**	**buona**

PIEVE PORTO MORONE			Pieve 23	Pieve 31	Pieve 32	Pieve 33
SOSTANZA ORGANICA	SO	%	2,28	3,07	2,06	2,20
CARBONIO TOTALE	Corg	%	1,32	1,78	1,20	1,27
CARBONIO MICROBICO	Cmic	ppm	52,8	87,0	49,9	23,0
RESPIRAZ. BASALE	Cbas	ppm	9,9	19,1	13,6	11,5
RESPIRAZ. CUMUL.	Ccum	ppm	340,6	458,5	328,4	298,4
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,781	0,913	1,132	2,076
QUOZIENTE DI MINERALIZZ.	qM	%	2,58	2,58	2,74	2,34
Fertilità Biologica			**media**	**media**	**media**	**media**

CORTEOLONA			cort 11	cort 13	cort 15	cort 22	cort 23	cort 24
SOSTANZA ORGANICA	SO	%	2,48	2,12	1,68	1,41	2,83	1,11
CARBONIO TOTALE	Corg	%	1,44	1,23	0,97	0,82	1,64	0,64
CARBONIO MICROBICO	Cmic	ppm	50,3	55,5	215,1	123,2	360,9	155,4
RESPIRAZ. BASALE	Cbas	ppm	7,1	10,1	8,3	5,4	12,9	5,1
RESPIRAZ. CUMUL.	Ccum	ppm	279,0	282,3	235,6	158,7	375,6	161,6
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,588	0,755	0,162	0,183	0,149	0,136
QUOZIENTE DI MINERALIZZ.	qM	%	1,94	2,30	2,42	1,95	2,29	2,52
Fertilità Biologica			**media**	**media**	**media**	**media**	**buona**	**media**

CORTEOLONA			cort 25	cort 31	cort 32	cort 33	cort 34	cort 41
SOSTANZA ORGANICA	SO	%	1,58	1,92	1,74	3,07	2,38	1,82
CARBONIO TOTALE	Corg	%	0,92	1,11	1,01	1,78	1,38	1,06
CARBONIO MICROBICO	Cmic	ppm	56,9	260,7	176,7	346,3	150,0	154,4
RESPIRAZ. BASALE	Cbas	ppm	4,6	7,3	11,8	15,7	8,4	7,3
RESPIRAZ. CUMUL.	Ccum	ppm	165,8	244,3	335,5	487,5	233,7	198,4
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,335	0,117	0,278	0,189	0,232	0,197
QUOZIENTE DI MINERALIZZ.	qM	%	1,81	2,19	3,33	2,74	1,70	1,88
Fertilità Biologica			**preallarme**	**media**	**media**	**buona**	**media**	**media**

CORTEOLONA			cort 42	cort 43	cort 44	cort 45	cort 51	cort 53	cort 55
SOSTANZA ORGANICA	SO	%	1,52	2,49	2,69	2,01	2,27	1,67	1,82
CARBONIO TOTALE	Corg	%	0,88	1,44	1,56	1,17	1,32	0,97	1,06
CARBONIO MICROBICO	Cmic	ppm	112,4	157,1	45,4	111,2	172,6	99,3	261,4
RESPIRAZ. BASALE	Cbas	ppm	5,6	8,7	7,2	11,8	17,5	5,9	9,6
RESPIRAZ. CUMUL.	Ccum	ppm	174,3	330,1	197,5	424,1	589,7	227,1	349,9
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,206	0,231	0,665	0,444	0,422	0,248	0,153
QUOZIENTE DI MINERALIZZ.	qM	%	1,97	2,29	1,27	3,64	4,48	2,35	3,31
Fertilità Biologica			**media**	**media**	**media**	**media**	**buona**	**media**	**buona**

Table 23. Tertiary Points (AM3) - Parona (25 samples) and Giussago (4 samples) results

PARONA			par 11	par 12	par 13	par 14	par15	par21
SOSTANZA ORGANICA	SO	%	1,47	2,02	3,84	2,08	2,84	1,31
CARBONIO TOTALE	Corg	%	0,85	1,17	2,23	1,20	1,65	0,76
CARBONIO MICROBICO	Cmic	ppm	179,3	110,4	142,0	55,9	99,9	130,6
RESPIRAZ. BASALE	Cbas	ppm	4,2	12,2	12,8	9,3	10,0	4,1
RESPIRAZ. CUMUL.	Ccum	ppm	118,3	343,9	450,9	263,8	320,0	151,2
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,098	0,462	0,374	0,691	0,416	0,131
QUOZIENTE DI MINERALIZZ.	qM	%	1,39	2,93	2,03	2,19	1,94	1,99
Fertilità Biologica			**media**	**media**	**media**	**media**	**preallarme**	**media**

PARONA			par22	par23	par24	par25	par31	par32
SOSTANZA ORGANICA	SO	%	3,18	1,94	5,95	2,31	1,74	3,49
CARBONIO TOTALE	Corg	%	1,84	1,12	3,45	1,34	1,01	2,02
CARBONIO MICROBICO	Cmic	ppm	173,8	205,7	259,4	150,8	66,5	91,8
RESPIRAZ. BASALE	Cbas	ppm	10,9	7,4	19,4	6,0	8,1	11,1
RESPIRAZ. CUMUL.	Ccum	ppm	403,6	203,7	608,9	206,2	252,2	329,8
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,262	0,149	0,312	0,166	0,505	0,502
QUOZIENTE DI MINERALIZZ.	qM	%	2,19	1,81	1,76	1,54	2,50	1,63
Fertilità Biologica			**buona**	**media**	**media**	**media**	**media**	**media**

PARONA			par33	par34	par35	par41	par42	par43
SOSTANZA ORGANICA	SO	%	2,05	1,63	7,32	1,78	3,96	2,27
CARBONIO TOTALE	Corg	%	1,19	0,94	4,25	1,03	2,30	1,32
CARBONIO MICROBICO	Cmic	ppm	62,2	37,8	259,1	28,7	98,3	171,6
RESPIRAZ. BASALE	Cbas	ppm	5,4	6,4	14,2	3,5	8,2	7,1
RESPIRAZ. CUMUL.	Ccum	ppm	177,2	160,7	435,4	114,7	188,4	229,2
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,362	0,701	0,228	0,509	0,347	0,174
QUOZIENTE DI MINERALIZZ.	qM	%	1,49	1,70	1,03	1,11	0,82	1,74
Fertilità Biologica			**preallarme**	**media**	**buona**	**preallarme**	**media**	**media**

PARONA			par44	par45	par51	par52	par53	par54	par55
SOSTANZA ORGANICA	SO	%	1,85	2,42	2,65	1,45	1,41	2,11	1,81
CARBONIO TOTALE	Corg	%	1,07	1,41	1,53	0,84	0,82	1,22	1,05
CARBONIO MICROBICO	Cmic	ppm	110,6	73,2	118,2	17,4	26,4	32,3	59,5
RESPIRAZ. BASALE	Cbas	ppm	4,1	8,0	7,6	6,8	5,0	5,1	6,6
RESPIRAZ. CUMUL.	Ccum	ppm	137,6	234,9	254,9	163,2	130,5	163,2	208,9
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,154	0,457	0,268	1,642	0,790	0,659	0,462
QUOZIENTE DI MINERALIZZ.	qM	%	1,28	1,67	1,66	1,94	1,59	1,33	1,99
Fertilità Biologica			**media**	**preallarme**	**media**	**preallarme**	**preallarme**	**preallarme**	**preallarme**

GIUSSAGO			Giuss 11	Giuss 12	Giuss 31	Giuss 33
SOSTANZA ORGANICA	SO	%	2,43	2,64	2,24	1,43
CARBONIO TOTALE	Corg	%	1,41	1,53	1,30	0,83
CARBONIO MICROBICO	Cmic	ppm	114,6	50,6	72,4	34,8
RESPIRAZ. BASALE	Cbas	ppm	7,8	8,4	12,6	6,2
RESPIRAZ. CUMUL.	Ccum	ppm	227,7	262,5	362,4	193,5
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,282	0,691	0,725	0,748
QUOZIENTE DI MINERALIZZ.	qM	%	1,62	1,72	2,79	2,34
Fertilità Biologica			**media**	**media**	**media**	**preallarme**

Table 24. Tertiary Points (AM3) - Voghera (24 samples) results

VOGHERA			Vog 11	Vog 12	Vog 13	Vog 14	Vog 15	Vog 21
SOSTANZA ORGANICA	SO	%	1,10	1,21	1,91	1,94	1,61	1,96
CARBONIO TOTALE	Corg	%	0,64	0,70	1,11	1,13	0,93	1,14
CARBONIO MICROBICO	Cmic	ppm	63,4	60,6	30,2	198,1	217,5	222,7
RESPIRAZ. BASALE	Cbas	ppm	5,6	14,2	6,3	4,0	6,9	6,2
RESPIRAZ. CUMUL.	Ccum	ppm	152,3	290,6	225,1	212,2	219,4	177,7
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,367	0,977	0,868	0,084	0,132	0,116
QUOZIENTE DI MINERALIZZ.	qM	%	2,38	4,15	2,03	1,88	2,35	1,56
Fertilità Biologica			**media**	**media**	**media**	**media**	**media**	**media**

VOGHERA			Vog 22	Vog 23	Vog 24	Vog 25	Vog 31	Vog 32
SOSTANZA ORGANICA	SO	%	2,33	2,66	1,67	1,88	1,83	2,90
CARBONIO TOTALE	Corg	%	1,35	1,54	0,97	1,09	1,06	1,68
CARBONIO MICROBICO	Cmic	ppm	87,8	175,7	26,1	177,0	167,1	213,5
RESPIRAZ. BASALE	Cbas	ppm	6,7	9,6	18,8	6,6	5,6	9,7
RESPIRAZ. CUMUL.	Ccum	ppm	241,8	302,4	369,4	197,5	196,8	258,2
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,319	0,227	3,000	0,155	0,141	0,189
QUOZIENTE DI MINERALIZZ.	qM	%	1,79	1,96	3,80	1,81	1,85	1,53
Fertilità Biologica			**media**	**media**	**media**	**media**	**media**	**media**

VOGHERA			Vog 33	Vog 34	Vog 35	Vog 41	Vog 42	Vog 43
SOSTANZA ORGANICA	SO	%	1,78	1,94	1,75	2,58	2,72	2,40
CARBONIO TOTALE	Corg	%	1,04	1,12	1,02	1,50	1,58	1,39
CARBONIO MICROBICO	Cmic	ppm	74,4	288,0	126,0	285,1	224,7	264,6
RESPIRAZ. BASALE	Cbas	ppm	4,5	7,0	4,9	5,8	6,1	9,7
RESPIRAZ. CUMUL.	Ccum	ppm	167,5	187,8	179,1	218,2	269,0	256,1
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,253	0,102	0,163	0,085	0,112	0,153
QUOZIENTE DI MINERALIZZ.	qM	%	1,62	1,67	1,76	1,46	1,70	1,84
Fertilità Biologica			**media**	**media**	**media**	**media**	**media**	**media**

VOGHERA			Vog 44	Vog 45	Vog 52	Vog 53	Vog 54	Vog 55
SOSTANZA ORGANICA	SO	%	2,06	2,41	2,14	2,39	1,73	2,38
CARBONIO TOTALE	Corg	%	1,19	1,40	1,24	1,39	1,01	1,38
CARBONIO MICROBICO	Cmic	ppm	132,6	107,8	102,3	172,0	44,6	218,1
RESPIRAZ. BASALE	Cbas	ppm	6,8	6,7	6,6	8,3	5,9	7,5
RESPIRAZ. CUMUL.	Ccum	ppm	207,3	239,9	249,8	281,3	189,5	210,9
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,214	0,261	0,268	0,202	0,553	0,143
QUOZIENTE DI MINERALIZZ.	qM	%	1,74	1,72	2,02	2,03	1,88	1,53
Fertilità Biologica			**media**	**media**	**media**	**media**	**preallarme**	**media**

Table 25. Tertiary Points (AM3) - Sannazzaro dei Burgondi (35 samples) results

SANNAZZARO DE' BURGUNDI			San 11	San 13	San 15	San 17	San 22	San 24
SOSTANZA ORGANICA	SO	%	1,57	2,37	1,42	2,34	1,69	1,05
CARBONIO TOTALE	Corg	%	0,91	1,38	0,82	1,36	0,98	0,61
CARBONIO MICROBICO	Cmic	ppm	20,0	139,8	16,9	57,7	99,4	57,8
RESPIRAZ. BASALE	Cbas	ppm	7,6	6,8	6,3	8,4	6,9	3,6
RESPIRAZ. CUMUL.	Ccum	ppm	143,8	224,2	141,4	225,1	237,9	147,0
QUOZIENTE METABOLICO	qCO2	h^{-1}	1,588	0,202	1,558	0,610	0,289	0,261
QUOZIENTE DI MINERALIZZ.	qM	%	1,58	1,63	1,72	1,65	2,43	2,41
Fertilità Biologica			**preallarme**	**media**	**preallarme**	**media**	**media**	**media**

SANNAZZARO DE' BURGUNDI			San 23	San 25	San 26	San 31	San 32	San 33
SOSTANZA ORGANICA	SO	%	1,11	2,73	1,15	1,86	1,81	2,02
CARBONIO TOTALE	Corg	%	0,64	1,58	0,66	1,08	1,05	1,17
CARBONIO MICROBICO	Cmic	ppm	12,3	245,8	37,4	97,5	156,9	68,4
RESPIRAZ. BASALE	Cbas	ppm	5,8	7,5	3,2	8,6	8,3	9,6
RESPIRAZ. CUMUL.	Ccum	ppm	104,6	341,5	54,0	155,4	171,2	188,0
QUOZIENTE METABOLICO	qCO2	h^{-1}	1,958	0,126	0,355	0,370	0,219	0,585
QUOZIENTE DI MINERALIZZ.	qM	%	1,63	2,16	0,81	1,44	1,63	1,60
Fertilità Biologica			**preallarme**	**buona**	**preallarme**	**media**	**media**	**preallarme**

SANNAZZARO DE' BURGUNDI			San 34	San 35	San 36	San 37	San 42	San 43
SOSTANZA ORGANICA	SO	%	2,24	1,88	2,77	1,97	1,06	1,15
CARBONIO TOTALE	Corg	%	1,30	1,09	1,60	1,14	0,61	0,67
CARBONIO MICROBICO	Cmic	ppm	115,5	122,7	130,3	42,7	94,9	63,0
RESPIRAZ. BASALE	Cbas	ppm	9,6	9,9	14,5	5,2	6,6	4,6
RESPIRAZ. CUMUL.	Ccum	ppm	217,1	203,7	335,1	169,4	161,0	106,8
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,347	0,335	0,465	0,504	0,290	0,306
QUOZIENTE DI MINERALIZZ.	qM	%	1,67	1,87	2,09	1,48	2,63	1,60
Fertilità Biologica			**media**	**media**	**media**	**preallarme**	**media**	**preallarme**

SANNAZZARO DE' BURGUNDI			San 44	San 45	San 46	San 52	San 53	San 54
SOSTANZA ORGANICA	SO	%	1,44	1,34	2,96	0,96	0,91	1,68
CARBONIO TOTALE	Corg	%	0,84	0,78	1,72	0,56	0,53	0,97
CARBONIO MICROBICO	Cmic	ppm	50,9	70,3	274,8	95,8	137,0	152,4
RESPIRAZ. BASALE	Cbas	ppm	8,5	5,9	19,7	6,1	3,8	7,0
RESPIRAZ. CUMUL.	Ccum	ppm	148,8	127,1	508,5	87,6	78,3	156,8
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,696	0,353	0,299	0,267	0,116	0,191
QUOZIENTE DI MINERALIZZ.	qM	%	1,78	1,63	2,96	1,57	1,48	1,61
Fertilità Biologica			**preallarme**	**preallarme**	**buona**	**preallarme**	**preallarme**	**media**

SANNAZZARO DE' BURGUNDI			San 55	San 56	San 62	San 63	San 64	San 65
SOSTANZA ORGANICA	SO	%	2,08	1,81	1,42	2,02	1,44	2,19
CARBONIO TOTALE	Corg	%	1,21	1,05	0,82	1,17	0,84	1,27
CARBONIO MICROBICO	Cmic	ppm	277,0	192,7	80,3	213,4	188,2	203,9
RESPIRAZ. BASALE	Cbas	ppm	12,9	13,2	7,4	11,4	17,8	14,7
RESPIRAZ. CUMUL.	Ccum	ppm	334,5	275,8	112,9	212,8	351,1	317,7
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,194	0,286	0,384	0,223	0,394	0,300
QUOZIENTE DI MINERALIZZ.	qM	%	2,78	2,63	1,37	1,82	4,19	2,50
Fertilità Biologica			**buona**	**media**	**preallarme**	**media**	**media**	**media**

SANNAZZARO DE' BURGUNDI			San 66	San 71	San 73	San 74	San 75
SOSTANZA ORGANICA	SO	%	1,42	1,16	1,24	1,45	1,89
CARBONIO TOTALE	Corg	%	0,82	0,67	0,72	0,84	1,09
CARBONIO MICROBICO	Cmic	ppm	187,8	73,6	36,5	112,0	147,8
RESPIRAZ. BASALE	Cbas	ppm	11,8	7,1	10,2	11,4	14,9
RESPIRAZ. CUMUL.	Ccum	ppm	194,2	121,8	176,9	231,1	288,0
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,263	0,400	1,166	0,423	0,419
QUOZIENTE DI MINERALIZZ.	qM	%	2,36	1,82	2,47	2,75	2,63
Fertilità Biologica			**media**	**preallarme**	**preallarme**	**media**	**media**

Table 28. Soil information for the Secondary Points (Second Level)

site	soil classification	UTS correlated	note
T1PS	Epigleyic Luvisols	77 - Epidystri-Epigleyic Luvisols	il sito rappresenta i suoli dell'UTS con tessitura più fine (FL) rispetto a quella modale dell'UTS correlata (FS)
T2PS	Dystric Arenosols	48 - Hyperdystric Arenosols	corrisponde, per tutti i parametri, ai valori modali tipici dell'UTS correlata
T3PS	Dystri-Endoskeletic Regosols	227 - Areni-Endogleyic Regosols (Episkeletic, Orthidystric)	il sito rappresenta i suoli dell'UTS meno sabbiosi, con meno scheletro e con falda più profonda
T4PS	Cambisols	208 - Epidystric-Episkeletic Cambisols	il sito rappresenta i suoli dell'UTS con tessitura più fine (FL) rispetto a quella modale dell'UTS correlata (SF)
T5PS	Protic Arenosols	83 - Orthieutri-Protic Arenosols	il sito rappresenta i suoli dell'UTS con tessitura meno grossolana (SF) rispetto a quella modale dell'UTS correlata (S)
T6PS	Orthieutri-Protic Arenosols	83 - Orthieutri-Protic Arenosols	corrisponde, per tutti i parametri, ai valori modali tipici dell'UTS correlata
T7PS	Arenosols	48 - Hyperdystric Arenosols	corrisponde, per tutti i parametri, ai valori modali tipici dell'UTS correlata
T8PS	Endoskeleti-Endogleyic Phaeozems	220 - Endoskeleti-Endogleyic Phaeozems	il sito rappresenta i suoli dell'UTS con tessitura meno grossolana (SF) rispetto a quella modale dell'UTS correlata (S)
T9PS	Haplic Luvisols	37 - Haplic Luvisols	corrisponde, per tutti i parametri, ai valori modali tipici dell'UTS correlata
T10PS	Haplic Luvisols	37 - Haplic Luvisols	corrisponde, per tutti i parametri, ai valori modali tipici dell'UTS correlata
T11PS	Endogleyic Luvisols	37 - Haplic Luvisols	il sito rappresenta i suoli dell'UTS con caratteri gley (screziature) sotto i 100 cm
T12PS	Endogleyic Luvisols	122 - Epigleyic Luvisols	il sito rappresenta i suoli dell'UTS con tessitura più sabbiosa (SF) rispetto a quella modale dell'UTS correlata (F)
T13PS	Haplic Arenosols	83 - Orthieutri-Protic Arenosols	il sito rappresenta i suoli dell'UTS meno profondi perchè limitati da falda (oltre 80 cm)
T14PS	Endogleyic Arenosols	205 - Orthidystri-Umbric Gleysols	il sito rappresenta i suoli dell'UTS con falda e caratteri gley più profondi (non è classificabile come GL), con più scheletro e senza un epipedon umbrico
T15PS	Endogleyic Luvisols	89 - Endogleyic Luvisols	corrisponde, per tutti i parametri, ai valori modali tipici dell'UTS correlata
T16PS	Haplic Luvisols	37 - Haplic Luvisols	il sito rappresenta i suoli dell'UTS con tessitura più fine (FL) rispetto a quella modale dell'UTS correlata (FS)
T17PS	Haplic Luvisols	82 - Haplic Luvisols	il sito rappresenta i suoli dell'UTS con tessitura più sabbiosa (S) rispetto a quella modale dell'UTS correlata (FS)
T18PS	Haplic Arenosols	171 - Proti-Epigleyic Arenosols (Orthidystric)	il sito rappresenta i suoli dell'UTS con reazione minore e con tessitura meno sabbiosa; il sito non mostra caratteri gley superficiali ma presenta una falda a 100

			cm
T19PS	Calcaric Fluvisols	170 - Hypereutri-Protic Arenosols	il sito rappresenta i suoli dell'UTS con caratteri fluvici ben espressi, senza scheletro e con contenuto maggiore di carbonati
T20PS	Calcaric Fluvisols	152 - Calcari-Epigleyic Fluvisols (Hypereutric)	il sito rappresenta i suoli dell'UTS con tessitura più fine e senza idromorfia superficiale
T21PS	Calcaric Cambisols	119 - Calcari-Fluvic Cambisols	corrisponde, per tutti i parametri, ai valori modali tipici dell'UTS correlata
T22PS	Haplic Luvisols	121 - Haplic Calcisols	il sito rappresenta i suoli dell'UTS una riorganizzazione meno evidente dei carbonati ed una tessitura meno argillosa
T23PS	Calcic Vertisols	118 - Haplic Calcisols	il sito rappresenta i suoli dell'UTS con un orizzonte vertico ben espresso ed una riorganizzazione meno evidente dei carbonati
T24PS	Haplic Calcisols	118 - Haplic Calcisols	corrisponde, per tutti i parametri, ai valori modali tipici dell'UTS correlata
T25PS	Calcaric Cambisols	121 - Haplic Calcisols	il sito rappresenta i suoli dell'UTS con meno argilla e con una riorganizzazione meno evidente dei carbonati (infatti il sito è classificato come CM mentre l'UTS è un CL)
T26PS	Haplic Calcisols	386 - Calcari-Leptic Cambisols	il sito rappresenta i suoli dell'UTS con una riorganizzazione più evidente dei carbonati (infatti il sito è classificato come CL mentre l'UTS è un CM)
T27PS	Calcari-Episkeletic Fluvisols	382 - Calcaric Cambisols	il sito rappresenta i suoli dell'UTS con caratteri fluvici ben espressi, con meno argilla e con scheletro più abbondante
T28PS	Calcaric Regosols	386 - Calcari-Leptic Cambisols	il sito rappresenta i suoli dell'UTS senza un orizzonte cambico e senza la limitazione poco profonda data dal calcare abbondante
T29PS	Calcaric Cambisols	385 - Calcari-Vertic Cambisols	il sito rappresenta i suoli dell'UTS con meno argilla, con più scheletro e senza espressione di caratteri vertici
T30PS	Calcaric Cambisols	382 - Calcaric Cambisols	corrisponde, per tutti i parametri, ai valori modali tipici dell'UTS correlata
T31PS	Calcaric Cambisols	386 - Calcari-Leptic Cambisols	il sito rappresenta i suoli dell'UTS con meno argilla, con più scheletro e più profondi (senza la limitazione data da calcare abbondante)
T32PS	Calcaric Cambisols	386 - Calcari-Leptic Cambisols	il sito rappresenta i suoli dell'UTS più profondi (senza la limitazione data da calcare abbondante)
T33PS	Calcari-Leptic Cambisols	386 - Calcari-Leptic Cambisols	il sito rappresenta i suoli dell'UTS con scheletro e più profondi (senza la limitazione data da calcare abbondante)
T34PS	Calcari-Leptic Regosols	386 - Calcari-Leptic Cambisols	il sito rappresenta i suoli dell'UTS con scheletro e senza un orizzonte cambico

Table 29. Elements concentrations in moss - Primary Points (AM1)

Site	Al	As	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Zn
pp 01	7600	2,60	0,25	1,79	10,8	21,8	0,11	158	8,4	9,0	110
pp 02	3300	0,62	0,61	1,13	7,6	116	0,14	95	8,50	23,8	760
pp 03	2900	0,51	0,23	0,99	7,0	25,8	0,16	84	6,9	8,2	111
pp 04	3700	0,84	0,24	1,14	10,5	15,0	0,11	70	7,6	11,5	57
pp 05	3200	0,66	0,14	1,16	8,4	8,9	0,10	68	6,6	4,1	39
pp 06	8500	1,69	0,22	2,55	16,5	805	0,10	368	14,8	8,3	120
pp 07	3500	0,49	0,12	0,90	6,8	9,3	0,10	61	4,9	4,1	45
media	4900	1,13	0,20	1,42	10,0	16	0,12	135	8,3	7,5	80
min	2900	0,49	0,12	0,90	6,8	8,9	0,10	61	4,9	4,1	39
max	8500	2,60	0,25	2,55	16,5	26	0,16	368	14,8	11,5	120
dev std	2500	0,84	0,06	0,64	3,6	7,5	0,02	120	3,4	2,9	37
U (%)	13	16	20	15	11	11	22	8	12	12	8

Table 30 Elements concentrations in moss - Secondary Points (AM2)

Site	Al	As	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Zn
ps 01	6500	0,84	0,37	1,29	11,9	11,0	0,06	97	5,9	5,8	43
ps 02	6400	1,17	0,81	1,57	11,8	16,5	0,17	109	8,5	10,4	62
ps 03	3000	1,27	0,30	0,88	4,6	14,9	0,15	71	4,7	7,5	59
ps 04*	2600	1,52	**2,51**	0,85	13,2	38,9	0,29	68	6,9	**42,2**	**359**
ps 05	3900	0,88	0,45	1,53	10,4	30,6	0,11	129	7,5	17,3,0	113
ps 06	13200	7,43	0,35	3,98	14,8	21,6	0,11	744	15,8	20,3	85
ps 07	3400	0,92	0,40	0,86	5,1	14,4	0,11	64	3,8	9,1	57
ps 08	7500	1,69	0,57	2,65	25,2	25,6	0,12	438	9,9	12,3	92
ps 09	14500	3,10	0,31	2,69	12,0	15,2	0,08	269	8,4	9,5	71
ps 10	4900	2,04	0,38	1,24	10,5	21,7	0,11	109	6,8	9,7	64
ps 11	6400	2,04	1,32	1,59	12,6	26,7	0,13	79	9,3	11,1	65
ps 12	12600	2,02	0,17	3,78	23,8	15,7	0,08	200	22,3	6,6	65
ps 13	2600	0,51	0,23	0,57	3,9	14,8	0,11	108	3,8	10,6	52
ps 14	12100	2,96	0,21	3,08	20,0	25,8	0,11	139	16,3	15,6	78
ps 15	3600	3,09	0,29	0,89	5,0	11,4	0,06	242	3,3	4,9	39
ps 16	2000	0,53	0,15	0,51	3,5	13,0	0,14	92	4,1	6,6	44
ps 17	21000	4,18	0,33	7,77	45,3	28,9	0,16	128	41,9	16,0	132
ps 18 (san 51)	6200	1,32	0,29	1,71	12,9	12,0	0,13	177	10,4	7,8	45
ps 19 (san 57)	16700	4,41	0,28	4,42	33,6	23,8	0,14	297	28,1	12,7	90
ps 20	7300	1,67	0,25	3,14	27,3	14,0	0,06	142	24,7	6,8	49
ps 21	3700	0,67	0,24	0,90	7,1	18,0	0,13	51	9,0	16,1	49
ps 22	2200	0,34	0,20	0,49	4,4	19,9	0,17	41	4,3	7,7	75
ps 23	6000	1,11	0,17	1,66	21,1	19,2	0,13	77	20,5	33,5	44
ps 24	7600	1,57	0,33	3,13	28,6	18,7	0,10	160	26,4	7,2	56
ps 25	7200	1,11	0,24	2,13	16,0	19,8	0,11	140	14,0	6,0	78
ps 26	2100	0,46	1,13	0,57	3,4	366	0,20	155	3,3	3,9	129
ps 27	2600	0,37	0,26	0,69	4,6	17,3	0,16	71	4,3	4,2	54
ps 28	2200	0,39	0,23	0,56	4,8	16,9	0,13	38	4,8	10,6	37
ps 29	9600	0,85	0,15	2,81	10,6	23,0	0,10	209	13,5	4,8	57
ps 30	2600	0,39	0,12	0,85	6,8	14,1	0,14	60	7,1	6,1	40
ps 31	2500	0,47	0,22	0,68	2,8	12,2	0,11	102	3,1	5,5	43
ps 32	8100	1,47	0,17	1,66	7,1	12,6	0,06	85	6,1	4,6	65
ps 33	3900	0,55	0,32	1,08	4,7	11,1	0,19	144	5,6	13,6	41
ps 34	6900	0,87	0,45	2,78	7,3	14,1	0,11	117	6,7	10,4	45
media	6700	1,60	0,33	1,94	12,8	18,0	0,12	155	11,0	10,2	64
min	2000	0,34	0,15	0,49	2,8	11,0	0,06	38	3,1	3,9	37
max	21000	7,43	1,32	7,77	45	30,6	0,20	744	42	33,5	132
dev std	4700	1,5	0,23	1,5	10,2	5,5	0,04	137	9,0	19	25
U (%)	13	15	19	14	11	10	22	7	11	10	9

* not considered in the statistical calculations

Table 31a. Elements concentrations in moss - Tertiary Points (AM3, Pieve Porto Morone)

Site	Al	As	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Zn
piev 11	2400	0,59	0,35	nd	8,9	24,1	0,12	nd	7,7	6,9	72
piev 12	13200	3,75	1,10	nd	42,2	44,0	0,15	nd	30,2	17,4	96
piev 13	6100	1,17	0,60	nd	21,7	14,3	0,08	nd	18,9	8,4	57
piev 21	2300	0,45	0,16	nd	7,4	17,4	0,11	nd	8,3	8,9	40
piev 22	3200	1,31	0,47	nd	9,2	19,7	0,12	nd	8,5	29,1	105
piev 23	6100	1,08	0,19	nd	18,9	16,5	0,13	nd	16,8	6,4	66
piev 31	11000	2,53	0,33	nd	37,5	25,8	0,10	nd	37,6	5,0	86
piev 32	7900	1,22	0,97	nd	20,2	27,1	nd	nd	26,8	3,5	103
piev 33	2300	0,49	0,57	nd	6,7	20,5	0,12	nd	14,2	13,1	68
media	6100	1,40	0,53	nd	19,2	23,3	0,12	nd	18,8	11,0	77
min	2300	0,45	0,16	nd	6,7	14,3	0,08	nd	7,7	3,5	40,5
max	13200	3,75	1,10	nd	42,2	44,0	0,15	nd	37,6	29,1	105
dev std	5200	1,1	0,33	nd	13,1	8,9	0,02	nd	10,7	8,0	21,9
U (%)	13	15	18	nd	10	10	22	nd	10	11	8

Table 31b. Elements concentrations in moss - Tertiary Points (AM3, Giussago)

Site	Al	As	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Zn
gius 11	22900	6,14	0,44	3,29	18,7	18,1	0,18	170	11,0	22,6	78
gius 12	2900	1,24	0,35	0,59	4,2	11,1	0,11	69	2,8	4,7	41
gius 31	15600	9,69	0,34	3,20	14,0	18,3	0,14	1239	11,3	15,7	62
gius 33	7300	3,36	0,24	1,52	10,5	19,7	0,13	274	6,7	10,2	60
media	12200	5,11	0,34	2,15	11,8	16,8	0,14	438	7,9	13,3	60
min	2900	1,24	0,24	0,59	4,2	11,1	0,11	69	2,8	4,8	41
max	22900	9,69	0,44	3,29	18,7	19,7	0,18	1239	11,3	22,6	78
dev std	8900	3,6	0,08	1,3	6,1	3,9	0,03	541	4	7,6	15,3
U (%)	12	13	19	14	11	10	22	6	12	11	9

Table 31c. Elements concentrations in moss - Tertiary Points (AM3, Corteolona)

Site	Al	As	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Zn
cor 11	1200	0,47	1,10	0,30	2,7	15,1	0,08	36	2,1	3,2	75
cor 13	7600	2,27	0,35	1,75	7,9	10,6	0,07	142	6,7	7,6	47
cor 15	6000	1,30	0,22	1,38	7,6	18,3	0,09	211	5,8	9,7	56
cor 22	4400	1,54	0,38	0,99	7,9	18,7	0,21	141	5,70	8,6	79
cor 23	14100	3,75	0,87	3,71	18,5	23,6	0,41	143	13,3	11,3	82
cor 24	6200	1,49	0,59	2,03	7,3	24,8	0,12	210	8,5	25,5	79
cor 25	4600	2,12	0,27	1,12	6,4	11,8	0,12	102	7,2	7,7	62
cor 31	7800	2,77	0,35	1,85	9,5	22,9	0,18	208	8,2	8,6	69
cor 32	15600	8,27	0,40	3,79	17,6	21,1	0,17	2017	14,7	13,4	83
cor 33	4400	1,15	0,36	1,25	15,3	28,7	0,16	83	15,6	39,0	100
cor 34	14100	4,37	0,24	4,06	21,4	27,4	0,16	222	15,0	17,8	66
cor 35 (PP4)	3700	0,84	0,24	1,14	10,5	15,0	0,11	69,5	7,7	11,5	57
cor 41	3100	0,91	0,67	1,00	9,7	19,9	0,07	84	8,1	13,1	87
cor 42	3500	1,47	1,48	0,92	6,0	13,6	0,10	120	4,6	7,7	47
cor 43	13200	5,74	0,60	4,10	16,4	21,3	0,09	191	15,5	19,6	73
cor 44	4300	0,93	0,20	0,99	6,3	18,9	0,12	193	5,6	8,2	74
cor 45	14200	4,48	0,31	2,50	9,9	14,3	0,13	217	8,2	8,1	64
cor 51	6600	1,40	0,30	2,66	24,7	15,6	0,10	112	21,6	7,7	174
cor 53	5000	1,12	0,18	1,05	7,4	18,1	0,16	186	6,8	12,8	55
cor 55	11200	2,16	0,36	3,51	28,3	18,9	0,12	161	21,1	7,6	66
media	7600	2,43	0,47	2,01	12,1	18,9	0,14	242	10,1	12,4	75
min	1200	0,47	0,18	0,30	2,7	10,6	0,07	36	2,1	3,2	47
max	15600	8,27	1,48	4,10	28,3	28,7	0,41	2017	21,6	39,0	174
dev std	4500	1,9	0,34	1,22	6,9	4,9	0,08	421	5,5	8,1	27
U (%)	13	14	18	14	11	10	22	7	11	11	8

Table 31d. Elements concentrations in moss - Tertiary Points (AM3, Voghera)

Site	Al	As	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Zn
vog 11 (san 77)	2700	0,61	0,30	1,00	8,3	23,3	0,14	72	8,0	11,2	73
vog 12	2100	0,40	0,80	0,82	5,8	21,7	0,11	58	6,1	9,6	262
vog 13	5200	1,11	0,25	1,52	15,4	22,5	0,24	68	14,7	7,7	57
vog 14	7800	2,78	0,76	3,44	37,6	26,7	0,07	146	31,8	28,7	118
vog 15	4000	0,60	0,23	0,84	9,1	15,7	0,12	78	8,0	18,8	59
vog 21	14600	1,98	0,24	3,30	30,4	27,1	0,19	210	24,2	9,9	90
vog 22	11400	1,56	0,40	2,80	27,2	25,0	0,20	106	23,7	11,5	93
vog 23	3300	0,51	0,21	0,78	7,8	17,7	0,13	45	7,5	11,3	57
vog 24	4700	0,67	0,34	1,20	12,3	20,2	0,15	65	9,5	11,8	52
vog 25	8600	1,34	0,56	2,81	26,3	30,3	0,39	147	33,0	15,5	92
vog 31	15600	3,43	0,25	5,66	46,7	29,1	0,13	427	41,1	14,7	116
vog 32	6200	1,19	0,89	2,19	15,2	22,6	0,14	121	17,6	16,1	115
vog 33	7800	1,39	0,86	2,87	27,5	32,8	0,23	160	23,3	27,4	212
vog 34	1700	0,40	0,21	0,44	4,0	14,7	0,19	39	3,9	4,5	62
vog 35	36100	3,51	0,34	7,73	74,2	37,9	nd	400	57,0	15,9	95
vog 41	6200	0,97	0,43	1,29	13,1	19,1	0,11	55	10,3	6,8	153
vog 42	2000	0,37	0,56	0,63	4,3	20,7	0,13	42	5,3	4,0	91
vog 43	7000	0,97	0,66	1,95	21,0	24,7	0,10	115	18,8	9,3	89
vog 44	16800	2,40	0,83	8,75	42,9	538	0,12	300	45,2	34,6	220
vog 45	1700	0,56	0,75	1,73	5,8	28,7	0,13	61	6,5	38,9	128
vog 51 (PP2)	3200	0,62	0,61	1,13	7,6	116	0,14	95	8,5	23,8	760
vog 52	2900	0,73	0,58	0,85	8,8	19,6	0,17	53	6,0	19,2	77
vog 53	5600	1,09	0,34	1,72	15,9	27,5	0,14	115	12,8	12,7	70
vog 54	4100	1,00	1,66	1,97	16,6	37,5	0,14	100	12,5	24,6	502
vog 55	3500	0,61	0,39	0,96	7,6	55,7	0,16	72	7,6	8,2	84
media	7600	1,26	0,54	2,39	20,2	26,1	0,16	127	18,1	15,5	124
min	1700	0,37	0,21	0,44	4,04	14,7	0,07	39,3	3,9	4,	52
max	36100	3,51	1,66	8,75	74,2	55,7	0,39	427	57,0	38,9	502
dev std	7500	0,9	0,33	2,16	16,8	8,9	0,06	107	14,3	9,2	97
U (%)	13	15	18	14	10	10	21	8	10	11	8

Table 31e. Elements concentrations in moss - Tertiary Points (AM3, Sannazzaro dei Burgondi)

Site	Al	As	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Zn
san 11	14500	6,26	0,24	5,17	20,6	19,4	0,15	1052	17,0	14,6	98
san 13	2600	0,73	0,19	0,61	4,6	8,6	0,07	79	3,3	5,4	32
san 15	2900	0,64	0,18	0,81	5,3	14,9	0,14	236	5,6	14,0	48
san 17	2100	0,50	0,18	0,61	3,7	13,6	0,09	54	3,6	5,6	68
san 22	2400	0,36	0,15	0,52	4,1	14,5	0,11	64	3,4	8,9	37
san 23	3000	0,61	0,35	0,79	5,3	10,3	0,08	75	4,2	5,9	36
san 24	4500	0,92	0,32	1,06	5,9	18,0	0,10	192	5,5	9,5	80
san 25	3200	0,80	0,25	0,82	4,9	10,2	0,11	nd	3,3	3,3	38
san 26	4100	0,88	0,27	0,93	6,3	15,0	0,16	147	6,2	8,2	60
san 31	7000	1,21	0,25	1,87	13,9	11,4	0,11	126	8,4	6,5	50
san 32	6400	1,24	0,24	1,69	12,1	12,1	0,15	235	8,6	11,0	58
san 33	5000	1,22	0,27	1,39	9,4	18,7	0,17	186	8,5	11,2	96
san 34	8200	1,71	0,46	1,98	12,7	16,1	0,10	243	9,1	6,1	70
san 35	6800	1,64	0,32	2,02	11,7	13,5	0,13	199	10,5	8,4	63
san 36	1500	0,40	0,41	0,63	7,6	9,4	0,13	41	4,5	2,6	44
san 37	6700	1,63	0,28	1,65	11,3	11,6	0,05	165	7,0	4,4	47
san 42	3500	0,55	0,42	1,15	9,2	14,6	0,09	64	9,7	10,4	127
san 43	8300	2,46	0,61	3,41	47,0	22,7	0,15	144	33,7	20,0	298
san 44	3400	0,73	0,38	1,07	10,7	12,6	0,07	78	8,0	4,9	65
san 45	8600	1,68	0,73	3,06	25,4	35,1	0,13	121	25,6	43,0	557
san 46	20100	6,74	0,38	7,20	67,9	20,9	0,10	381	60,8	11,0	72
san 51 (18 ps)	6200	1,32	0,29	1,71	12,9	12,0	0,13	177	10,4	7,8	45
san 52	8800	1,46	0,39	1,97	12,1	18,4	0,13	176	10,2	7,3	74
san 53	17300	3,18	0,31	4,34	20,4	23,0	0,11	373	18,4	11,1	102
san 54	10400	1,62	0,33	2,61	15,5	19,6	0,13	305	12,8	6,2	68
san 55	3500	0,82	0,76	1,72	25,6	14,6	0,07	74	16,6	10,7	274
san 56	12200	1,86	0,58	4,02	37,7	17,8	0,16	189	32,7	6,8	70
san 57 (19 ps)	16700	4,41	0,28	4,42	33,6	23,8	0,14	297	28,1	12,7	90
san 62	9000	1,76	0,20	2,47	20,0	20,3	0,15	571	16,1	8,4	87
san 63	7900	1,58	0,22	1,99	16,5	14,2	nd	119	12,6	5,4	49
san 64	10000	1,55	0,23	3,23	27,6	19,2	0,11	163	23,9	8,0	73
san 65	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
san 66	4500	0,87	0,14	1,55	16,4	17,2	0,13	90	13,7	6,6	61
san 71	5900	1,07	0,29	2,18	18,8	19,6	0,13	214	16,3	16,1	147
san 73	3100	0,73	0,17	1,48	12,7	8,7	0,10	86	10,7	3,1	31
san 74	3700	1,16	0,31	1,72	16,6	13,1	0,10	98	13,6	6,7	45
san 75	3700	0,97	0,37	1,38	13,4	15,6	0,16	80	11,7	11,9	58
san 77 (vog 11)	2700	0,61	0,30	1,00	8,3	23,3	0,14	72	8,0	11,2	73
media	6800	1,56	0,33	2,06	16,4	16,3	0,12	194	13,6	9,6	92
min	1500	0,36	0,14	0,52	3,7	8,6	0,05	41	3,3	2,6	31
max	20100	6,74	0,76	7,20	67,9	35,1	0,17	1052	60,8	43,0	557
dev std	4600	1,4	0,15	1,4	13,1	5,3	0,03	184	11,2	6,8	97
U (%)	13	15	19	14	10	11	22	7	11	11	8

Table 31f. Elements concentrations in moss - Tertiary Points (AM3, Parona)

Site	Al	As	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Zn
par 11	12000	2,39	0,57	2,67	29,3	30,4	0,11	197	12,6	96,3	133
par 12	20700	3,92	0,63	6,29	50,7	40,4	0,42	325	40,2	30,9	139
par 13	3500	0,72	0,40	0,78	5,7	15,8	0,13	238	3,3	4,8	64
par 14	4600	0,97	0,48	0,98	6,8	24,0	0,14	90,8	5,2	17,2	81
par 15	11700	1,73	0,33	2,14	23,9	27,8	0,16	174	10,4	27,1	82
par 21	5600	1,00	0,45	1,31	10,0	19,6	0,21	147	8,2	11,2	68
par 22	3000	2,40	0,39	0,77	7,3	24,2	0,12	100	4,5	13,3	95
par 23	14300	2,48	0,71	3,89	31,2	84,1	0,30	177	21,4	30,4	92
par 24	5100	0,98	0,36	1,01	8,6	16,8	0,12	101	5,5	6,2	53
par 25	3200	0,46	0,68	0,71	5,8	16,9	0,07	53	4,4	13,6	73
par 31	3500	0,78	0,31	0,87	6,0	14,3	0,13	68	4,7	10,0	201
par 32	19200	3,01	0,50	3,36	18,4	30,8	0,24	352	16,4	23,9	115
par 33	10500	1,81	0,80	2,30	17,1	22,5	0,17	129	11,6	15,5	71
par 34	4700	0,84	0,35	1,06	11,2	16,9	0,10	106	6,4	23,8	60
par 35	9200	2,50	0,33	1,92	8,7	18,6	0,12	259	6,5	11,7	71
par 41	6300	0,85	0,37	1,10	7,9	40,7	0,13	155	7,3	29,7	199
par 42	5700	0,80	0,41	0,95	7,1	33,4	0,11	117	6,9	18,0	95
par 43	4900	0,85	0,63	1,22	5,5	18,4	0,13	107	4,9	15,2	72
par 44	4300	0,85	0,63	1,23	13,5	14,9	0,09	84	7,2	7,2	262
par 45	5700	0,84	0,90	0,97	7,8	22,8	0,17	108	5,8	11,8	95
par 51	7700	1,55	1,15	3,15	23,1	28,7	0,09	120	15,7	18,0	118
par 52	10400	2,37	0,90	4,19	35,4	28,6	0,35	202	28,5	19,9	100
par 53	13200	2,46	0,45	2,18	21,9	30,6	0,08	181	13,4	41,3	194
par 54	7600	1,31	0,67	2,41	19,4	19,3	0,23	121	13,5	17,4	74
par 55	6700	5,94	0,10	4,52	7,6	27,7	n.d.	427	8,5	8,9	158
media	8200	1,58	0,56	1,98	15,9	26,7	0,16	155	11,0	21,4	109
min	3000	0,46	0,31	0,71	5,5	14,3	0,07	53	3,3	4,8	53
max	20700	3,92	1,15	6,29	50,7	84,1	0,42	352	40,2	96,3	262
dev std	4900	0,9	0,22	1,4	11,6	14,4	0,09	77	8,7	18,3	54
U (%)	12	15	17	14	11	10	21	7	11	10	8

Table 32. Elements average concentrations in mosses for Primary, Secondary and Tertiary Points (AM1, AM2, AM3) - national and international values and high values locations

Area	As	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Zn
	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
AM1	2,6	0,25	1,79	10,8	21,8	0,11	158	8,48	9	110
AM2	0,84	0,37	1,29	11,9	11	0,06	97	5,9	5,8	43
Pieve Porto M.	1,4	0,53		19,2	23,3	0,12		18,8	11,0	77
Giussago	5,1	0,34	2,15	11,8	16,8	0,14	438	7,96	13,3	60
Corteolona	2,3	0,47	2,01	12,1	18,9	0,14	242	10,1	12,4	75
Voghera	1,2	0,54	2,39	19,7	50,2	0,16	127	17,7	15,9	149
San Nazzaro B.	1,6	0,33	2,06	16,4	16,3	0,12	194	13,6	9,6	92
Parona	1,58	0,56	1,98	15,9	26,7	0,16	155	11,0	21,4	109
uncertainty %	*18*	*19*	*14*	*13*	*10*	*21*	*7*	*12*	*12*	*9*
(1)Parona		1,61		10	19	0,15		10	19	153
(2)M. Sibillini	0,6	0,6		4,3	6,3	0,06		4,3	6,2	60
(3)Castano P.	1,5	0,62		13	29	0,14		38	23	72
(4)Trezzo D'Adda	2,5	0,9		13	61	0,17		16,4	35,5	284
(5)Valle Aosta	1,9	0,4		36	17	0,08		31	19	99
(6)Sicilia		0,25			16,5	0,07		13,9	8,7	55
(7) Italia	0,4	0,26		3,6	9,1	0,07		3,8	9,4	48
(7) Germania	0,16	0,21		0,9	7,1	0,04		1,1	4,6	41
(7) Belgio	0,78	0,75		8,1	9,7	0,13			23,8	111
(7) Romania	1,56	0,46		8,5	21,5			3,4	14,3	79
AM1 PP2		*0,69*		*7,6*	***117***			*8,5*	*23,8*	*760*
AM1 PP6	*7,4*				***805***					
PS 17			*7,8*	*45*			*1285*	*42*		
PS 4		***2,5***		*13,2*	*40*			*6,9*	***42***	***359***

(1) Cenci, 2002; (2) Cenci *et al.*, 2001, (3) Dabergami e Cenci, 2002; (4) Cenci *et al.*, 2003; (5) Cenci *et al.*, 2004; (6) Grammatica *et al.*, *in stampa*; (7) Unece, 2003

Table 33. Selected Secondary (AM2) and Tertiary Points (AM3) - average concentration (µg/kg) of Rh and Pt in moss, compared with local and international experiences.

Locality	Moss Rh µg/kg	Moss Pt µg/kg	Locality	Moss Rh µg/kg	Moss Pt µg/kg
PS 01	0,1	21,1	PAR 14	1,3	12,0
PS 02	0,9	18,7	PAR 23	1,7	11,8
PS 03	0,4	16,5	PAR 35	2,7	11,9
PS 05	2,3	16,3	PAR 41	2,1	12,4
PS 06	0,3	16,1	PAR 53	2,0	11,7
PS 07	0,1	17,8	VOG 24	1,9	11,7
PS 08	0,6	17,2	VOG 32	1,2	11,9
PS 15	0,1	15,8	VOG 53	6,0	4,5
PS 17	1,2	15,9	SAN 23	7,4	3,5
PS 19	1,2	16,2	SAN 42	6,7	2,8
PS 21	0,9	3,9	SAN 64	7,0	2,1
PS 22	1,8	5,1	COR 24	6,7	2,7
PS 23	2,1	5,5	COR 42	6,9	2,2
PS 24	1,4	3,6	PIEV 11	4,3	5,5
PS 26	0,8	4,9	PIEV 33	4,4	3,7
PS 27	1,4	5,0	GIUS 11	4,9	2,2
PS 28	2,0	4,2	(1)Parco Naz.	0,8-1,4	0,3-0,9
PS 29	1,1	5,8	(2)Castano P	0,4-8	3-13
PS 30	1,0	6,1	(3) V. Aosta	0,8-3,2	4,6-50
PS 31	0,8	5,8	(4)Roma	2,9-5,3	2,7-5,1
PS 33	2,2	5,7	(5)Erba	2,5-15	17-96
PS 34	0,7	6,5	(6)A 66		

	Rh	Pt
media	2,3	9,5
Min.	0,1	2,1
Max.	7,4	21,1
uncert %	*18*	*12*

(1)Cenci *et al.*, 2001; (2)Dabergami, 2002; (3)Cenci *et al.*, 2004; (4))Beccaloni *et al.*, 2004; (5)Hess *et al.*, 1998; (6)Zereini, 1997

Table 34. Deposition rate (g ha^{-1} y^{-1}) for AM1, AM2 and AM3, compared with National and European experiences.

Area	As	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Zn
AM1 e AM2	3,2	0,35	1,6	7,5	18,7	0,15	137	12,3	8,9	91
Pieve Porto Morone	2,7	0,55	nd	12	24,7	0,15	nd	21	8,7	109
Giussago	9,9	0,35	2	7,4	17,8	0,17	414	8,9	10,5	86
Corteolona	4,5	0,49	1,9	7,5	20	0,17	229	11,3	9,8	106
Voghera	2,3	0,56	2,3	12,3	53	0,19	120	19,7	12,5	202
San Naz dei Burgundi	3,2	0,34	1,9	10,2	17,2	0,15	184	15,1	7,6	130
Parona	3,1	0,58	1,9	9,9	28,3	0,19	147	12,3	16,9	149
Sicilia [1]	7,3	0,2		6	12,1	0,07		10,9	46	55
Parona (PV) [2]	3,3	1,7		6	20	0,2		11,3	14,8	208
Trezzo D'Adda (MI) [3]	6,6	0,9		8,1	64	0,2		18,4	28,1	386
Castano Primo (MI) [4]	3,9	0,6		8	31	0,17		42	17	98
Gorizia [5]	1,5	0,3		8	61	0,21		12	6	100
Castelporziano (RM) [6]		3,3		45,6	60			35	58,1	289
Urban industrial areas[7]		1,4		12	25,6			14,6	25,8	
Austria [8]		2,7		6,2	100			2,1	8,5	500
Belgio [9]		7,3			73				110	440
Denmark [10]		0,3		1,25	7,9			2,1	10,4	79,7
Germany [11]		2,5		7	52,6			11	57,2	540
Holland [12]		0,5-2		1,2-3,8	16-38			6,1-15	33-66	73-250
Poland [13]		2		30	40			20	100	540
U.K. [14]		1,9		7,5	57			16	54	221
Sweden [15]		0,75		5	15			0,5	6,25	118
Switzerland [16]		0,8		3,7	18			11	28	119

[1]Rural domains, investigations with moss and soils, Cenci *et al.*, 2001. [2] Agricultural, urban, industrial domains, determinations with moss and soils, Cenci, 2002. [3] Agricultural, urban, industrial domains, determinations with moss and soils, Cenci *et al.*, 2003. [4] Agricultural, urban, industrial domains, determinations with moss and soils, Dabergami e Cenci, 2002. [5] Agricultural, urban domains, determinations with moss and soils, Cenci *et al.*, 2001. [6] Rural domain, Morselli *et al.*, 1999. [7] Ryaboshapko *et al.*, 1999. [8] Zechmeister, 1997. [9] VMM, 1996. [10] Hovmand & Kemp, 2000. [11] Müller *et al.*, 1991; [12]: Severin *et al.*, 1991. [13]: SFT, 1998. Westhoek *et al.*, 1997. [14] Alloway *et al.*, 1998 e 1999. [15] Swedish EPA, 1993. [16] Herter & Kuelling, 2001; Scherer *et al.*, 1998.

Table 35a. Enrichment Factors for action AM1

Site	As	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Zn
pp 01	1	10	1	1	9	21	1	2	4	14
pp 02	4	101	6	6	157	77	11	11	34	360
pp 03	1	30	2	3	23	19	4	4	3	41
pp 04	1	16	2	4	11	49	3	5	11	10
pp 05	2	12	2	1	2	46	3	1	6	10
pp 06	1	16	2	1	49	23	5	2	5	11
pp 07	1	8	1	1	10	39	2	1	5	10
media	1	15	2	2	11	33	3	2	6	16
min	1	8	1	1	2	19	1	1	3	10
max	2	30	2	4	23	49	5	5	11	41
dev std	0,4	8	1	1	8	14	1	2	3	13

Table 35b. Enrichment Factors for action AM2

Site	As	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Zn
ps 01	1	29	1	2	8	8	2	2	4	7
ps 02	1	28	2	2	7	18	3	3	4	8
ps 03	2	51	2	2	18	40	3	4	7	17
ps 04	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d
ps 05	2	11	2	1	8	3	6	2	54	10
ps 06	4	9	2	1	5	9	6	3	7	5
ps 07	1	47	2	2	12	14	2	2	2	11
ps 08	1	7	2	2	6	8	7	2	2	4
ps 09	1	6	1	1	3	6	2	1	2	3
ps 10	1	31	2	3	15	18	2	3	7	11
ps 11	1	22	1	2	6	6	1	2	3	4
ps 12	1	4	1	1	2	9	1	1	2	4
ps 13	1	19	1	1	6	4	6	2	8	6
ps 14	1	5	1	1	7	7	1	2	3	5
ps 15	3	44	1	2	7	21	8	2	5	8
ps 16	2	30	2	1	18	63	4	3	7	23
ps 17	3	6	2	1	2	6	11	1	1	3
ps 18 (san 51)	1	11	1	1	5	14	1	2	4	5
ps 19 (san 57)	2	3	1	1	2	9	2	1	2	3
ps 20	1	7	1	1	3	7	1	1	2	4
ps 21	3	37	1	1	12	77	2	2	26	14
ps 22	2	27	1	1	18	67	2	3	10	27
ps 23	2	10	2	2	8	32	2	3	27	7
ps 24	1	10	1	1	4	9	2	1	3	5
ps 25	1	9	1	1	7	9	2	1	3	9
ps 26	7	n.d	3	2	n.d	n.d	18	5	19	64
ps 27	1	26	1	1	11	23	2	1	6	14
ps 28	2	36	1	1	16	87	2	2	23	14
ps 29	2	14	2	2	5	27	2	3	5	7
ps 30	2	12	1	1	10	72	2	1	9	10
ps 31	2	18	2	1	16	48	4	3	7	17
ps 32	2	17	2	1	5	11	3	2	3	9
ps 33	3	46	2	1	7	77	3	1	21	11
ps 34	2	24	3	2	8	20	3	3	6	8
media	2	20	2	1	8	26	3	2	9	9
min	1	3	1	1	2	3	1	1	1	3
max	7	51	3	3	18	87	18	5	54	27
dev std	1	14	1	1	5	26	3	1	11	6

Table 35c. Enrichment Factors for action AM3 (Pieve Porto Morone)

Site	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
piev 11	0,5	8	3	10	9	4	4	9
piev 12	1	25	2	8	9	2	4	5
piev 13	1	20	1	4	20	1	4	7
piev 21	1	16	1	16	67	2	17	14
piev 22	2	31	1	12	19	1	17	24
piev 23	1	6	1	5	26	1	3	8
piev 31	1	7	1	4	13	1	1	6
piev 32	1	28	1	5	n.d.	1	1	8
piev 33	1	34	1	14	31	2	19	17
media	1	19	1	9	24	2	8	11
min	0,5	6	1	4	9	1	1	5
max	2	34	3	16	67	4	19	24
dev std	0,5	11	1	5	19	1	7	6

Table 35d. Enrichment Factors for action AM3 (Giussago)

Site	As	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Zn
gius 11	1	3	1	1	2	2	1	1	2	2
gius 12	1	19	1	2	7	19	5	2	2	8
gius 31	1	4	1	1	4	5	10	2	2	3
gius 33	1	6	1	2	4	8	5	2	2	4
media	1	8	1	2	4	8	5	2	2	4
min	1	3	1	1	2	2	1	1	2	2
max	1	19	1	2	7	19	10	2	2	8
dev std	0,4	7	0	0	2	7	4	1	0	3

Table 35e. Enrichment Factors for action AM3 (Corteolona)

Site	As	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Zn
cor 11	1	117	2	3	32	25	2	4	7	33
cor 13	1	11	1	1	4	7	2	2	2	5
cor 15	1	19	1	1	9	20	4	1	6	10
cor 22	1	27	1	2	11	27	5	3	4	13
cor 23	1	19	1	1	4	26	2	1	1	3
cor 24	1	39	2	1	10	23	3	2	10	9
cor 25	2	14	1	1	9	36	2	3	5	13
cor 31	1	21	2	2	12	43	4	3	4	10
cor 32	1	3	1	1	3	5	6	2	2	3
cor 33	1	7	1	2	4	9	2	4	12	6
cor 34	2	6	2	1	5	10	2	2	3	4
cor 35 (PP4)	1	16	2	4	11	49	3	5	11	10
cor 41	1	57	2	4	15	17	3	5	8	20
cor 42	1	109	2	3	11	20	6	3	6	11
cor 43	2	11	2	1	3	5	2	2	4	4
cor 44	1	7	1	2	3	8	4	3	3	6
cor 45	1	5	1	1	2	5	1	1	1	3
cor 51	1	18	1	1	4	18	2	1	5	23
cor 53	1	11	1	2	9	31	6	3	8	9
cor 55	1	11	1	1	4	15	2	1	2	5
media	1	26	1	2	8	20	3	3	5	10
min	1	3	1	1	2	5	1	1	1	3
max	2	117	2	4	32	49	6	5	12	33
dev std	0,3	32	0	1	7	13	2	1	3	8

Table 35f. Enrichment Factors for action AM3 (Voghera)

Site	As	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Zn
vog 11 (san 77)	1	17	1	1	10	71	2	1	11	14
vog 12	1	97	1	1	25	111	3	1	19	105
vog 13	1	7	1	1	3	44	1	1	3	6
vog 14	2	15	1	2	5	10	2	2	11	9
vog 15	1	12	1	1	6	25	1	1	18	10
vog 21	1	3	1	1	4	n.d.	2	1	3	5
vog 22	1	9	1	1	4	37	1	1	4	7
vog 23	1	14	1	1	9	70	2	2	17	12
vog 24	1	15	1	1	7	34	1	1	9	7
vog 25	1	14	1	1	6	61	2	2	8	8
vog 31	1	2	1	1	2	10	2	1	3	4
vog 32	1	35	2	1	8	60	2	2	12	16
vog 33	1	10	1	1	7	44	2	1	13	18
vog 34	2	27	1	1	16	154	2	1	11	29
vog 35	1	2	1	1	1	n.d.	1	1	2	2
vog 41	1	20	1	1	4	38	1	1	5	21
vog 42	1	99	2	1	27	183	3	2	12	46
vog 43	2	32	2	2	9	39	3	3	9	13
vog 44	1	9	2	1	11	9	1	2	6	7
vog 45	3	116	5	2	22	85	4	3	113	54
vog 51 (PP2)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
vog 52		56	1	2	14	109	1	1	29	25
vog 53	1	14	1	1	9	48	2	1	8	9
vog 54	1	48	1	1	3	15	1	1	12	52
vog 55	1	25	1	1	19	51	2	1	9	17
media	1	29	1	1	10	60	2	1	14	21
min	1	2	1	1	1	9	1	1	2	2
max	3	116	5	2	27	183	4	3	113	105
dev std	0,5	32	1	0	7	46	1	1	22	23

Table 35g. Enrichment Factors for action AM3 (Sannazzaro dei Burgundi)

Site	As	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Zn
san 11	4	6	2	1	4	13	11	2	2	6
san 13	2	20	2	2	10	24	6	3	4	10
san 15	2	11	2	2	15	25	11	4	11	11
san 17	2	16	2	1	10	20	2	3	4	15
san 22	1	17	1	2	15	51	4	2	7	10
san 23	2	76	2	2	13	48	4	3	7	12
san 24	1	46	1	2	12	38	4	2	11	19
san 25	3	14	2	1	6	30		2	2	8
san 26	1	20	1	2	11	38	2	3	5	9
san 31	1	12	2	2	5	20	3	2	3	6
san 32	2	12	2	2	6	84	9	2	6	8
san 33	2	14	2	2	8	16	7	3	4	12
san 34	2	17	1	1	5	2	7	1	2	6
san 35	3	20	2	1	5	10	6	2	3	7
san 36	2	52	2	4	12	41	4	4	3	18
san 37	2	14	2	2	4	4	4	2	2	7
san 42	1	81	2	3	19	68	2	6	15	43
san 43	3	17	2	4	9	32	2	6	7	28
san 44	1	51	2	3	10	5	3	4	3	16
san 45	1	17	2	3	8	16	1	5	12	50
san 46	2	6	1	1	2	7	2	1	2	3
san 51 (18 ps)	1	15	1	1	5	15	1	2	4	5
san 52	1	12	1	0	5	20	1	1	3	5
san 53	2	9	1	1	6	15	3	2	3	6
san 54	2	26	1	1	6	14	5	2	2	6
san 55	1	39	1	2	7	12	2	2	8	47
san 56	1	4	1	1	2	9	1	1	2	4
san 57 (19 ps)	2	2	1	1	2	9	2	1	2	3
san 62	1	4	1	1	7	32	5	2	4	8
san 63	2	5	1	1	4		3	1	2	5
san 64	1	10	1	1	4	19	2	1	3	6
san 65	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
san 66	1	17	1	1	5	16	2	1	4	8
san 71	1	28	2	2	10	42	2	4	12	22
san 73	2	47	2	2	6	23	3	2	6	10
san 74	3	27	2	1	8	34	3	2	8	9
san 75	2	7	1	1	6	14	2	1	9	10
san 77 (vog 11)	1	17	1	1	10	64	2	1	11	14
media	2	22	2	2	8	26	4	2	5	13
min	1	2	1	0,4	2	2	1	1	2	3
max	4	81	2	4	19	84	11	6	15	50
dev std	1	19	0,4	1	4	19	3	1	4	12

Table 35h. Enrichment Factors for action AM3 (Parona)

Site	As	Cd	Co	Cr	Cu	Hg	Mn	Ni	Pb	Zn
par 11	1	8	2	3	5	4	3	2	16	8
par 12	1	11	2	3	8	13	2	5	5	4
par 13	1	59	2	2	19	39	13	2	4	19
par 14	1	34	2	1	15	17	3	3	9	13
par 15	1	8	1	3	4	4	1	2	3	5
par 21	1	14	2	2	5	12	2	2	3	5
par 22	6	30	2	3	20	35	5	3	8	22
par 23	1	3	2	1	7	2	2	1	3	2
par 24	1	20	1	2	10	22	4	2	4	10
par 25	1	80	2	2	15	23	3	3	12	20
par 31	1	12	2	2	7	10	2	2	5	32
par 32	1	4	1	1	4	7	3	2	3	5
par 33	1	21	2	1	6	11	2	2	4	4
par 34	1	8	1	2	6	2	3	2	7	4
par 35	2	8	1	1	4	15	6	2	3	6
par 41	1	10	1	2	14	4	2	2	6	17
par 42	1	12	1	1	11	5	2	2	3	10
par 43	1	44	2	1	16	16	4	2	9	13
par 44	2	14	2	2	5	2	3	2	2	22
par 45	1	75	1	2	10	45	4	2	6	17
par 51	1	13	2	2	5	1	2	2	3	6
par 52	1	15	2	2	4	15	2	3	4	5
par 53	1	15	1	2	8	6	1	2	7	12
par 54	1	8	1	1	3	3	3	1	3	4
par 55*	5	5	4	1	12		9	2	4	18
media	1	22	2	2	9	13	3	2	5	11
min	1	3	1	1	3	1	1	1	2	2
max	6	80	2	3	20	45	13	5	16	32
dev std	1	22	0,4	1	5	12	2	1	3	8

Table 36. Granulometry and water content in the three farms

Site	Depth	Sand	Clay	Silt	H_2O
	cm	%	%	%	%
C. Nuova	0 – 30	73	5	22	11,4
C. Nuova	30 – 50	72	6	22	10,6
C. Nuova	50 – 80	78	6	16	6,5
C. Novella	0 – 30	34	10	56	11,6
C. Novella	30 – 50	39	12	49	16,1
C. Novella	50 – 80	61	10	29	8,6
C. Orsine	0 – 35	68	5	27	16,6
C. Orsine	35 – 50	70	6	24	6,9
C. Orsine	50 - 80	70	7	23	6,2

Table 37. Trace elements and macro-elements concentrations in the 3 soil layers

Site	layer	Al	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
	cm	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Cas Or (biol)	0-5	6.7	6,7	0,22	33	12,1	0,04	18,7	18,3	61
Cas Or (biol)	0-15	7.0	6,4	0,27	32	12,2	0,04	19,4	18,5	61
Cas Or (biol)	15-30	6.3	9,7	0,33	34	13,1	0,05	20,4	17,4	61
Cas Nu (stal)	0-5	7.3	9,2	0,30	32	12,8	0,05	21,8	15,1	53
Cas Nu (stal)	0-15	6.5	7,5	0,24	31	11,2	0,04	18,2	16,9	57
Cas Nu (stal)	0-30	7.3	9,8	0,31	31	11,8	0,05	22,3	15,4	52
Cas No (am)	0-5	7.5	20,6	0,84	58	28,5	0,08	34,5	29,0	88
Cas No (am)	0-15	7.1	21,0	0,79	61	30,2	0,09	32,0	22,7	84
Cas No (am)	0-30	7.6	22,4	0,79	59	30,8	0,08	34,4	24,6	95
AM3 Cor Ol	media	5.5	15,1	0,42	66	28,0	0,08	42,0	22,3	84
Uncertainty %		*3*	*10*	*15*	*8*	*8*	*24*	*8*	*9*	*7*

Site	Layer	Ca	Fe	K	Mg	Na	Si	C	Ti	S	P
	cm	%	%	%	%	%	%	%	mg/kg	mg/kg	mg/kg
Cas Or (biol)	0-5	1.0	2.0	2.0	0.7	1.7	33.3	1.13	2640	274	1040
Cas Or (biol)	0-15	1.0	2.0	2.1	0.7	1.7	32.6	1.13	2697	283	1090
Cas Or (biol)	15-30	1.1	2.1	2.0	0.6	1.7	33.4	1.70	2490	413	880
Cas Nu (stal)	0-5	1.1	2.2	2.1	0.8	1.7	31.7	0.96	2580	403	810
Cas Nu (stal)	0-15	1.0	1.9	2.1	0.6	1.8	33.7	1.15	2600	286	1000
Cas Nu (stal)	0-30	1.1	2.2	2.1	0.8	1.6	31.7	1.03	2600	348	800
Cas No (am)	0-5	1.0	3.0	2.0	0.9	1.2	31.2	0.92	3730	264	790
Cas No (am)	0-15	1.1	3.0	1.9	0.8	1.3	32.0	0.94	3680	253	790
Cas No (am)	0-30	1.1	3.0	2.0	0.9	1.2	31.0	0.91	3680	268	840

Table 38. PCDD/Fs values in the three farms

Site	WHO-TEQ for PCDD/Fs	WHO-TEQ for PCDD/Fs	WHO-TEQ for PCDD/Fs
	pg/g	pg/g	pg/g
	Layer 0-5 cm	Layer 0-15cm	Layer 15-30 cm
C. Orsine (biologica)	0,75	0,73	0,8
C. Nuova (stallatico)	0,5	0,36	0,25
C. Novella (ammendante)	1,4	1,6	1,7

Table 39. Results in Farm 1 (Cascina Orsine)

Az. 1 - Cascina Orsine			1° campionamento - Settembre 2004		2° campionamento - Gennaio 2005		3° campionamento - Marzo 2005		4° campionamento - Luglio 2005	
			(0-15) cm	(15-30) cm	(0-15) cm	(15-30) cm	(0-15) cm	(15-30) cm	(0-15) cm	(15-30) cm
SOSTANZA ORGANICA	SO	%	2,05	1,82	2,03	1,87	1,74	1,88	1,72	1,68
CARBONIO MICROBICO	Cmic	ppm	239,9	123,3	176,3	201,7	123,5	131,8	109,0	156,8
RESPIRAZ. BASALE	Cbas	ppm	5,2	2,3	3,1	4,0	4,8	3,9	7,3	3,2
RESPIRAZ. CUMUL.	Ccum	ppm	254,0	194,6	103,5	138,8	154,6	98,2	189,6	157,7
QUOZIENTE METABOLICO	qCO_2	h^{-1}	0,090	0,078	0,073	0,083	0,162	0,123	0,281	0,085
QUOZIENTE DI MINERALIZZ.	qM	%	2,13	1,85	0,88	1,29	1,53	0,90	1,90	1,62
Fertilità Biologica			**buona**	**media**	**media**	**media**	**stress**	**stress**	**media**	**stress**

(a) biochemical characterisation

Az. 1 - Cascina Orsine		1° campionamento - Settembre 2004		2° campionamento - Gennaio 2005		3° campionamento - Marzo 2005		4° campionamento - Luglio 2005	
		(0-15) cm	(15-30) cm	(0-15) cm	(15-30) cm	(0-15) cm	(15-30) cm	(0-15) cm	(15-30) cm
CARBONIO ORGANICO	%	1,19	1,05	1,18	1,08	1,01	1,09	1,00	0,97
CARBONIO ESTRAIBILE	%	0,84	0,84	0,87	0,80	0,85	0,78	0,84	0,81
CARBONIO FRAZIONE UMICA	%	0,43	0,56	0,46	0,41	0,44	0,46	0,47	0,43
GRADO DI UMIFICAZIONE	%	51,5	65,8	53,4	50,8	50,8	51,8	59,0	56,0
TASSO DI UMIFICAZIONE	%	36,3	52,9	39,4	37,6	37,6	43,6	42,2	47,2

(b) organic matter characterisation

Table 40. Results in Farm 2 (Cascina Nuova)

Az. 2 - Cascina Nuova			1° campionamento - Settembre 2004		2° campionamento - Gennaio 2005		3° campionamento - Marzo 2005		4° campionamento - Luglio 2005	
			(0-15) cm	(15-30) cm	(0-15) cm	(15-30) cm	(0-15) cm	(15-30) cm	(0-15) cm	(15-30) cm
SOSTANZA ORGANICA	SO	%	1,90	1,61	1,77	1,67	2,12	2,25	2,04	1,69
CARBONIO MICROBICO	Cmic	ppm	302,1	120,4	100,1	101,7	100,8	121,6	156,6	92,4
RESPIRAZ. BASALE	Cbas	ppm	1,5	3,9	1,1	3,7	4,1	3,2	2,2	3,3
RESPIRAZ. CUMUL.	Ccum	ppm	139,9	105,4	109,3	111,5	116,9	118,9	155,3	126,8
QUOZIENTE METABOLICO	qCO_2	h^{-1}	0,021	0,135	0,046	0,152	0,170	0,110	0,058	0,150
QUOZIENTE DI MINERALIZZ.	qM	%	1,27	1,12	1,06	1,15	0,95	0,91	1,31	1,29
Fertilità Biologica			**media**	**media**	**media**	**media**	**media**	**media**	**media**	**media**

(a) biochemical characterisation

Az. 2 - Cascina Nuova		1° campionamento - Settembre 2004		2° campionamento - Gennaio 2005		3° campionamento - Marzo 2005		4° campionamento - Luglio 2005	
		(0-15) cm	(15-30) cm	(0-15) cm	(15-30) cm	(0-15) cm	(15-30) cm	(0-15) cm	(15-30) cm
CARBONIO ORGANICO	%	1,10	0,94	1,03	0,97	1,23	1,31	1,18	0,98
CARBONIO ESTRAIBILE	%	0,82	0,71	0,91	0,90	0,86	0,91	0,90	0,79
CARBONIO FRAZIONE UMICA	%	0,51	0,37	0,42	0,39	0,43	0,39	0,46	0,35
GRADO DI UMIFICAZIONE	%	46,4	39,3	40,4	39,8	50,0	42,9	51,1	44,3
TASSO DI UMIFICAZIONE	%	62,3	52,4	45,8	42,9	35,0	29,8	38,9	35,7

(b) organic matter characterisation

Table 41. Results in Farm 3 (Cascina Novella)

Az. 3 - Cascina Novella			1° campionamento - Settembre 2004 (0-15) cm	1° campionamento - Settembre 2004 (15-30) cm	2° campionamento - Gennaio 2005 (0-15) cm	2° campionamento - Gennaio 2005 (15-30) cm	3° campionamento - Marzo 2005 (0-15) cm	3° campionamento - Marzo 2005 (15-30) cm	4° campionamento - Luglio 2005 (0-15) cm	4° campionamento - Luglio 2005 (15-30) cm
SOSTANZA ORGANICA	SO	%	1,99	1,89	1,73	1,61	1,81	1,71	1,75	1,89
CARBONIO MICROBICO	Cmic	ppm	311,6	111,9	81,8	81,3	79,4	97,5	125,7	139,0
RESPIRAZ. BASALE	Cbas	ppm	1,0	4,4	4,0	1,5	3,9	2,2	2,4	2,9
RESPIRAZ. CUMUL.	Ccum	ppm	89,0	149,6	138,7	138,1	138,3	88,6	171,1	183,1
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,013	0,164	0,204	0,077	0,205	0,094	0,079	0,086
QUOZIENTE DI MINERALIZZ.	qM	%	0,77	1,36	1,37	1,48	1,32	0,89	1,68	1,67
Fertilità Biologica			**media**	**media**	**media**	**media**	**stress**	**stress**	**media**	**media**

(a) biochemical characterisation

Az. 3 - Cascina Novella		1° campionamento - Settembre 2004 (0-15) cm	1° campionamento - Settembre 2004 (15-30) cm	2° campionamento - Gennaio 2005 (0-15) cm	2° campionamento - Gennaio 2005 (15-30) cm	3° campionamento - Marzo 2005 (0-15) cm	3° campionamento - Marzo 2005 (15-30) cm	4° campionamento - Luglio 2005 (0-15) cm	4° campionamento - Luglio 2005 (15-30) cm
CARBONIO ORGANICO	%	1,16	1,10	1,01	0,93	1,05	0,99	1,02	1,10
CARBONIO ESTRAIBILE	%	0,76	0,75	0,71	0,64	0,70	0,68	0,74	0,71
CARBONIO FRAZIONE UMICA	%	0,38	0,38	0,28	0,30	0,31	0,33	0,34	0,35
GRADO DI UMIFICAZIONE	%	32,8	34,7	27,3	32,1	44,3	48,5	45,9	49,3
TASSO DI UMIFICAZIONE	%	50,3	51,3	38,6	46,4	29,5	33,3	33,5	31,9

(b) organic matter characterisation

Table 42. Comparison between the three farms

			Az. 1 - Cascina Orsine (0-15) cm	Az. 1 - Cascina Orsine (15-30) cm	Az. 2 - Cascina Nuova (0-15) cm	Az. 2 - Cascina Nuova (15-30) cm	Az. 3 - Cascina Novella (0-15) cm	Az. 3 - Cascina Novella (15-30) cm
SOSTANZA ORGANICA	SO	%	1,88	1,81	1,96	1,81	1,82	1,78
CARBONIO MICROBICO	Cmic	ppm	162,16	153,38	164,90	109,00	149,63	107,41
RESPIRAZ. BASALE	Cbas	ppm	5,11	3,35	2,22	3,53	2,82	2,74
RESPIRAZ. CUMUL.	Ccum	ppm	175,42	147,33	130,35	115,64	134,26	139,84
QUOZIENTE METABOLICO	qCO2	h^{-1}	0,15	0,09	0,07	0,14	0,13	0,11
QUOZIENTE DI MINERALIZZ.	qM	%	1,61	1,42	1,15	1,12	1,29	1,35
Fertilità Biologica			MEDIA		MEDIA		MEDIA	

(a) biochemical characterisation

		Az. 1 - Cascina Orsine (0-15) cm	Az. 1 - Cascina Orsine (15-30) cm	Az. 2 - Cascina Nuova (0-15) cm	Az. 2 - Cascina Nuova (15-30) cm	Az. 3 - Cascina Novella (0-15) cm	Az. 3 - Cascina Novella (15-30) cm
CARBONIO ORGANICO	%	1,09	1,05	1,14	1,05	1,06	1,03
CARBONIO ESTRAIBILE	%	0,85	0,81	0,87	0,83	0,73	0,70
CARBONIO FRAZIONE UMICA	%	0,45	0,46	0,45	0,37	0,33	0,34
GRADO DI UMIFICAZIONE	%	53,68	56,08	47,0	41,6	37,6	41,2
TASSO DI UMIFICAZIONE	%	38,86	45,31	45,5	40,2	38,0	40,7

(b) organic matter characterisation

Table 43. Concentration of elements in sediment core sample collected in *La Zelata*

Thickness	C	N	S	P	Si	Al	Ca	K	Fe	Mg	Na
cm	%	%	(mg/kg)	(mg/kg)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
0-1,2	11,0	0,90	5120	1480	24,3	6,4	1,8	1,8	3,8	1,1	1,0
2,4	10,8	0,87	4360	1550	24,3	5,7	1,8	1,6	3,6	0,9	1,0
3,6	11,4	0,93	6310	1320	23,3	6,7	1,8	1,8	4,0	1,2	0,9
4,8	11,8	0,97	6790	1280	23,2	6,8	1,7	1,8	4,1	1,2	0,9
6	8,1	0,71	5590	1170	25,2	7,5	1,5	1,9	4,3	1,2	1,0
7,2	11,4	0,95	6110	1320	24,0	6,7	1,7	1,8	4,1	1,1	1,0
8,4	10,6	0,86	6240	1270	24,4	6,7	1,7	1,8	4,0	1,1	1,0
9,6	10,7	0,89	5990	1200	23,1	6,3	1,6	1,7	3,8	1,0	0,9
10,8	8,7	0,71	5600	1220	25,1	6,9	1,6	1,9	3,7	1,1	1,1
12	8,8	0,74	5497	1228	25,1	7,2	1,6	1,9	3,9	1,2	1,0
13,2	8,6	0,68	5996	1215	25,2	6,9	1,6	1,9	3,6	1,1	1,1
14,4	7,6	0,59	5825	1078	24,6	6,3	1,5	1,7	3,1	1,0	1,1
15,6	7,5	0,56	6117	1210	25,5	6,8	1,6	1,9	3,4	1,0	1,2
16,8	7,5	0,56	5952	1088	26,1	6,7	1,6	1,9	3,2	1,0	1,3
18	8,1	0,62	5608	1134	25,4	7,0	1,6	1,9	3,5	1,1	1,2
19,2	8,1	0,65	5613	1145	25,4	7,0	1,6	1,9	3,6	1,1	1,2
20,4	7,7	0,63	4729	1336	25,2	7,4	1,5	2,0	3,9	1,2	1,1
21,6	8,3	0,68	4807	1171	23,6	7,1	1,4	1,9	3,8	1,2	1,0
22,8	8,7	0,71	5265	1125	23,2	6,6	1,4	1,8	3,7	1,1	1,0
24	7,9	0,66	5613	1192	25,1	7,2	1,6	1,9	3,9	1,2	1,1
25,2	7,5	0,61	5667	1153	25,0	7,4	1,5	2,0	4,0	1,2	1,1
26,4	7,8	0,64	5308	1151	25,2	7,6	1,5	2,0	4,0	1,2	1,1
27,6	7,7	0,63	5060	1177	25,5	7,4	1,5	2,0	3,9	1,2	1,2
28,8	8,4	0,68	5630	1135	25,1	7,4	1,6	2,0	4,1	1,2	1,1
30	8,4	0,69	4952	1171	25,4	7,5	1,6	2,0	4,1	1,2	1,2
31,2	6,4	0,52	3962	1322	25,7	6,6	1,5	1,8	3,4	1,0	1,2
32,4	8,4	0,67	5649	1299	25,1	7,1	1,5	1,9	4,0	1,1	1,0
33,6	8,7	0,71	5642	1122	25,6	7,1	1,5	1,9	4,0	1,1	1,1
34,8	8,7	0,75	3156	1795	24,4	6,7	1,4	1,7	4,1	1,0	0,9
36	9,3	0,79	6258	1507	25,4	6,7	1,5	1,8	4,6	1,1	0,9
37,2	8,1	0,69	6067	1534	25,8	6,9	1,5	1,8	4,4	1,1	1,0
38,4	7,8	0,68	5552	1171	25,3	7,5	1,5	1,9	4,3	1,2	1,0
39,6	6,7	0,56	5652	1108	24,8	6,8	1,3	1,8	3,6	1,1	1,0
40,8	5,5	0,44	4900	1187	26,9	7,1	1,5	2,0	3,7	1,1	1,3
42	5,4	0,47	4462	1693	26,4	7,1	1,5	1,9	3,9	1,1	1,2
43,2	6,9	0,61	5784	1411	26,3	7,2	1,5	1,9	4,2	1,1	1,1

Table 44. Concentration of trace elements in sediment core sample collected in *La Zelata*

Thickness (cm)	**Cu** (mg/kg)	**Cr** (mg/kg)	**Hg** (mg/kg)	**Mn** (mg/kg)	**Ni** (mg/kg)	**Pb** (mg/kg)	**Ti** (mg/kg)	**Zn** (mg/kg)
0-1,2	57	143	0,15	430	69	57	3432	163
2,4	48	129	0,15	414	49	57	3034	154
3,6	57	150	0,17	444	65	63	3533	170
4,8	59	156	0,19	482	76	61	3638	178
6	54	158	0,28	488	69	73	3882	209
7,2	60	156	0,19	548	71	66	3601	188
8,4	60	153	0,19	531	67	62	3540	185
9,6	54	147	0,18	506	52	61	3213	172
10,8	60	147	0,16	515	70	58	3459	175
12	58	147	0,19	493	71	63	3724	192
13,2	54	134	0,17	461	66	58	3354	172
14,4	52	117	0,15	414	48	53	2931	152
15,6	49	130	0,14	430	68	55	3203	159
16,8	51	126	0,14	422	68	54	3101	154
18	53	129	0,16	442	65	59	3405	175
19,2	54	130	0, 19	448	68	63	3462	177
20,4	54	140	0,19	481	61	67	3649	189
21,6	39	141	0,21	459	31	64	3381	183
22,8	33	134	0,19	456	24	63	3174	181
24	57	142	0,19	477	63	64	3557	190
25,2	57	145	0,21	476	63	68	3692	201
26,4	55	145	0,21	481	66	71	3776	197
27,6	55	143	0,20	475	68	66	3726	197
28,8	70	153	0,22	501	71	70	3846	197
30	57	166	0,23	506	71	71	3811	197
31,2	53	136	0,17	469	51	64	3200	173
32,4	58	149	0,28	488	66	83	3661	222
33,6	61	150	0,25	479	68	89	3725	236
34,8	105	144	0,28	535	55	92	3387	232
36	52	147	0,23	510	62	86	3655	217
37,2	49	144	0,21	495	60	73	3638	199
38,4	54	158	0,23	486	70	74	3824	206
39,6	44	133	0,22	442	35	61	3159	196
40,8	48	135	0,15	461	72	58	3412	177
42	52	140	0,21	550	64	65	3503	220
43,2	64	143	0,25	513	67	67	3680	249

Table 45. Concentration of elements in sediment core sample collected in *San Massimo Gropello*

Thickness	C	N	S	P	Si	Al	Ca	K	Fe	Mg	Na
cm	%	%	(mg/kg)	(mg/kg)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
0-1,1	14,8	1,16	15353	1506	19,0	3,0	7,2	1,1	7,0	0,5	0,6
2,2	15,1	1,15	14460	1533	19,0	3,0	6,7	1,1	6,8	0,5	0,6
3,3	14,4	1,12	14862	1520	18,2	3,0	6,4	1,1	6,5	0,5	0,5
4,4	14,8	1,14	18026	1623	18,7	3,3	6,7	1,2	6,6	0,6	0,6
5,5	14,9	1,14	19868	1657	18,6	3,3	6,7	1,2	6,4	0,6	0,6
6,6	15,0	1,08	25432	1459	17,8	3,1	7,3	1,1	6,4	0,5	0,6
7,7	14,9	0,98	35684	1109	16,9	3,5	6,6	1,1	6,7	0,6	0,6
8,8	15,9	1,00	38415	899	17,4	3,4	6,0	1,2	6,6	0,6	0,7
9,9	16,2	0,94	41819	780	17,4	3,4	5,6	1,2	6,4	0,5	0,7
11	15,6	0,88	40357	693	19,1	3,5	5,3	1,2	5,8	0,5	0,8
12,1	14,7	0,86	40041	683	19,1	3,6	5,0	1,2	5,4	0,6	0,7
13,2	13,3	0,78	38630	678	19,6	4,2	4,7	1,4	5,2	0,7	0,8
14,3	15,9	0,90	47695	646	18,4	3,5	5,3	1,2	5,5	0,5	0,7
15,4	14,6	0,90	41358	670	21,3	3,6	4,6	1,1	4,6	0,5	0,9
16,5	14,3	0,92	26321	696	24,7	4,0	3,2	1,2	2,9	0,4	1,0
17,6	12,1	0,82	24572	789	23,2	4,6	3,3	1,3	2,7	0,6	1,0
18,7	19,2	1,17	34937	590	20,3	2,5	4,3	1,0	2,7	0,3	0,7
19,8	30,8	1,91	62515	609	9,2	1,5	4,7	0,6	4,6	0,3	0,3
20,9	36,4	2,25	65778	609	4,1	0,9	5,3	0,4	4,8	0,3	0,2
22	40,9	2,25	64905	574	1,3	0,4	5,3	0,2	4,6	0,3	0,1
23,1	41,8	2,43	66669	601	1,1	0,3	5,1	0,2	4,5	0,3	0,1
24,2	42,0	2,62	65160	619	0,3	0,2	5,5	0,1	4,4	0,3	0,1
25,3	42,2	2,71	55969	621	0,3	0,2	5,6	0,2	3,6	0,3	0,1
26,4	43,5	2,59	55160	592	0,3	0,1	5,7	0,1	3,5	0,3	0,1
27,5	43,4	2,48	56175	582	0,3	0,1	5,4	0,1	3,6	0,3	0,1
28,6	45,0	2,26	56984	548	0,3	0,1	5,2	0,1	3,6	0,2	0,1
29,7	45,2	2,18	54246	538	0,3	0,1	5,4	0,0	3,6	0,2	0,1
30,8	44,6	2,39	50388	553	0,3	0,1	5,4	0,1	3,3	0,3	0,1
31,9	44,7	2,28	49437	570	0,3	0,1	5,2	0,1	3,1	0,3	0,1
33	45,4	2,06	53983	535	0,3	0,1	5,1	0,1	3,4	0,2	0,1
34,1	45,3	1,96	55395	455	0,3	0,1	5,3	0,1	3,6	0,3	0,1
35,2	44,6	1,93	49680	466	0,3	0,4	5,1	0,1	3,1	0,3	0,1
36,3	44,1	1,92	55474	462	0,4	0,3	5,7	0,2	3,3	0,3	0,1
37,4	42,3	1,90	52369	474	1,0	0,4	5,5	0,2	3,3	0,3	0,1

Table 46. Concentration of trace elements in sediment core sample collected in *San Massimo Gropello*

Thickness (cm)	Cr (mg/kg)	Hg (mg/kg)	Mn (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Ti (mg/kg)	Zn (mg/kg)
1,1	79	0,11	682	n.d.	32	2360	90
2,2	79	0,11	689	n.d.	30	2133	87
3,3	77	0,11	623	n.d.	32	2207	90
4,4	80	0,12	611	n.d.	33	2353	94
5,5	81	0,12	603	n.d.	35	2370	96
6,6	79	0,11	571	n.d.	31	2223	91
7,7	82	0,13	581	n.d.	33	2303	90
8,8	79	0,12	577	n.d.	35	2283	90
9,9	76	0,11	558	n.d.	33	2246	89
11	73	0,10	513	16	33	2116	88
12,1	79	0,10	512	17	34	2111	88
13,2	77	0,09	498	24	36	2285	90
14,3	73	0,10	504	16	37	1910	91
15,4	67	0,09	397	28	37	1900	76
16,5	71	0,08	304	54	44	1863	58
17,6	78	0,07	278	54	32	1999	58
18,7	58	0,04	261	47	24	1096	48
19,8	45	0,12	269	35	30	791	43
20,9	38	0,05	279	39	21	559	40
22	27	0,05	271	52	15	292	35
23,1	28	0,05	246	52	16	234	31
24,2	21	0,04	254	59	13	224	25
25,3	25	0,04	271	71	13	192	48
26,4	20	0,03	268	77	13	115	26
27,5	22	0,03	260	74	17	111	42
28,6	18	0,03	240	76	14	41	21
29,7	17	0,04	245	84	17	17	20
30,8	20	0,04	258	74	15	64	23
31,9	21	0,03	251	87	19	54	23
33	18	0,03	245	85	17	47	22
34,1	18	0,03,	258	78	20	89	19
35,2	22	0,04	258	84	15	117	25
36,3	25	0,04	282	77	18	189	21
37,4	28	0,04	292	75	19	314	27

Table 47. PCDD/Fs in layers of sediment core sample collected in *La Zelata*

sediment layers	1, 2, 3, 4	5, 6, 7, 8, 9	10, 11, 12, 13	14, 15, 16, 17
Congeneri analyzed	pg/g	pg/g	pg/g	pg/g
2,3,7,8-TCDD:	0,13	0,051	0,029	0,20
1,2,3,7,8-PeCDD:	0,40	0,27	0,32	1,6
1,2,3,4,7,8-HxCDD:	0,44	0,30	0,70	2,8
1,2,3,6,7,8-HxCDD:	0,83	0,67	1,4	5,5
1,2,3,7,8,9-HxCDD:	0,76	0,55	1,0	3,6
1,2,3,4,6,7,8-HpCDD:	7,9	5,4	8,3	29
OCDD:	36	23	9,9	34
2,3,7,8-TCDF:	2,8	2,2	0,46	2,2
1,2,3,7,8-PeCDF:	1,7	1,4	0,80	5,0
2,3,4,7,8-PeCDF:	2,6	1,9	2,2	11
1,2,3,4,7,8-HxCDF:	2,1	1,6	2,5	9,9
1,2,3,6,7,8-HxCDF:	1,8	1,3	2,8	12
2,3,4,6,7,8-HxCDF:	2,2	1,6	5,5	20
1,2,3,7,8,9-HxCDF:	0,61	0,49	2,1	7,5
1,2,3,4,6,7,8-HpCDF:	9,5	6,9	13	39
1,2,3,4,7,8,9-HpCDF:	0,79	0,70	2,7	8,8
OCDF:	15	9,9	9,3	28
I-TEQ	3,1	2,3	3,2	14
WHO-TEQ	3,3	2,4	3,4	14

Table 48. PCDD/Fs in layers of sediment core sample collected in *San Massimo Groppello*

sediment layers	1, 2, 3, 4	5, 6, 7, 8, 9	10, 11, 12, 13	14, 15, 16, 17
Congeneri analyzed	pg/g	pg/g	pg/g	pg/g
2,3,7,8-TCDD:	0,20	0,18	0,15	0,18
1,2,3,7,8-PeCDD:	0,75	0,67	0,38	0,59
1,2,3,4,7,8-HxCDD:	0,66	0,68	0,82	0,81
1,2,3,6,7,8-HxCDD:	1,6	1,6	2,0	2,0
1,2,3,7,8,9-HxCDD:	1,2	1,2	1,2	1,2
1,2,3,4,6,7,8-HpCDD:	18	20	23	23
OCDD:	106	123	137	140
2,3,7,8-TCDF:	3,5	4,2	5,1	4,0
1,2,3,7,8-PeCDF:	2,0	1,8	3,1	2,1
2,3,4,7,8-PeCDF:	3,0	3,3	3,3	3,7
1,2,3,4,7,8-HxCDF:	2,9	3,1	3,5	3,6
1,2,3,6,7,8-HxCDF:	2,4	2,8	3,2	3,4
2,3,4,6,7,8-HxCDF:	3,4	3,3	3,8	3,5
1,2,3,7,8,9-HxCDF:	0,94	0,93	1,00	1,1
1,2,3,4,6,7,8-HpCDF:	16	16	16	16
1,2,3,4,7,8,9-HpCDF:	1,5	1,6	1,8	1,5
OCDF:	30	26	25	26
I-TEQ	4,3	4,5	4,8	5,0
WHO-TEQ	4,6	4,7	4,8	5,1

Table 49. Parameters used to calculate Sanitary risk

Substance	Max conc. found	Daily quantity taken (1)	A.D.I. (2)
Cadmio	1.06 mg/kg	0.098 µg/kg p.c./sett. (3)	7 µg/kg p.c./sett. (3)
Mercurio	0.34 mg/kg	0.03 µg/kg p.c./sett. (3)	5 µg/kg p.c./sett. (3)
Piombo	46 mg/kg	4.2 µg/kg p.c./sett. (3)	25 µg/kg p.c./sett. (3)
Zinco	131 mg/kg	1.7 µg/kg p.c./giorno	103 µg/kg p.c./giorno
Rame	57.50 mg/kg	0.75 µg/kg p.c./giorno	500 µg/kg p.c./giorno
Nichel	176 mg/kg	2.3 µg/kg p.c./giorno	5 µg/kg p.c./giorno
Diossine e Furani	11 ng/kg	0.143 pg/kg p.c./giorno (4)	2 pg/kg p.c./giorno (4)

(1) : Viene riportata la concentrazione assunta giornalmente o settimanalmente da un bambino di 6 anni di 15 kg di peso corporeo.
(2) : Valori di A.D.I. riportati dalla JECFA; aggiornamento novembre 2004.
(3) : In questo caso si è riportata la dose settimanale tollerabile, che viene usata per i contaminanti che bioaccumulano.
(4) : Si fa riferimento al composto più tossico, e cioè la 2, 3, 7, 8 TCDD.

Appendix A

Terrestrial coordinates of the 7 SPUs (AM1) identified in the province of Pavia through LUCAS

Point	Longitude	Latitude
SPU 1	1.477.552	5.001.930
SPU 2	1.495.552	5.001.929
SPU 3	1.513.553	5.001.930
SPU 4	1.531.553	5.001.930
SPU 5	1.495.552	4.983.930
SPU 6	1.513.552	4.983.929
SPU 7	1.513.552	4.965.930

Terrestrial coordinates (Gaussboaga projection, Monte Mario) of the 34 AM2 points identified in the province of Pavia through submultiples of the LUCAS network (inter-node distance of 9 km)

AM2	Longitude	Latitude	AM2	Longitude	Latitude
1SP	1.468.552	5.019.930	18SP	1.486.552	4.992.930
2SP	1.477.552	5.019.930	19SP	1.495.552	4.992.930
3SP	1.486.552	5.019.930	20SP	1.504.552	4.992.930
4SP	1.522.553	5.019.930	21SP	1.513.552	4.992.930
5SP	1.468.552	5.010.930	22SP	1.522.553	4.992.930
6SP	1.477.552	5.010.930	23SP	1.531.553	4.992.930
7SP	1.486.552	5.010.930	24SP	1.540.553	4.992.930
8SP	1.495.552	5.010.930	25SP	1.504.552	4.983.930
9SP	1.504.552	5.010.930	26SP	1.522.553	4.983.930
10SP	1.513.552	5.010.930	27SP	1.504.552	4.974.930
11SP	1.522.553	5.010.930	28SP	1.513.552	4.974.930
12SP	1.468.552	5.001.930	29SP	1.522.553	4.974.930
13SP	1.486.552	5.001.930	30SP	1.504.552	4.965.930
14SP	1.504.552	5.001.930	31SP	1.522.553	4.965.930
15SP	1.522.553	5.001.930	32SP	1.513.552	4.956.930
16SP	1.540.553	5.001.930	33SP	1.522.553	4.956.930
17SP	1.477.552	4.992.930	34SP	1.522.553	4.947.930

Terrestrial coordinates (Gaussboaga projection, Monte Mario) of the 116 sampling points concerning action AM3.

Terrestrial coordinates concerning the area of Pieve Porto Morone (AM3)

Point	Longitude	Latitude	Point	Longitude	Latitude
piev11	1533053	4997430	piev23	1536053	4995930
piev12	1534553	4997430	piev31	1533053	4994430
piev13	1536053	4997430	piev32	1534553	4994430
piev21	1533053	4995930	piev33	1536053	4994430
piev22	1534553	4995930			

Terrestrial coordinates concerning the area of Giussago (AM3)

Point	Longitude	Latitude	Point	Longitude	Latitude
gius11	1510552	5016930	gius31	1510552	5013930
gius12	1512052	5016930	gius33	1513552	5013930

Terrestrial coordinates concerning the area of Corteolona (AM3)

Point	Longitude	Latitude	Point	Longitude	Latitude
cor11	1525552	5004930	cor34	1530053	5001930
cor13	1528552	5004930	cor35	1531553	5001930
cor15	1531552	5004930	cor41	1525553	5000430
cor22	1527053	5003430	cor42	1527053	5000430
cor23	1528553	5003430	cor43	1528553	5000430
cor24	1530053	5003430	cor44	1530053	5000430
cor25	1531553	5003430	cor45	1531553	5000430
cor31	1525553	5001930	cor51	1525553	4998930
cor32	1527053	5001930	cor53	1528553	4998930
cor33	1528553	5001930	cor55	1531553	4998930

Terrestrial coordinates concerning the area of Voghera (AM3)

Point	Longitude	Latitude	Point	Longitude	Latitude
vog11	1495552	4989930	vog34	1500052	4986930
vog12	1497052	4989930	vog35	1501552	4986930
vog13	1498552	4989930	vog41	1495552	4985430
vog14	1500052	4989930	vog42	1497052	4985430
vog15	1501552	4989930	vog43	1498552	4985430
vog21	1495552	4988430	vog44	1500052	4985430
vog22	1497052	4988430	vog45	1501552	4985430
vog23	1498552	4988430	vog51	1495552	4983930
vog24	1500052	4988430	vog52	1497052	4983930
vog25	1501552	4988430	vog53	1498552	4983930
vog31	1495552	4986930	vog54	1500052	4983930
vog32	1497052	4986930	vog55	1501552	4983930
vog33	1498552	4986930			

Terrestrial coordinates concerning the area of Sannazaro dei Burgondi (AM3)

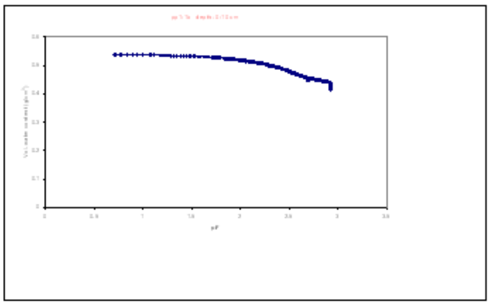
Point	Longitude	Latitude	Point	Longitude	Latitude
san11	1486552	4998930	san45	1492552	4994430
san13	1489552	4998930	san46	1494052	4994430
san15	1492552	4998930	18SP	1486552	4992930
san17	1495552	4998930	san52	1488052	4992930
san22	1488052	4997430	san53	1489552	4992930
san23	1489552	4997430	san54	1491052	4992930
san24	1491052	4997430	san55	1492552	4992930
san25	1492552	4997430	san56	1494052	4992930
san26	1494052	4997430	19SP	1495552	4992930
san31	1486552	4995930	san62	1488052	4991430
san32	1488052	4995930	san63	1489552	4991430
san33	1489552	4995930	san64	1491052	4991430
san34	1491052	4995930	san65	1492552	4991430
san35	1492552	4995930	san66	1494052	4991430
san36	1494052	4995930	san71	1486552	4989930
san37	1495552	4995930	san73	1489552	4989930
san42	1488052	4994430	san74	1491052	4989930
san43	1489552	4994430	san75	1492552	4989930
san44	1491052	4994430	san77	1495552	4989930

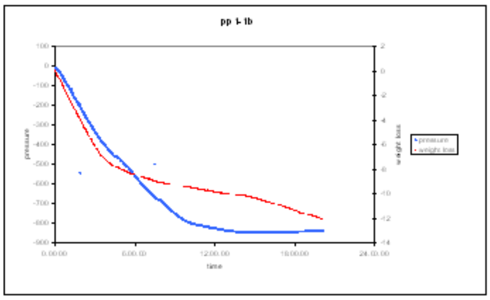
Terrestrial coordinates concerning the area of Parona (AM3)

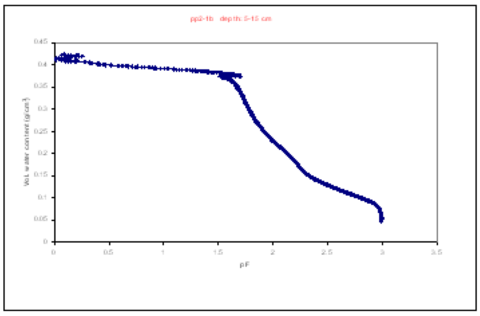
Point	Longitude	Latitude	Point	Longitude	Latitude
par11	1480552	5018430	par34	1485052	5015430
par12	1482052	5018430	par35	1486552	5015430
par13	1483552	5018430	par41	1480552	5013930
par14	1485052	5018430	par42	1482052	5013930
par15	1486552	5018430	par43	1483552	5013930
par21	1480552	5016930	par44	1485052	5013930
par22	1482052	5016930	par45	1486552	5013930
par23	1483552	5016930	par51	1480552	5012430
par24	1485052	5016930	par52	1482052	5012430
par25	1486552	5016930	par53	1483552	5012430
par31	1480552	5015430	par54	1485052	5012430
par32	1482052	5015430	par55	1486552	5012430
par33	1483552	5015430			

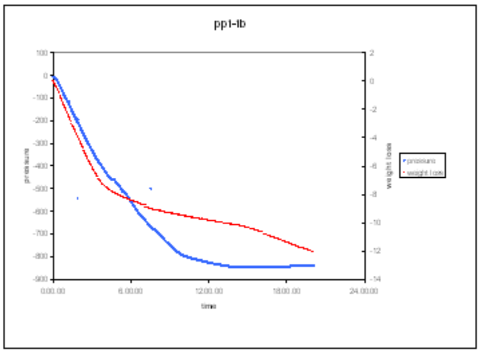
Appendix B

As an example we report the water retention curves and the values concerning Primary Points 1 and 2. PP1 is characterised by an intermediate texture (Loam, Silt-loam).
PP2 is prevalently Sand.



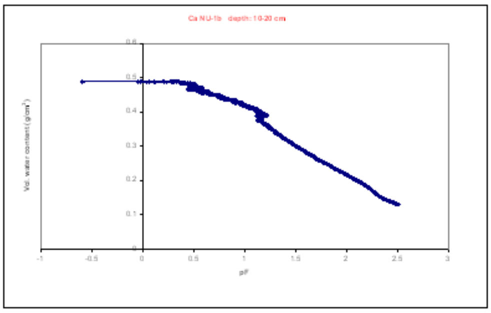


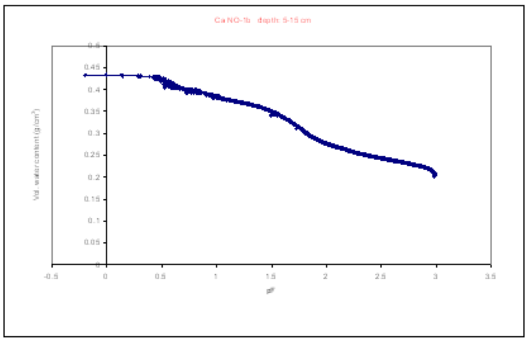


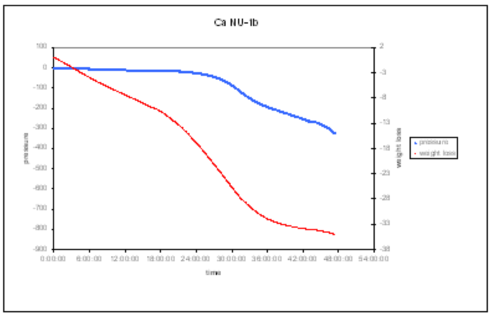


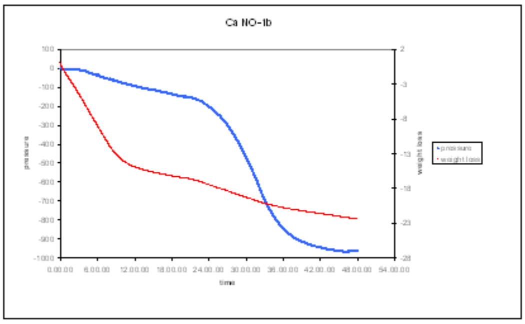
	PP1	PP2
Horizon	1	1
Bulk density (g/cm^3)	1.40	1.61
Saturation water content (g/cm^3)	0.54	0.42
Porosity	0.47	0.39

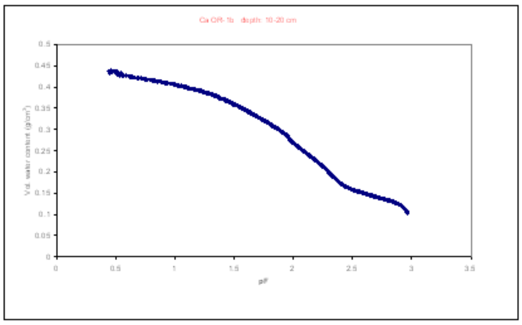
As an example we report the water retention curves and the values concerning the three SAMA areas.
The first horizon of Cascina Orsine, Cascina Nuova and Cascina Novella is characterised by a coarse texture (Sandy-loam to Loam).

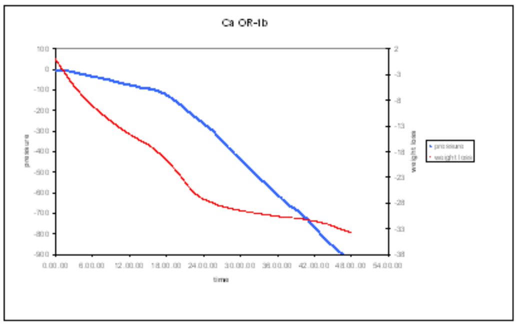












	C. Orsine	C. Nuova	C. Novella
Horizon	1	1	1
Bulk density (g/cm^3)	1.28	1.27	1.52
Saturation water content (g/cm^3)	0.45	0.49	0.43
Porosity	0.52	0.52	0.42

Appendix C

Concentration levels (pg/g) of the dioxin and furan congeners for the 7 Primary Points

	PP1	PP1	PP2	PP2	PP3	PP3	PP4	PP4	PP5	PP5	PP6	PP6	PP7	PP7
	superf	prof	superf	prof	superf	prof	superf	prof	superf	prof	superf	prof	superf	prof
PCDD/Fs	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g
2,3,7,8-TCDD	0,32		0,046	0,014	<0.0292	<0.00426	0,042	<0.015	0,058	0,061	<0.0307	<0.00793	0,079	0,064
1,2,3,7,8-PeCDD	<0.0911		0,11	0,019	0,18	<0.00951	0,19	<0.018	0,12	0,22	0,094	0,035	0,15	0,062
1,2,3,4,7,8-HxDD	0,29		0,19	<0.0165	0,17	<0.0194	0,20	<0.015	0,15	0,073	0,18	0,10	0,12	0,10
1,2,3,6,7,8-HxDD	0,40		0,46	<0.0274	0,32	<0.0171	0,31	<0.025	0,31	0,17	0,21	0,079	0,25	0,19
1,2,3,7,8,9-HxDD:	0,37		0,32	<0.0164	0,31	<0.0217	0,27	0,023	0,42	0,37	0,96	0,51	0,46	0,45
1,2,3,4,6,7,8-HpDD	6,8		6,3	0,39	3,0	0,30	3,4	0,40	2,8	1,0	6,5	5,0	2,9	2,8
OCDD	44		38	2,3	16	1,5	18	7,3	18	5,5	90	62	30	15
2,3,7,8-TCDF	1,5		0,70	0,076	0,44	0,048	0,62	0,045	0,56	0,052	0,41	0,076	0,11	<0.021
1,2,3,7,8-PeCDF	0,64		0,54	0,041	0,40	0,046	0,50	0,043	0,43	0,046	0,23	0,069	0,11	<0.00781
2,3,4,7,8-PeCDF	0,83		0,74	0,057	0,61	0,062	0,75	0,055	0,56	0,046	0,28	0,054	0,16	<0.020
1,2,3,4,7,8-HxDF	0,99		1,1	0,067	0,87	0,074	0,83	0,093	0,71	0,066	0,36	0,12	0,24	<0.021
1,2,3,6,7,8-HxDF	0,86		0,69	0,058	0,62	0,059	0,62	0,040	0,51	0,046	0,26	0,087	0,18	0,012
2,3,4,6,7,8-HxDF	0,97		0,91	0,073	0,76	0,073	0,52	0,055	0,55	0,053	0,32	0,090	0,23	0,034
1,2,3,7,8,9-HxDF	<0.274		0,24	<0.0192	0,22	<0.0208	0,19	0,027	0,19	<0.012	0,074	<0.0269	0,048	<0.0088
1,2,3,4,6,7,8-HpDF	5,1		5,7	0,34	4,6	0,39	4,0	0,37	2,8	0,27	1,9	0,76	1,6	0,19
1,2,3,4,7,8,9-HpDF	0,64		0,54	0,044	0,51	0,066	0,44	0,060	0,38	0,041	0,20	0,080	0,14	0,0110
OCDF	9,4		11	0,53	7,9	0,91	8,2	1,3	7,2	0,64	3,0	1,2	7,7	0,39
I-TEQ	1,6		1,1	0,10	0,92	0,086	1,00	0,10	0,85	0,30	0,69	0,29	0,48	0,20
WHO-TEQ	1,6		1,1	0,11	0,99	0,088	1,1	0,11	0,89	0,41	0,65	0,25	0,52	0,22

Concentration levels (pg/g) of the dioxin and furan congeners for the 9 groups relative to the 34 Secondary Points

PCDD/Fs	PS-2A	PS-2B	PS-2C	PS-2D	PS-2E	PS-2F	PS-2G	PS-2H	PS-2I
	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g
2,3,7,8-TCDD	0,17	<0.0669	0,084	0,28	0,059	0,12	0,046	<0.115	<0.0359
1,2,3,7,8-PeCDD	0,14	0,100	0,14	0,83	0,17	0,25	0,063	0,38	0,090
1,2,3,4,7,8-HxDD	0,20	0,14	0,18	1,2	0,26	0,35	0,083	0,27	0,14
1,2,3,6,7,8-HxDD	0,48	0,58	0,38	2,4	0,48	0,39	0,20	0,38	0,17
1,2,3,7,8,9-HxDD:	0,29	0,40	0,36	1,8	0,47	0,83	0,17	0,63	0,18
1,2,3,4,6,7,8-HpDD	6,2	9,0	4,9	31	7,9	4,6	1,8	3,7	2,6
OCDD	42	84	39	207	71	31	9,7	22	22
2,3,7,8-TCDF	0,94	0,68	0,72	14	0,57	0,30	0,38	0,40	0,22
1,2,3,7,8-PeCDF	0,53	0,39	0,48	7,8	0,47	0,22	0,29	0,16	0,22
2,3,4,7,8-PeCDF	0,77	0,64	0,66	7,0	0,69	0,27	0,23	0,37	0,26
1,2,3,4,7,8-HxDF	1,0	0,78	0,89	13	1,1	0,45	0,56	0,66	0,44
1,2,3,6,7,8-HxDF	0,77	0,57	0,58	7,5	0,74	0,33	0,44	0,60	0,32
2,3,4,6,7,8-HxDF	1,1	0,98	0,82	6,7	0,88	0,39	0,50	0,51	0,33
1,2,3,7,8,9-HxDF	0,26	0,20	0,23	3,2	0,24	<0.0935	0,100	<0.123	0,14
1,2,3,4,6,7,8-HpDF	9,4	15	6,7	50	7,8	2,0	2,9	3,2	2,5
1,2,3,4,7,8,9-HpDF	0,56	0,55	0,50	7,1	0,65	0,24	0,36	0,41	0,38
OCDF	28	94	21	142	25	5,9	6,4	8,4	9,9
I-TEQ	1,4	1,3	1,1	11	1,3	0,81	0,52	0,96	0,50
WHO-TEQ	1,4	1,2	1,1	11	1,2	0,90	0,53	1,1	0,52

Concentration levels (pg/g) of the dioxin and furan congeners for each of the Tertiary Points

Corteolona	COR-A	COR-B	COR-C
PCDD/Fs	pg/g	pg/g	pg/g
2,3,7,8-TCDD	<0.147	<0.0869	0,081
1,2,3,7,8-PeCDD	<0.11	0,14	0,15
1,2,3,4,7,8-HxDD	<0.145	0,27	0,17
1,2,3,6,7,8-HxDD	0,44	1,1	0,30
1,2,3,7,8,9-HxDD	0,41	0,64	0,27
1,2,3,4,6,7,8-HpDD	8,6	34	5,6
OCDD	62	539	49
2,3,7,8-TCDF	1,4	0,84	0,76
1,2,3,7,8-PeCDF	0,57	0,49	0,45
2,3,4,7,8-PeCDF	0,68	0,71	0,69
1,2,3,4,7,8-HxDF	1,1	0,86	0,74
1,2,3,6,7,8-HxDF	0,53	0,59	0,66
2,3,4,6,7,8-HxDF	0,95	1,2	0,78
1,2,3,7,8,9-HxDF	0,35	0,25	0,27
1,2,3,4,6,7,8-HpDF	5,2	10	5,8
1,2,3,4,7,8,9-HpDF	0,57	0,68	0,59
OCDF	12	31	17
I-TEQ	1,3	2,1	1,1
WHO-TEQ	1,3	1,7	1,1

Giussago, Pieve Porto M. PCDD/Fs	GIUS-A pg/g	PIEV-A pg/g	PIEV-B pg/g
2,3,7,8-TCDD	0,046	0,10	<0.0656
1,2,3,7,8-PeCDD	0,15	0,11	0,11
1,2,3,4,7,8-HxDD	0,19	0,36	0,21
1,2,3,6,7,8-HxDD	0,37	1,3	0,43
1,2,3,7,8,9-HxDD	0,30	0,82	0,52
1,2,3,4,6,7,8-HpDD	3,9	20	6,1
OCDD	21	154	97
2,3,7,8-TCDF	1,0	1,4	0,59
1,2,3,7,8-PeCDF	0,65	0,66	0,44
2,3,4,7,8-PeCDF	0,80	0,75	0,67
1,2,3,4,7,8-HxDF	1,2	1,3	1,1
1,2,3,6,7,8-HxDF	0,82	0,73	0,65
2,3,4,6,7,8-HxDF	0,99	1,2	0,76
1,2,3,7,8,9-HxDF	0,34	0,37	0,29
1,2,3,4,6,7,8-HpDF	5,7	7,4	5,7
1,2,3,4,7,8,9-HpDF	0,62	0,75	0,54
OCDF	11	19	24
I-TEQ	1,2	1,8	1,2
WHO-TEQ	1,3	1,7	1,1

Voghera PCDD/Fs	VOG-A pg/g	VOG-B pg/g	VOG-C pg/g	VOG-D pg/g
2,3,7,8-TCDD	0,058	0,080	<0.0855	0,057
1,2,3,7,8-PeCDD	0,18	0,22	0,13	0,17
1,2,3,4,7,8-HxDD	<0.142	0,16	<0.0841	0,15
1,2,3,6,7,8-HxDD	0,28	0,27	0,25	0,25
1,2,3,7,8,9-HxDD	0,42	0,42	0,31	0,31
1,2,3,4,6,7,8-HpDD	3,4	2,5	2,5	2,6
OCDD	36	25	25	36
2,3,7,8-TCDF	0,38	0,35	0,42	0,45
1,2,3,7,8-PeCDF	0,32	0,31	0,30	0,34
2,3,4,7,8-PeCDF	0,43	0,44	0,37	0,46
1,2,3,4,7,8-HxDF	0,60	0,64	0,70	0,67
1,2,3,6,7,8-HxDF	0,39	0,40	0,52	0,46
2,3,4,6,7,8-HxDF	0,47	0,48	0,58	0,53
1,2,3,7,8,9-HxDF	0,16	0,17	0,18	0,16
1,2,3,4,6,7,8-HpDF	2,7	2,8	2,8	3,0
1,2,3,4,7,8,9-HpDF	0,32	0,40	0,42	0,37
OCDF	10	12	13	16
I-TEQ	0,77	0,81	0,75	0,80
WHO-TEQ	0,82	0,88	0,78	0,84

Sannazaro dei Burgondi PCDD/Fs	SAN A pg/g	SAN B pg/g	SAN C pg/g	SAN D pg/g	SAN E pg/g
2,3,7,8-TCDD	0,074	0,064	0,23	0,059	0,050
1,2,3,7,8-PeCDD	0,11	0,11	<0.0758	0,15	0,13
1,2,3,4,7,8-HxDD	<0.112	0,18	0,092	0,17	0,15
1,2,3,6,7,8-HxDD	0,25	0,48	0,21	0,37	0,32
1,2,3,7,8,9-HxDD	0,20	0,35	0,17	0,38	0,35
1,2,3,4,6,7,8-HpDD	2,9	8,0	2,2	4,4	4,8
OCDD	15	65	14	29	41
2,3,7,8-TCDF	1,1	0,69	0,41	0,71	0,52
1,2,3,7,8-PeCDF	0,39	0,47	0,28	0,53	0,39
2,3,4,7,8-PeCDF	0,50	0,67	0,41	0,65	0,54
1,2,3,4,7,8-HxDF	0,67	0,91	0,53	0,92	0,72
1,2,3,6,7,8-HxDF	0,51	0,69	0,42	0,63	0,56
2,3,4,6,7,8-HxDF	0,60	1,00	0,47	0,82	0,67
1,2,3,7,8,9-HxDF	0,18	0,24	0,14	0,21	0,17
1,2,3,4,6,7,8-HpDF	3,4	8,7	3,0	4,7	4,7
1,2,3,4,7,8,9-HpDF	0,33	0,52	0,29	0,42	0,35
OCDF	6,0	22	6,2	9,7	14
I-TEQ	0,85	1,2	0,81	1,0	0,90
WHO-TEQ	0,88	1,2	0,83	1,1	0,91

Parona PCDD/Fs	PAR-A	PAR-B	PAR-C	PAR-D
2,3,7,8-TCDD	0,15	0,092	0,054	0,30
1,2,3,7,8-PeCDD	0,32	0,21	0,17	0,15
1,2,3,4,7,8-HxDD	0,42	0,22	0,22	<0.13
1,2,3,6,7,8-HxDD	2,6	0,57	0,52	0,56
1,2,3,7,8,9-HxDD	2,0	0,41	0,26	0,34
1,2,3,4,6,7,8-HpDD	133	7,5	5,4	8,7
OCDD	794	52	37	65
2,3,7,8-TCDF	1,6	1,1	1,4	1,1
1,2,3,7,8-PeCDF	1,3	0,61	0,75	0,69
2,3,4,7,8-PeCDF	1,6	0,78	1,0	0,93
1,2,3,4,7,8-HxDF	2,5	1,2	1,2	1,3
1,2,3,6,7,8-HxDF	2,2	0,77	0,73	0,84
2,3,4,6,7,8-HxDF	4,7	0,98	1,2	1,5
1,2,3,7,8,9-HxDF	0,52	0,33	0,39	0,35
1,2,3,4,6,7,8-HpDF	18	6,7	9,4	12
1,2,3,4,7,8,9-HpDF	1,2	0,60	0,60	0,71
OCDF	46	20	31	37
I-TEQ	5,2	1,4	1,5	1,8
WHO-TEQ	4,6	1,4	1,5	1,8

Appendix D

Concentration levels (pg/g) of the dioxin and furan congeners in the three areas (biological, manure and sludge amended areas)

PCDD/Fs	C. Orsine 0-5	C. Orsine 0-15	C. Orsine 15-30	C. Nuova 0-5	C. Nuova 0-15	C. Nuova 0-30	C. Novellla 0-5	C. Novellla 0-15	C. Novellla 0-30
	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g
2,3,7,8-TCDD	<0.0292	0,024	<0.0223	0,030	0,0044	<0.00344	0,049	0,051	0,047
1,2,3,7,8-PeCDD	<0.0266	0,033	0,067	0,081	0,031	0,017	0,12	0,16	0,15
1,2,3,4,7,8-HxDD	0,14	0,11	0,12	0,096	0,063	0,059	0,19	0,16	0,19
1,2,3,6,7,8-HxDD	0,31	0,30	0,30	0,15	0,14	0,089	1,2	1,3	1,5
1,2,3,7,8,9-HxDD	0,24	0,21	0,22	0,13	0,11	0,063	0,60	0,67	0,74
1,2,3,4,6,7,8-HpDD	4,7	4,4	4,7	1,9	1,5	0,99	22	24	26
OCDD	26	25	25	8,7	7,4	4,6	311	346	382
2,3,7,8-TCDF	0,36	0,36	0,35	0,19	0,23	0,17	0,65	0,67	0,68
1,2,3,7,8-PeCDF	0,41	0,34	0,42	0,23	0,19	0,13	0,42	0,44	0,53
2,3,4,7,8-PeCDF	0,54	0,49	0,54	0,27	0,22	0,17	0,60	0,67	0,71
1,2,3,4,7,8-HxDF	0,75	0,74	0,79	0,46	0,42	0,26	0,91	0,94	1,00
1,2,3,6,7,8-HxDF	0,45	0,49	0,45	0,34	0,25	0,15	0,61	0,66	0,66
2,3,4,6,7,8-HxDF	0,64	0,68	0,70	0,34	0,32	0,22	1,5	1,5	1,6
1,2,3,7,8,9-HxDF	0,22	0,22	0,22	0,13	0,11	0,063	0,27	0,27	0,27
1,2,3,4,6,7,8-HpDF	4,2	4,5	4,6	3,2	2,5	1,7	11	12	12
1,2,3,4,7,8,9-HpDF	0,43	0,42	0,44	0,25	0,24	0,17	0,64	0,67	0,68
OCDF	8,0	8,1	8,4	5,4	4,9	3,3	33	36	33
I-TEQ	0,77	0,74	0,79	0,47	0,36	0,25	1,7	1,8	2,0
WHO-TEQ	0,75	0,73	0,80	0,50	0,36	0,25	1,4	1,6	1,7

Appendix E

Chart. PROFILE 1 (1PP/11)

Description of the station

Locality	Valle Lomellina (PV), Locality C.na Macedonio
Surveyor and date	ERSAF, 01/03/05
Soil use	rice
Height and slope	98 m on the sea level; 0 %
Stone on surface	absent
Substrate	non calcareous fluvial sediments with prevalently sandy-loamy granulometry
Layer	160 cm
Geographic area	Lomellina
Landscape	Fluvial terraces with slow drainage
USDA classification (2003)	fine silty, mixed (non acid), superactive, mesic Fluvaquentic Epiaquept
WRB classification (1998)	Humi-Anthraquic Gleysols (Endoeutric)
Related STU	**187 - Hyperdystri-Umbrihumic Cambisols**

Description of the horizons

Ap 0-30 cm, humid, brown (principally 7.5YR4/4, secondly 7.5YR5/2), common medium variegations of strong brown colour (7.5YR5/6) with clear limit, Loam, slightly developed big polyhedral subangular fragments, common very thin roots, non calcareous, linear abrupt lower limit.

Apg 30-50 cm, very humid, dark greenish grey (5G4/1), common variegations of strong brown colour (7.5YR5/6) with clear limit, Clay-loam, massive, common non cemented extremely small concentrations of Fe-Mn, absence of macro-pores, few and very thin roots, non calcareous, linear abrupt lower limit.

Bw 50-95 cm, very humid, principally yellowish brown (10YR5/8), secondly light brownish grey (10YR6/2), small and abundant variegations of strong brown colour (7.5YR5/6) with clear limit, Silt-loam, massive, few fine macro-pores, common cutans not defined along the pores, common thin and very thin roots, non calcareous, wavy abrupt lower limit.

Cg 95-160 cm and beyond, very humid, dark greenish grey (5G4/1), Silt-loam, massive, non calcareous, few and very fine macro-pores, absence of roots, lower limit unknown.

Physico-chemical determinations

Horizons	Texture (%)								PH		Total $CaCO_3$	SO	CO	exchange complex (meq/100g)						TSB
	Sg	Sf	Smf	Stot	Lg	Lf	Ltot	A	(H_2O)	(KCl)	%	%	%	CSC	Ca	Mg	K	Na	Ac compl	%
Ap	11	15	19	45	12	22	34	21	5.3	4.5	0.0	2.5	1.5	25.1	10.6	1.2	0.5	0.1	12.75	49.2
Apg	3	6	12	21	18	25	43	36	5.8	5.1	0.0	1.6	0.9	37.5	18.6	2.4	0.2	0.2	16.06	57.2
Bw	0	1	8	9	22	44	66	25	6.6	5.4	0.0	0.5	0.3	42.4	24.7	3.5	0.2	0.2	13.81	67.4
Cg	2	16	24	42	37	19	56	2	5.7	4.4	0.0	0.3	0.2	8.8	4.5	0.7	0.1	0.1	3.44	60.8

Chart. PROFILE 2 (2PP/11)

Description of the station

Locality	Garlasco (PV), Locality C.na San Giuliano
Surveyor and date	ERSAF, 01/03/05
Soil use	rice
Height and slope	90 m on the sea level; 0 %
Surface stoniness	absent
Substrate	non calcareous fluvial sediments with prevalently sandy-loamy granulometry
Geographic area	Lomellina
Landscape	Stable and plain surfaces of the low sandy plain
Class. USDA (2003)	coarse loamy, mixed, superactive, mesic Aquic Arenic Haplustalf
WRB classification (1998)	Areni-Epigleyic Luvisols (Profondic, Epidystric)
Related STU	**85 - Orthidystric Luvisols**

Description of the horizons

Ap 0-30 cm, humid, brown (10YR5/3), Loamy-sand scarcely gravelly, moderately developed big polyhedral subangular fragments, few medium roots, non calcareous, linear abrupt lower limit.

Apg 30-45 cm, humid, dark greyish brown (10YR4/2), common very small variegations of yellowish brown colour (10YR5/8) with clear limit, Loamy-sand scarcely gravelly, massive, common non cemented small concentrations ofFe-Mn, absence of macro-pores, absence of roots, non calcareous, irregular abrupt lower limit.

BE 45-65 cm, humid, yellowish brown (10YR5/6), Loamy-sand, very developed big polyhedral subangular aggregation, low non cemented small concentrations of Fe-Mn, absence of roots, non calcareous, irregular abrupt lower limit.

Bt1 65-140 cm, humid, yellowish brown (10YR5/8), Sandy-loam, not very developed big polyhedral subangular aggregation (nearly loose), several non cemented average concentrations of Fe-Mn, absence of roots, non calcareous, irregular abrupt lower limit.

Bt2 140-160 cm, humid, principally strong brown (7.5YR4/6), secondly yellowish brown (10YR5/8), Sandy-loam, very developed medium polyhedral subangular aggregation, few argillans, several non cemented medium concentrations of Fe-Mn, absence of roots, non calcareous, wavy abrupt lower limit

BE’ 160-180 cm, humid, principally brownish yellow (10YR6/8), secondly yellowish brown (10YR5/8), loose sand, low non cemented small concentrations of Fe-Mn, absence of roots, non calcareous, linear abrupt lower limit.

B’t 180-190 cm, humid, principally strong brown (7.5YR4/6), secondly yellowish brown (10YR5/8), Sandy-loam, very developed medium polyhedral subangular aggregation, few argillans, absence of roots, non calcareous, linear abrupt lower limit

Bw 190-210 cm and beyond, humid, yellowish brown (10YR5/8), Loamy-sand (very fine sand), massive, low non cemented small concentrations of Fe-Mn, absence of roots, non calcareous, lower limit unknown.

Physico-chemical determinations

Horizons	Texture (%)								PH		Total $CaCO_3$	SO	CO	exchange complex (meq/100g)						TSB
	Sg	Sf	Smf	Stot	Lg	Lf	Ltot	A	(H_2O)	(KCl)	%	%	%	CSC	Ca	Mg	K	Na	Ac compl	%
Ap	26	24	28	78	10	11	21	1	5.8	5	0	1.7	1	7	2	0.2	0.1	0.1	4.69	32.8
Apg	30	38	16	84	7	8	15	1	6.3	5.5	0	0.5	0.3	5.6	1.6	0.1	0.1	0.1	3.81	32.2
BE	21	33	20	74	11	13	24	2	6.7	5.4	0	0.3	0.2	5.7	1.7	0.2	0.1	0	3.69	35.4
Bt1	10	36	21	67	12	14	26	7	6.6	5.2	0	0.2	0.1	6.3	2	0.2	0.1	0	3.87	38.2
Bt2	6	27	37	70	8	7	15	15	6.8	5.1	0	0.2	0.1	12	4.6	0.5	0.2	0.1	6.25	46.5
BE’	2	54	37	93	3	3	6	1	7	5.3	0	0.1	0	4.6	2.1	0.2	0.1	0.1	2.19	52.7
B’t	Not analyzed																			
Bw	1	18	55	74	18	7	25	1	7	5	0	0	0	8	4.8	0.4	0	0.1	2.75	65.7

Chart. PROFILE 3 (3PP/11)

Description of the station

Locality	Pavia, Locality Ca' della Bottella
Surveyor and date	ERSAF, 01/03/05
Soil use	Poplar grove
Height and slope	59 m on the sea level; 0 %
Surface stoniness	absent
Substrate	non calcareous fluvial sediments with prevalently sandy-loamy granulometry
Geographic area	Valle del Ticino
Landscape	Surfaces contiguous to watercourses and fluvial isles, subject to floods during the ordinary flood events
Class. USDA (2003)	coarse-loamy over sandy or sandy skeletal, mixed, superactive, mesic Mollic Ustifluvent
WRB classification (1998)	Hypereutri-Humic Fluvisols
Related STU	**139 - Calcari-Humic Fluvisols (Hypereutric)**

Description of the horizons

Ap 0-30 cm, humid, very dark grey (10YR3/1), Sandy-loam scarcely gravelly, strongly developed big polyhedral subangular fragments, common fine micro-pores, common thin and very thin roots, non calcareous, linear abrupt lower limit.

A 30-50 cm, humid, very dark greyish brown (10YR3/2), Sandy-loam scarcely gravelly, moderately developed big polyhedral subangular aggregation, common fine micro-pores, few fine and very fine roots, non calcareous, linear abrupt lower limit.

C1 50-90 cm, humid, dark yellowish brown (10YR3/4), Silt-loam, scarcely developed very big polyhedral subangular aggregation, common fine micro-pores, few medium and big roots, non calcareous, linear clear lower limit.

2C2 90-200 cm and beyond, not very humid, light brown (10YR6/3), loose sand, many fine macro-pores, few big roots, non calcareous, lower limit unknown.

Physico-chemical determinations

Horizons	Texture (%)								PH		Total $CaCO_3$	SO	CO	exchange complex (meq/100g)						TSB
	Sg	Sf	Smf	Stot	Lg	Lf	Ltot	A	(H_2O)	(KCl)	%	%	%	CSC	Ca	Mg	K	Na	Ac. Compl	%
Ap	12	21	24	57	17	23	40	3	7.4	7	2	2.6	1.5	13.4	10	1	1	0	-	90
A	11	21	23	55	19	23	42	3	6.5	6.1	0	1.6	0.9	11	5.6	0.4	0.9	0	4.13	63
C1	2	6	18	26	30	36	66	8	7.3	5.4	0	0.8	0.4	14.9	8.7	0.7	0.1	0.2	5.19	65
2C2	62	6	31	99	1	0	1	0	7.4	6.7	0	0.1	0.1	1.1	0.8	0.2	0	0.1	-	56

Chart. PROFILE 4 (4PP/11)

Description of the station

Locality	S. Cristina Bissone (PV), Locality C.na Tedeschina
Surveyor and date	ERSAF, 07/03/05
Soil use	corn
Height and slope	70 m on the sea level; 0 %
Surface stoniness	absent
Substrate	non calcareous fluvial sediments with prevalently sandy-loamy granulometry
Layer	185 cm
Geographic area	Low Pavia-Lodi Lombardia plain
Landscape	Paleo-river beds delimited by terrace rims or joined to the plain
Class. USDA (2003)	fine loamy, mixed, active, mesic (Thapto-lamellic) Ultic Haplustalf
WRB classification (1998)	Chromi-Lamellic Luvisols (Cutanic)

Related STU **37 - Haplic Luvisols**

Description of the horizons

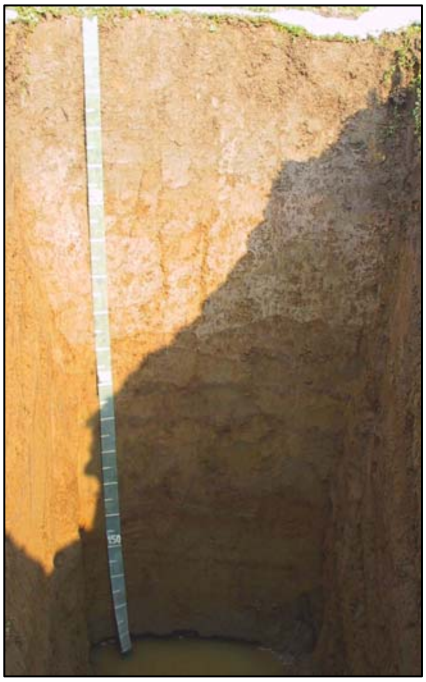
Ap1 0-20 cm, humid, brown (10YR5/3), Silt, moderately developed medium polyhedral subangular fragments, common very thin roots, non calcareous, linear abrupt lower limit.

Ap2 20-45 cm, humid, yellowish brown (10YR5/4), Silt, moderately developed big polyhedral subangular aggregation, common very thin roots, non calcareous, linear abrupt lower limit.

Bt1 45-85 cm, humid, principally strong brown (7.5YR5/6), secondly yellowish brown (10YR5/6), small and abundant variegations of strong brown colour (7.5YR4/6) with clear limit, Silt, moderately developed big polyhedral subangular aggregation, many small non cemented concentrations of Fe-Mn, many argillans on the faces of the aggregates, absence of roots, non calcareous, wavy abrupt lower limit.

2E/Bt2 85-170 cm, humid, yellowish brown (10YR5/8), loose sand with sub-horizontal brown interleaved lamellas (7.5YR5/4), Sandy-loam, weakly developed thin polyhedral subangular aggregation, very small non cemented concentrations of Fe-Mn which are common through all the horizon, absence of roots, non calcareous, linear abrupt lower limit.

2Cg 170-185 cm and beyond, wet, greyish brown (10YR5/2), loose sand, absence of roots, non calcareous, lower limit unknown.



The term "Thapto-lamellic" is connected to the presence of clay lamellas in depth, within a buried soil, different and more developed than the surface soil.

Physico-chemical determinations

Horizons	Texture (%)								PH		Total $CaCO_3$	SO	CO	exchange complex (meq/100g)						TSB
	Sg	**Sf**	**Smf**	**Stot**	**Lg**	**Lf**	**Ltot**	**A**	**(H_2O)**	**(KCl)**	**%**	**%**	**%**	**CSC**	**Ca**	**Mg**	**K**	**Na**	**Ac. Compl**	**%**
Ap1	12	17	17	46	20	26	46	8	6.6	6.1	0	2.8	1.6	13.5	6.4	0.8	0.8	0.1	5.44	60
Ap2	13	13	17	43	21	27	48	9	6.7	6.3	0	2.4	1.4	12.8	6.5	0.9	1	0.1	4.31	66
Bt1	12	16	15	43	15	20	35	22	6.8	5.9	0	0.3	0.2	12.9	7.7	0.8	0.4	0.5	3.44	73
2E/Bt2	34	6	35	75	4	7	11	14	7.1	6	0	0.2	0.01	10.9	5.1	0.5	0.3	0.5	4.5	59
2Cg	80	11	0	91	1	3	4	5	7.6	6.6	0	0.1	0.05	2.5	1.6	0.4	0	0.2		89

Chart. PROFILE 5 (5PP/11)

Description of the station

Locality	Casei Gerola (PV) periferia Nord-Est
Surveyor and date	ERSAF, 07/03/05
Soil use	vineyard inter-row seeded with alfa-alfa
Height and slope	79 m on the sea level; 0 %
Surface stoniness	absent
Substrate	silt and calcareous clay
Geographic area	Oltrepo Pavese plain within the Appennini area
Landscape	Wide artificially drained depressions (recent reclamation), made up of very thin sediments
Class. USDA (2003)	fine, mixed, superactive, mesic Vertic Haplustept
WRB classification (1998)	Fluvi-Vertic Cambisols

Related STU — **121 - Haplic Calcisols (this STU also includes soils with apical features)**

Description of the horizons

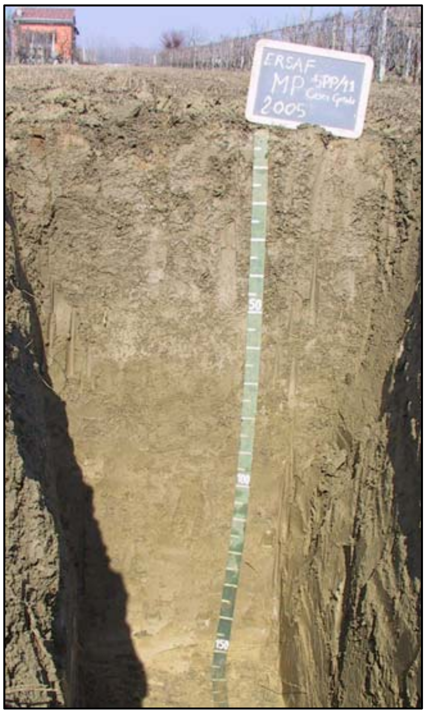
Ap1 0-20 cm, humid, brown (10YR5/3), common medium variegations of strong brown colour (7.5YR5/6) with clear limit, Silt-loam clayey, moderately developed medium polyhedral angular fragments, few and very fine macro-pores, common very thin and thin roots, calcareous, wavy abrupt lower limit.

Ap2 20-45 cm, humid, yellowish brown (10YR5/4), Silt-loam clayey, moderately developed big polyhedral angular aggregation, few and very fine macro-pores, few and very thin roots, calcareous, wavy clear lower limit.

Bss 45-100 cm, humid, yellowish brown (principally 10YR5/4, secondly 10YR5/6), Silt-loam clayey, strongly developed medium polyhedral angular aggregation, common agricutans, few slickensides, few and very thin roots, calcareous, linear clear lower limit.

BC 100-130 cm, humid, principally yellowish brown (10YR5/6), secondly brownish yellow (10YR6/6), Silt-loam clayey, not very developed big polyhedral subangular aggregation, few and very thin roots, calcareous, linear clear lower limit.

C 130-155 cm and beyond, humid, brownish yellow (10YR6/6), Silt-loam clayey, massive, absence of roots, calcareous, lower limit unknown.



Physico-chemical determinations

Horizons	Texture (%)								PH		Total CaCO3	Active $CaCO_3$	SO	CO	exchange complex (meq/100g)					TSB
	Sg	Sf	Smf	Stot	Lg	Lf	Ltot	A	(H_2O)	(KCl)	%		%	%	CSC	Ca	Mg	K	Na	%
Ap1	0	1	8	9	7	47	54	37	7.9	7.0	17.3	12.3	2.9	1.7	26.5	19.5	2.0	0.7	0.1	83.5
Ap2	2	2	0	4	8	49	57	39	8.0	7.0	17.2	11.9	2.1	1.2	24.3	22.5	2.1	0.5	0.1	100.0
Bss	0	1	0	1	10	54	64	35	8.1	7.1	21.6	12.4	1.1	0.7	22.9	19.0	2.7	0.4	0.1	97.0
BC	0	0	1	1	12	57	69	30	8.2	7.2	20.7	11.3	1.1	0.6	20.7	18.6	3.8	0.4	0.1	100.0
C	0	0	8	8	17	48	65	27	8.5	7.1	18.9	9.6	1.1	0.6	19.4	16.1	3.9	0.4	0.1	100.0

Chart. PROFILE 6 (6PP/12)

Description of the station

Locality	Corvino San Quirico (PV), Locality Valle Stroggini
Surveyor and date	ERSAF, 07/03/05
Soil use	vineyard inter-row seeded with alfa-alfa
Height and slope	190 m on the sea level; 15% (very variable but < 25%)
Erosion	absent
Surface stoniness	absent
Substrate	clay and argillite
Layer	160 cm
Geographic area	Low hills of Val Versa
Landscape	Versants with high to very high slopes, with prevalent south exposition, frequently used as pasture lands, vineyards and orchards on the least steep surfaces or artificially terraced
Class. USDA (2003)	fine silty, mixed, superactive, mesic Typic Haplustept
WRB classification (1998)	Calcari-Fluvic Cambisols
Related STU	**382 - Calcaric Cambisols**

Description of the horizons

Ap1 0-20 cm, humid, olive brown (2,5Y4/4), Silt-loam, moderately developed big polyhedral subangular fragments, few small concentrations of $CaCO_3$, common medium macro-pores, common very thin and thin roots, scarcely calcareous, linear abrupt lower limit.

Ap2 20-70 cm, humid, yellowish brown (10YR5/6), Silt clayey, moderately developed big polyhedral subangular aggregation, few small concentrations of $CaCO_3$, common medium macro-pores, few very thin and thin roots, scarcely calcareous, wavy abrupt lower limit.

Bw 70-105 cm, humid, yellowish brown (principally 10YR5/8, secondly 10YR5/4), Silt-loam clayey, strongly developed big polyhedral subangular aggregation, few extremely small non cemented concentrations of Fe-Mn, common very fine macro-pores, few thin roots, scarcely calcareous, linear clear lower limit.

C 105-180 cm and beyond, humid, principally light olive brown (2,5Y5/6), secondly yellowish brown (10YR5/8), Silt-loam, massive, many small non cemented concentrations of Fe-Mn, very few and very fine macro-pores, absence of roots, scarcely calcareous, lower limit unknown.

Physico-chemical determinations

Horizons	Texture (%)								PH		Total CaCO3	Active $CaCO_3$	SO	CO	exchange complex (meq/100g)					TSB
	Sg	Sf	Smf	Stot	Lg	Lf	Ltot	A	(H_2O)	(KCl)	%	%	%	%	CSC	Ca	Mg	K	Na	%
Ap1	1	2	11	14	25	36	61	25	8.06	7.16	4.7	0	2.3	1.4	21.83	17.28	1.59	0.69	0.07	89.92
Ap2	1	6	15	22	23	24	47	31	8.2	7.14	1.6	0	1	0.6	22.9	18.4	1.34	0.25	0.09	87.69
Bw	1	1	11	13	28	32	60	27	8.19	7.13	2.2	0	0.9	0.5	21.44	18.71	1.49	0.22	0.09	95.66
C	1	3	17	21	33	25	58	21	8.13	7.06	0.6	0	0.3	0.2	20.14	16.44	1.29	0.14	0.1	89.23

Chart. PROFILE 7 (7PP/21)

Description of the station

Locality	Varzi (PV), Locality Buschi Sagliano
Surveyor and date	ERSAF, 19/05/05
Soil use	Copsy chestnut grove with the presence of sessile oak, hop-hornbeam, manna tree, hazelnut tree and false acacia
Height and slope	710 m on the sea level, 30 %
Erosion	moderate superficial water erosion; it is enhanced by coppice management
Surface stoniness	absent
Substrate	Heterogeneous complexes
Geographic area	High hill and middle-mountain of Oltrepo Pavese
Landscape	High part of the versant with rounded ridge, moderate to moderately high slope
Class. USDA (2003)	coarse-loamy, mixed, superactive, mesic Typic Haplustept
WRB classification (1998)	Calcaric Cambisols

Related STU **386 - Calcari-Leptic Cambisols**

Description of the horizons

L 5-0 cm, discontinuous abrupt lower limit.

A 0-2 cm, humid, dark brown (10Y3/3), Sandy-loam, moderately developed medium granular aggregation, common medium macro-pores, common very thin roots, non calcareous, irregular abrupt lower limit.

Bw1 2-30 cm, humid, principally olive brown (2,5Y4/4), secondly dark yellowish brown (10YR4/6), Sandy-loam, moderately developed medium polyhedral subangular aggregation, common fine and medium micro-pores, many thin and big roots, scarcely calcareous, linear clear lower limit.

Bw2 30-45 cm, humid, olive brown (2,5Y4/4), Sandy-loam, not very developed big polyhedral subangular aggregation, common fine and medium micro-pores, common medium and big roots, calcareous, linear abrupt lower limit.

C1 45-55 cm, humid, light yellowish brown (2,5Y6/4), Sandy-loam, massive, common fine and medium micro-pores, many medium and thin roots, very calcareous, linear abrupt lower limit.

C2 55-110 cm and beyond, humid, light yellowish brown (2,5Y6/4), abundant sub-horizontal dark greenish grey variegations (5GB4/1), medium and big with clear contrast, Sandy-loam, massive, very few and very fine macro-pores, absence of roots, very calcareous, lower limit unknown.

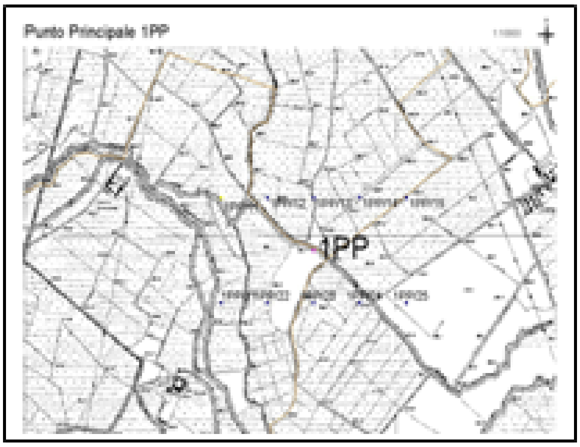
Physico-chemical determinations

Horizons	Texture (%)								PH		Total $CaCO_3$	Active $CaCO_3$	SO	CO	exchange complex (meq/100g)					TSB
	Sg	Sf	Smf	Stot	Lg	Lf	Ltot	A	(H_2O)	(KCl)	%	%	%	%	CSC	Ca	Mg	K	Na	%
A	10	16	45	71	11	10	21	8	7.5	6.9	0.5	0.0	11.2	6.5	38.7	62.5	4.6	0.8	1.3	95.6
Bw1	4	26	28	58	9	20	29	13	8.0	7.1	5.2	0.0	1.7	1.0	19.2	24.6	2.0	0.1	0.9	90.1
Bw2	1	2	52	55	12	22	34	11	8.3	7.2	17.3	3.3	1.1	0.6	16.6	15.5	1.4	0.1	0.8	97.3
C1	0	20	40	60	12	19	31	9	8.7	7.3	20.0	3.8	0.3	0.2	12.0	13.9	1.4	0.1	0.8	100.0
C2	0	20	43	63	11	17	28	9	8.4	7.4	18.3	4.0	0.1	0.1	11.7	13.4	1.6	0.1	1.0	100.0

Appendix F

Sampling Charts
Primary Points, and an example for the Secondary and Tertiary Points

PP1: Sampling Area Description



Map

Photo Nr.1

Photo Nr. 2

Photo Nr. 3

Location ID: Valle Lomellina – C.na Macedonio

Geographic area: Provincia di Pavia – Lomellina

Sampling date: 28 October 2004

<u>Coordinates</u> Position format: UTM/UPS Map Datum: WGS 84

32T	Lat.	0476945
	Long.	5002211

Quota and inclination: 98 m; 0%

Area description: river terraces with slow drain; rice field of marly-clay soil. The superficial layer of 20-30 cm is composed of mixed soil. Square zone, presence of irrigation channels. Absence of vegetation, except rare birch tree.

Land-use: rice

Applied fertilizers: <u>2004</u> 5.25 q/ha SIAPORTUR (N_{org}, potash, lime)
135 kg/ha Urea
135 kg/ha 23N-0P-30K

<u>2003</u> 180 kg/ha nail horns
3.75 q/ha 0N-10÷12P-24K-25Ca
105 kg/ha Urea
220 kg/ha 16N-0P-30K

Stones on surface: absent

Substratum: river sediments not calcareous; particle size mainly loamy sand

Horizons description:

Ap (0÷10 → arable soil, organic) 0÷30 cm, damp, brown (mainly 7,5YR4/4, secondarily 7,5YR5/2), frequent middle-size variegations of strong brown color (7,5YR5/6) of clean limit, loam, sub-angular polyhedric fragments, big and weakly developed; frequent very thin roots, not calcareous, low limit abrupt-linear.

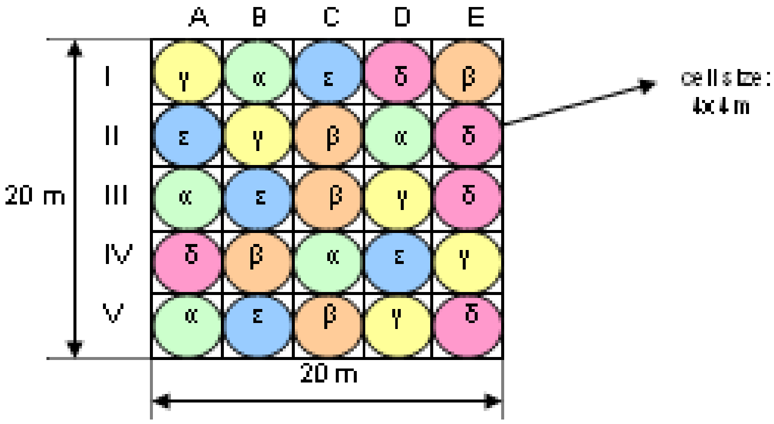
Apg (25÷50 → mixed soil) 30÷50 cm, very damp, grey dark-greenish colour (5G4/1), frequent variegations of strong brown colour (7,5YR5/6) of clean limit, clay loam, massive, frequent extremely small concentrations not cemented of Fe-Mn, macropores absent, few very thin roots, not calcareous, low limit abrupt-linear.

Bw (50÷80 → clay) 50÷95 cm, very damp, mainly brown yellowish (10YR5/8), secondarily grey pale-brownish (10YR6/2), abundant small variegations of strong brown color (7,5YR5/6) of clean limit, silt loam, massive, few thin macropores, frequent indefinite cutans along the pore, frequent thin and very thin roots, not calcareous, low-limit abrupt-undulated.

Cg (80÷100+→ clay) 95÷160 cm and over, very damp, grey dark-greenish color (5G4/1), silt loam, massive, not calcareous, few very thin macropores, roots absent, low limit unknown.

Classification: fine silty, mixed (non acid) superactive, mesic Fluvaquentic Epiaquept

Sampling scheme:

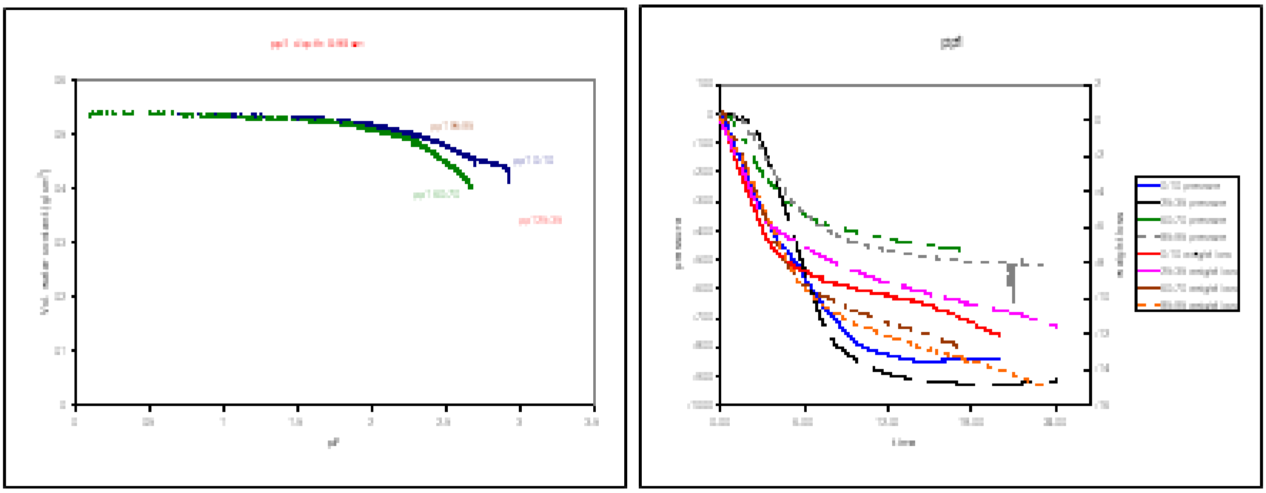


Random-stratified sampling approach for PP1 sampling. A composite sample is obtained by mixing equal aliquots of all 5 sub-samples, for each stratum (same colour)

Analysis Results

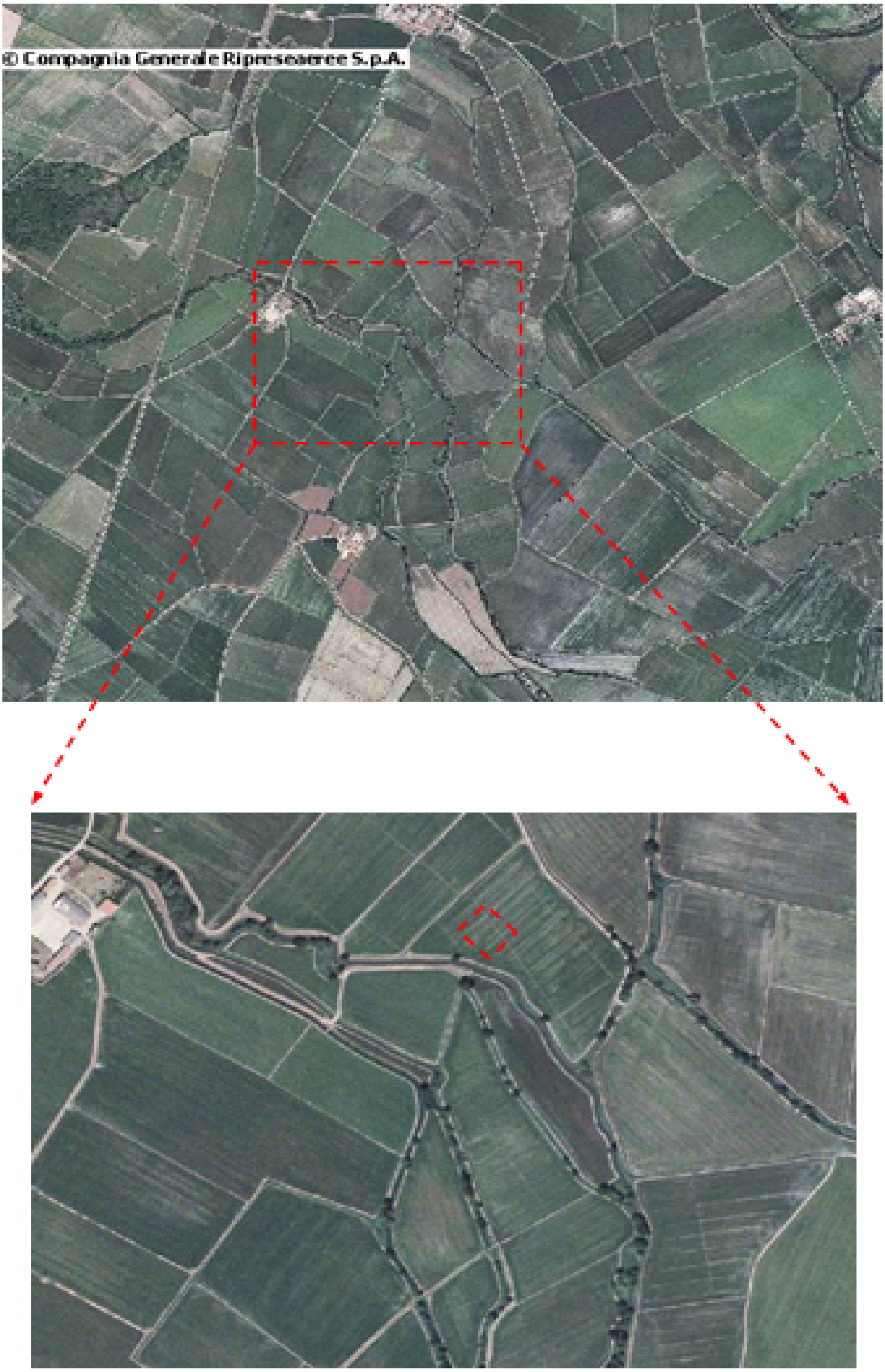
Sample		α 0÷10 cm	β 0÷10 cm	γ 0÷10 cm	δ 0÷10 cm	ε 0÷10 cm	Mean value	α 80÷100 cm	β 80÷100 cm	γ 80÷100 cm	δ 80÷100 cm	ε 80÷100 cm	Mean value
Humidity	%	nd	nd	nd	nd	nd	25.2	nd	nd	nd	nd	nd	23.4
Texture	% sand	nd	nd	nd	nd	nd	45	nd	nd	nd	nd	nd	42
	% clay	nd	nd	nd	nd	nd	21	nd	nd	nd	nd	nd	2
	% silt	nd	nd	nd	nd	nd	34	nd	nd	nd	nd	nd	56
pH		5.5	5.9	4.6	4.4	4.7	5.0	5.5	5.9	5.9	6.1	5.7	5.8
C	% total	1.8	1.8	1.7	1.8	1.8	1.8	0.34	0.33	0.18	0.12	0.11	0.22
	% organic	1.6	1.5	1.3	1.6	1.6	1.5	0.31	0.28	0.18	0.11	0.09	0.19
	% $CaCO_3$	1.3	2.9	3.5	1.5	1.8	2.2	0.25	0.42	0.00	0.08	0.17	0.18
H	%	0.68	0.77	0.69	0.70	0.69	0.71	0.71	0.57	0.49	0.35	0.34	0.49
N	%	0.16	0.16	0.15	0.15	0.16	0.16	0.03	0.03	0.02	0.01	0.01	0.02
Mercury	μg/g	0.061	0.063	0.060	0.062	0.060	0.061	0.026	0.016	0.008	0.007	0.008	0.013
Fe2O3	%	8.6	9.0	8.6	9.4	9.3	9.0	10.3	8.6	6.9	7.3	7.0	8.0
Na2O	%	1.5	1.5	1.5	1.5	1.5	1.5	1.8	2.0	2.3	1.8	1.9	1.9
SiO2	%	54.5	54.8	55.2	54.0	54.1	54.5	54.1	55.3	56.6	53.3	54.0	54.6
Al2O3	%	16.8	16.8	16.7	16.8	16.8	16.7	17.2	17.1	17.2	17.0	15.9	16.9
CaO	%	2.5	2.5	2.5	2.4	2.5	2.4	3.2	3.3	3.4	4.1	4.0	3.6
K2O	%	1.9	1.9	1.9	1.9	1.9	1.9	1.8	2.0	2.2	1.6	1.6	1.8
MgO	%	2.2	2.1	2.1	2.1	2.1	2.1	2.9	3.0	2.9	4.1	3.5	3.3
TiO2	mg/kg	8429	8759	8398	8952	8890	8686	9218	8954	8413	12589	11143	10063
P2O5	mg/kg	1689	1522	1584	1585	1592	1594	1497	1597	1974	1869	1824	1752
S	mg/kg	494	475	491	508	508	495	< 20	28	51	81	86	62

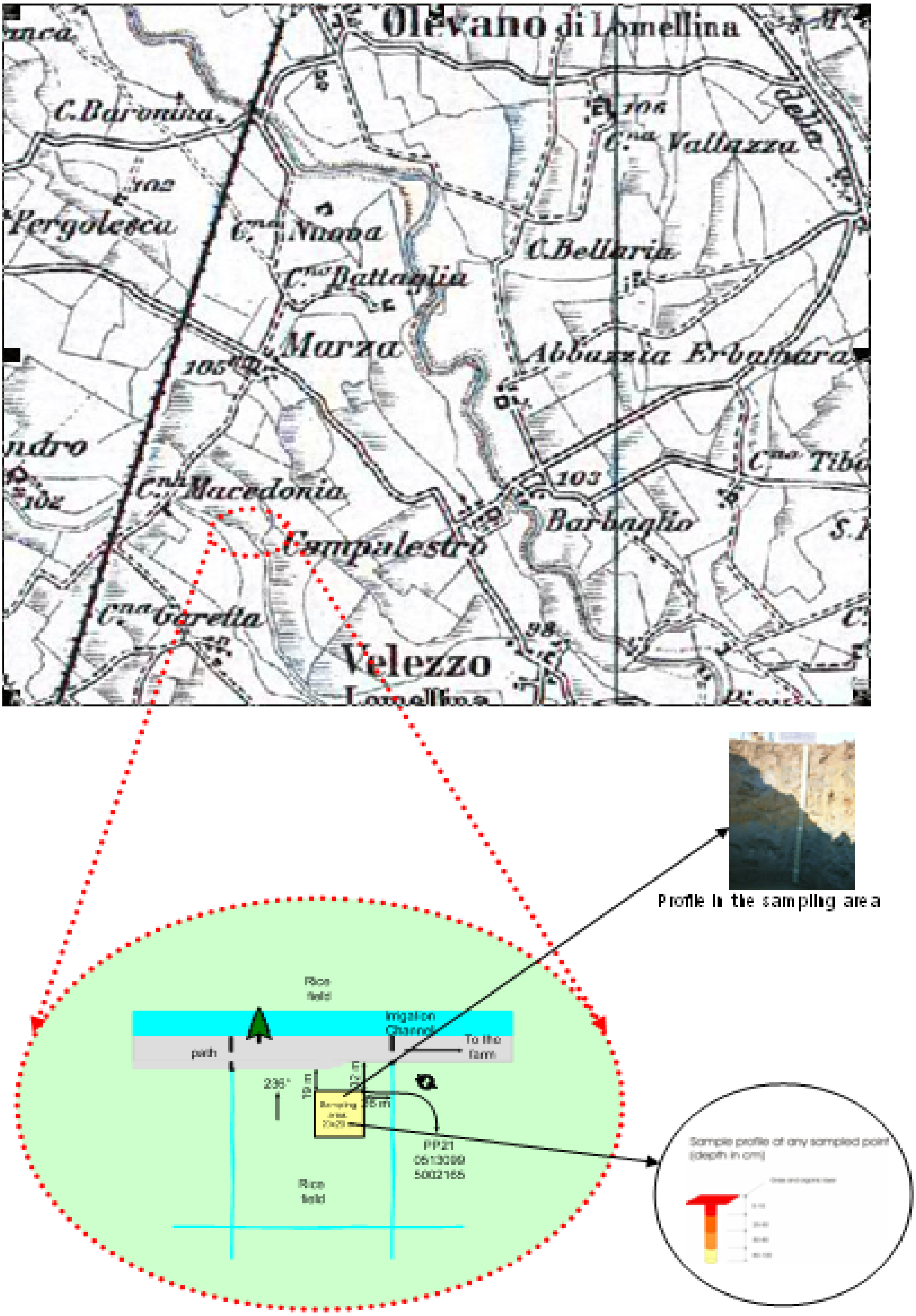
		0÷10 cm depth	25÷50 cm depth	50÷80 cm depth	80÷100 cm depth
Bulk density	g/cm³	1.37	1.43	1.545	1.40
saturated water content	g/cm³	0.53	0.52	0.53	0.56
Porosity		0.485	0.459	0.417	0.473



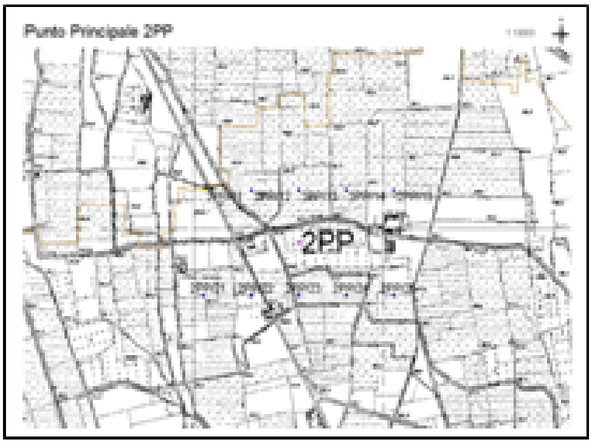
Soil retention curves

Location of PP1 sampling area




Olevano di Lomellina
C. Baronina
102
Pergolesca
C.na Nuova
C.na Battaglia
Marza
105
C.na Macedonia
Campalestro
C.na Caretta
Velezzo
Lomellina
106
C.na Vallazza
C. Bellaria
Abbazzia Erbamara
103
Barbaglio
98
Rice field
Irrigation Channel
path
To the farm
236°
19 m
25 m
PP21
0513099
5002165
Rice field
Profile in the sampling area
Sample profile at any sampled point (depth in cm)

PP2: Sampling Area Description



Map 1

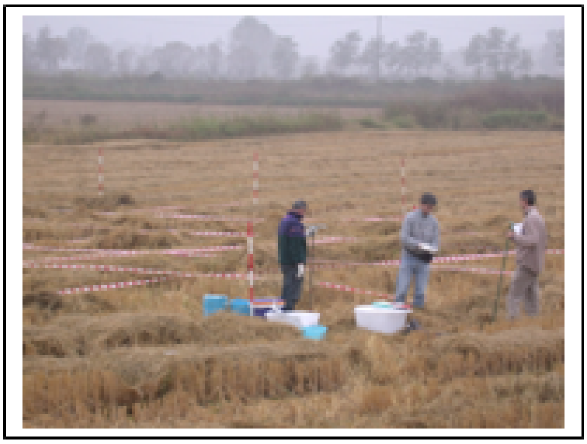


Photo Nr.1

Photo Nr.2

Photo Nr.3

Location ID: Garlasco - Dorno – C.na San Giuliano

Geographic area: Provincia di Pavia – Lomellina

Sampling date: 25 October 2004

Coordinates Position format: UTM/UPS Map Datum: WGS 84
32T Lat. 0495000
Long. 5002159

Quota and inclination: 90 m; 0 %

Area description: SS 206, right road side in direction Garlasco → Dorno; stable and plane surfaces of sandy lowland; rice and corn fields, quite dry. Compact but permeable soil; poplars in the nearby.

Land-use: rice

Applied fertilizers: 2004 6 q/ha organic fertilizer
150 kg/ha 30N-0P-20K

2003 and prev years: same as above

Stones on surface: absent

Substratum: river sediments not calcareous; particle size mainly loamy sand

Horizons description:

Ap (0÷25) 0÷30 cm, damp, brown (10YR5/3), loamy sand, poorly gravelly, sub-angular polyhedric fragments, big and moderately developed, few middle-size roots, not calcareous, low limit abrupt-linear.

Apg (25÷50) 30÷45 cm, damp, brown dark greyish colour (10YR4/2), frequent very small variegations of brown yellowish colour (10YR 5/8) of clean limit, loamy sand poorly gravelly, massive, frequent small concentrations not cemented of Fe-Mn, macro pores absent, no roots, not calcareous, low limit abrupt- irregular.

BE (50÷80) 45÷65 cm, damp, brown yellowish (10YR5/6), loamy sand, big and strongly developed sub-angular polyhedric aggregation. Few small concentrations not cemented of Fe-Mn, roots absent, not calcareous, low limit abrupt- irregular.

Bt1 (80÷100+) 65÷140 cm, damp, brown yellowish (10YR5/8), sandy loam, big and weakly developed (almost incoherent) sub-angular polyhedric aggregation, frequent middle-size concentrations not cemented of Fe-Mn, roots absent, not calcareous, low limit abrupt- irregular.

Bt2 140÷160 cm, damp, mainly strong brown colour (7,5YR4/6), secondarily brown yellowish (10YR5/8), sandy loam, medium sub-angular polyhedric aggregation strongly developed, few argillans. Many middle-size concentrations not cemented of Fe-Mn, roots absent, not calcareous, low limit abrupt-undulated.

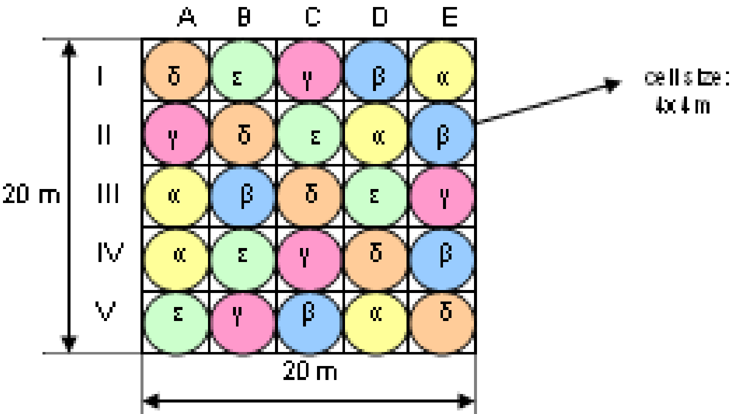
BE' 160÷180 cm, damp, mainly yellow brownish (10YR6/8), secondarily brown yellowish (10YR5/8), incoherent sand, few small concentrations not cemented of Fe-Mn, roots absent, not calcareous, low limit abrupt-linear.

B't 180÷190 cm, damp, mainly strong brown (7,5YR4/6), secondarily brown yellowish (10YR5/8), sandy loam, medium sub-angular polyhedric aggregation strongly developed, few argillans, roots absent, not calcareous, low limit abrupt-linear.

Bw 190-210 cm and over, damp, brown yellowish (10YR5/8), loamy sand (very thin sand), massive, few small concentrations not cemented of Fe-Mn, roots absent, not calcareous, low limit unknown.

Classification: coarse loamy, mixed superactive, mesic Aquic Arenic Haplustalf

Sampling scheme:

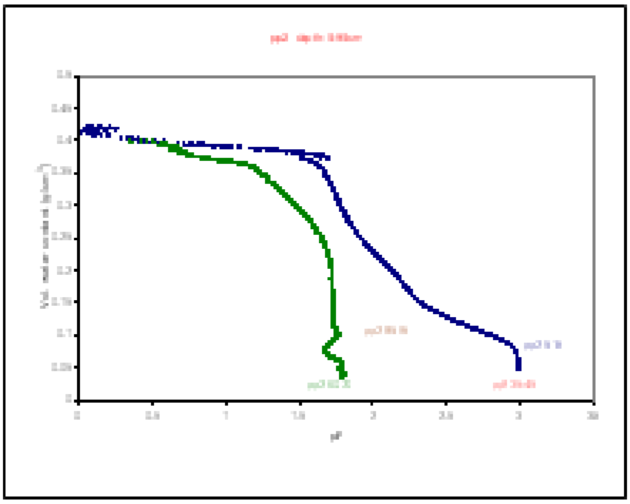


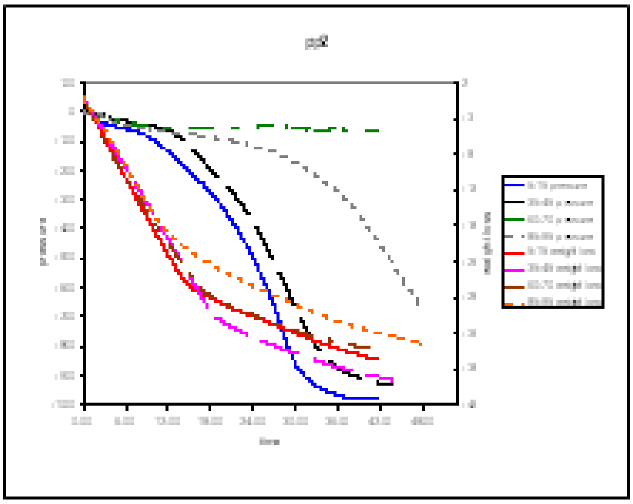
Random-stratified sampling approach for PP2 sampling. A composite sample is obtained by mixing equal aliquots of all 5 sub-samples, for each stratum (same colour)

Analysis Results

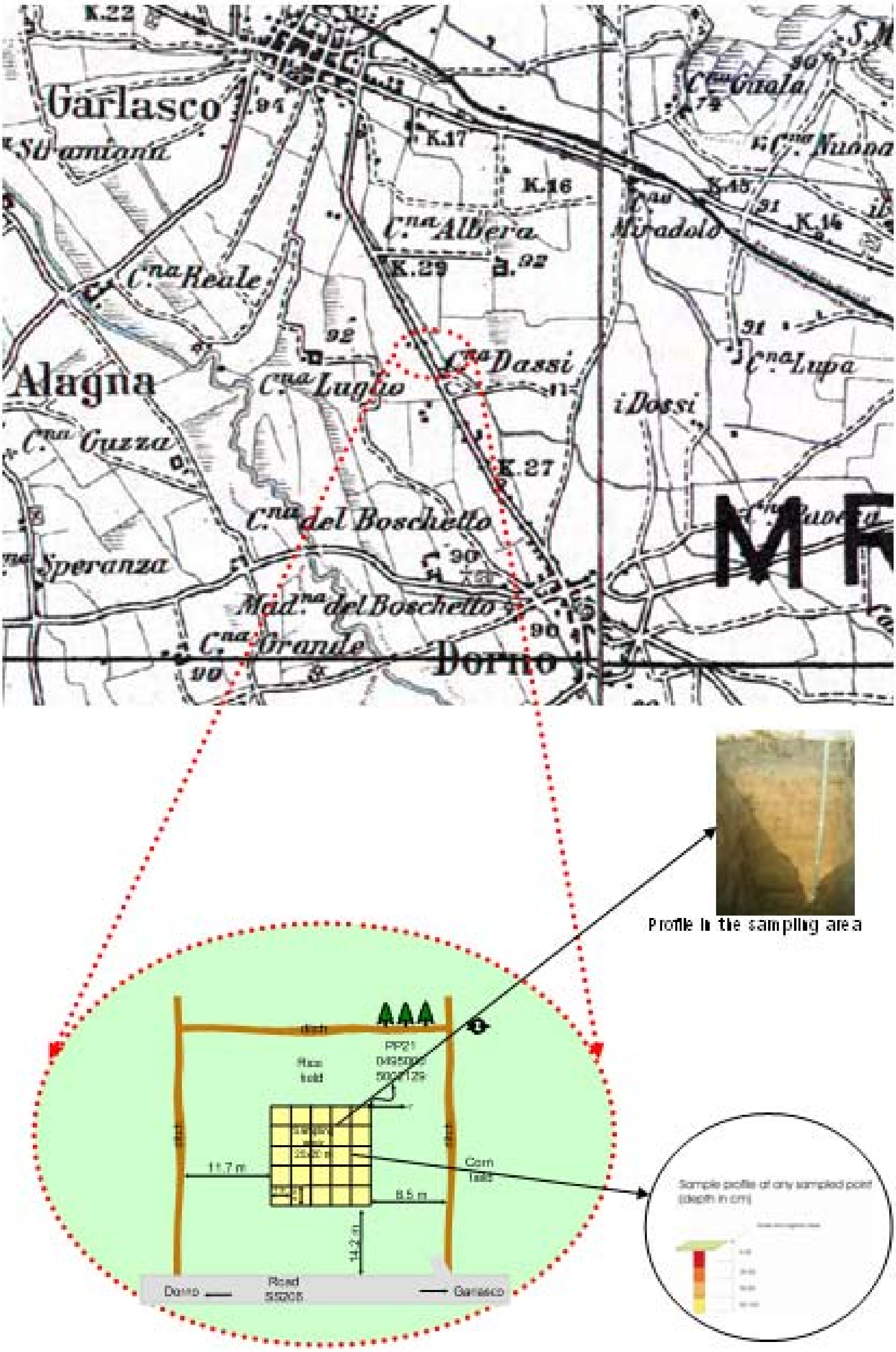
Sample		α 0÷25 cm	β 0÷25 cm	γ 0÷25 cm	δ 0÷25 cm	ε 0÷25 cm	Mean value	α 80÷100 cm	β 80÷100 cm	γ 80÷100 cm	δ 80÷100 cm	ε 80÷100 cm	Mean value
Humidity	%	nd	nd	nd	nd	nd	10.4	nd	nd	nd	nd	nd	15.2
Texture	% sand	nd	nd	nd	nd	nd	78	nd	nd	nd	nd	nd	67
	% clay	nd	nd	nd	nd	nd	1	nd	nd	nd	nd	nd	7
	% silt	nd	nd	nd	nd	nd	21	nd	nd	nd	nd	nd	14
pH		5.4	5.2	5.3	5.2	5.3	5.3	5.7	5.8	5.5	5.5	5.0	5.5
C	% total	1.2	1.2	1.1	1.1	1.2	1.2	0.20	0.23	0.18	0.17	0.23	0.20
	% organic	1.0	0.9	1.0	1.0	1.0	1.0	0.18	0.18	0.17	0.14	0.20	0.17
	% $CaCO_3$	1.7	2.5	1.3	1.2	1.8	1.7	0.17	0.42	0.08	0.25	0.25	0.23
H	%	0.35	0.37	0.36	0.35	0.37	0.36	0.38	0.37	0.35	0.31	0.41	0.36
N	%	0.11	0.11	0.11	0.11	0.11	0.11	0.03	0.03	0.03	0.03	0.03	0.03
Mercury	µg/g	0.044	0.043	0.043	0.045	0.043	0.044	0.012	0.010	0.009	0.009	0.012	0.010
Fe2O3	%	2.2	2.1	2.3	2.1	2.1	2.1	3.7	3.7	3.8	3.3	4.1	3.7
Na2O	%	2.6	2.6	2.4	2.5	2.5	2.5	2.2	2.1	2.1	2.3	2.0	2.1
SiO2	%	68.5	69.1	66.5	68.0	68.6	68.1	63.8	62.9	63.3	65.1	61.2	63.2
Al2O3	%	13.8	13.5	14.0	13.7	13.8	13.7	16.8	17.1	16.9	16.2	17.7	16.9
CaO	%	1.7	1.6	1.7	1.6	1.6	1.6	1.5	1.5	1.5	1.6	1.5	1.5
K2O	%	2.4	2.3	2.4	2.4	2.4	2.4	2.6	2.7	2.7	2.6	2.7	2.6
MgO	%	1.4	1.3	1.5	1.3	1.3	1.3	1.7	1.7	1.7	1.7	1.9	1.7
TiO2	mg/kg	3991	4010	4325	4051	4125	4100	5191	5140	5316	5121	5320	5218
P2O5	mg/kg	1993	1915	2051	2048	1973	1973	1613	1641	1586	1546	1718	1621
S	mg/kg	1073	1068	1122	1093	1188	1109	69	74	65	59	106	75

		0÷25 cm depth	25÷50 cm depth	50÷80 cm depth	80÷100 cm depth
Bulk density	g/cm³	1.61	1.48	1.57	1.61
Saturated water content	g/cm³	0.42	0.44	0.40	0.42
Porosity		0.394	0.443	0.406	0.391



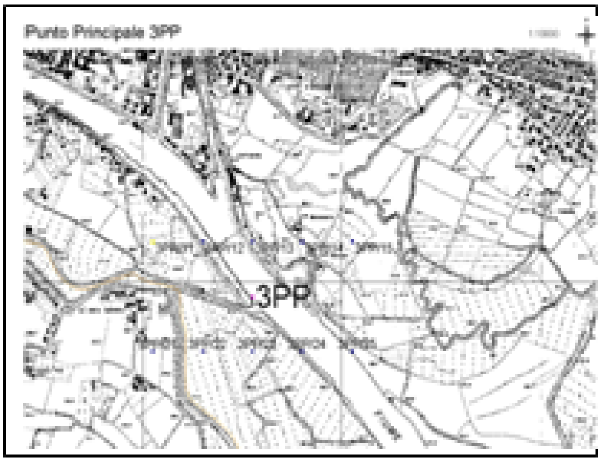


Soil retention curves



Garlasco
Alagna
C.na Reale
C.na Lugo
C.na Dassi
C.na Albera
Miradolo
C.na Lupa
i Dossi
C.na Guzza
C.na del Boschetto
Speranza
Mad.na del Boschetto
C.na Grande
Dorno
C.na Giola
C.na Nuova
K.22
K.17
K.16
K.29
K.27
Profile in the sampling area
PP21
Rice
field
ditch
11.7 m
8.5 m
Corn
field
Road
SS206
Garlasco
Sample profile at any sampled point
(depth in cm)

PP3: Sampling Area Description



Map 1

Photo Nr.1

Photo Nr.2

Photo Nr.3

Location ID: Pavia Sud – Borgo Ticino

Geographic area: Provincia di Pavia – Valle del Ticino

Sampling date: 27 October 2004

<u>Coordinates</u> Position format: UTM/UPS Map Datum: WGS 84

32T Lat. 0513099

Long. 5002165

Quota and inclination: 59 m; 0 %

Area description: surfaces adjacent to water and river islands; possibly flooded during events of ordinary flood. Rows of young poplars, in the confluence between Ticino and Po rivers (so called "Methane Bridge" about 300 m downstream (91° E]). Soil up to ~10 cm, interface up to 35 cm and then alluvial sand. Very drainable soil; scarse vegetation.

Land-use: certified poplars

Applied fertilizers: none (because are certified poplars)

Stones on surface: absent

Substratum: river sediments not calcareous; particle size mainly loamy sand

Horizons description:

Ap (0÷10) 0÷30 cm, damp, dark grey colour (10YR3/1), loam sandy, poorly gravelly, sub-angular polyhedric fragments, big and strongly developed, frequent thin macro pores, frequent thin and very thin roots, not calcareous, low limit abrupt-linear

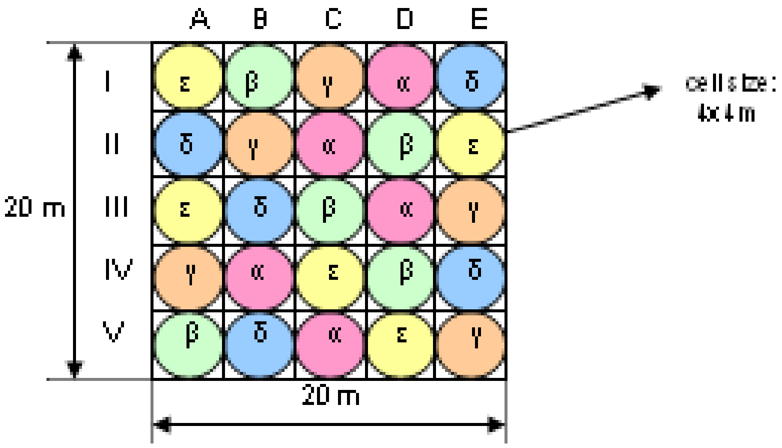
A (10÷50→) 30÷50 cm, damp, brown greyish very dark (10YR3/2), sandy loam poorly gravelly, sub-angular polyhedric aggregation big and moderately developed, frequent thin macro pores, few thin and very thin roots, not calcareous, low limit abrupt-linear.

C1 (50÷80→) 50÷90 cm, damp, dark brown yellowish (10YR3/4), silt loam, sub-angular polyhedric aggregation big and weakly developed, frequent thin macro pores, few middle-size and big roots, not calcareous, low limit clear-linear.

2C2 (80÷100+→) 90÷200 cm and over, light damp, brown pale (10YR6/3), incoherent sand, many thin macro pores, few big roots, not calcareous, low limit unknown.

Classification: coarse-loamy over sandy or sandy skeletal, mixed, super active, mesic Mollic Ustifluvent

Sampling scheme:

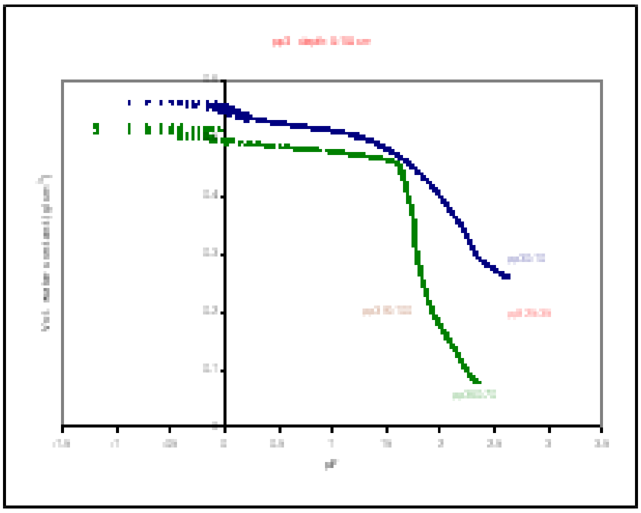


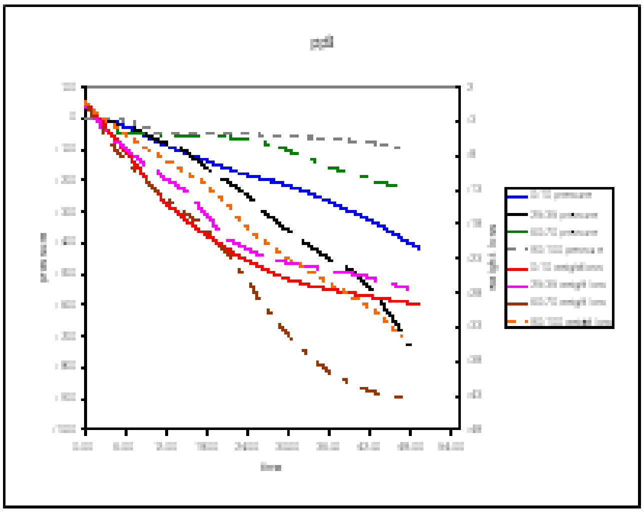
Random-stratified sampling approach for PP3 sampling. A composite sample is obtained by mixing equal aliquots of all 5 sub-samples, for each stratum (same colour)

Analysis Results

Sample		α 0÷10 cm	β 0÷10 cm	γ 0÷10 cm	δ 0÷10 cm	ε 0÷10 cm	Mean value	α 80÷100 cm	β 80÷100 cm	γ 80÷100 cm	δ 80÷100 cm	ε 80÷100 cm	Mean value
Humidity	%	nd	nd	nd	nd	nd	16.4	nd	nd	nd	nd	nd	17.1
Texture	% sand	nd	nd	nd	nd	nd	57	nd	nd	nd	nd	nd	99
	% clay	nd	nd	nd	nd	nd	3	nd	nd	nd	nd	nd	0
	% silt	nd	nd	nd	nd	nd	40	nd	nd	nd	nd	nd	1
pH		5.8	5.8	5.5	5.3	5.7	5.6	6.4	6.0	6.5	6.2	6.1	6.3
C	% total	1.3	1.2	1.2	1.2	1.5	1.3	0.13	0.17	0.16	0.15	0.18	0.16
	% organic	1.0	1.0	0.9	0.9	1.3	1.0	0.11	0.15	0.14	0.13	0.18	0.14
	% $CaCO_3$	2.7	2.0	2.3	2.3	2.1	2.3	0.17	0.17	0.17	0.17	0.00	0.13
H	%	0.51	0.51	0.46	0.44	0.49	0.48	0.19	0.20	0.18	0.17	0.19	0.19
N	%	0.12	0.12	0.12	0.12	0.14	0.12	0.01	0.02	0.02	0.02	0.02	0.02
Mercury	µg/g	0.20	0.20	0.23	0.23	0.29	0.231	0.19	0.20	0.23	0.23	0.31	0.233
Fe_2O_3	%	4.7	4.7	4.4	4.5	4.4	4.5	3.1	3.1	2.8	2.8	3.2	3.0
Na_2O	%	2.5	2.3	2.4	2.4	2.3	2.4	2.8	2.8	2.8	2.9	2.7	2.8
SiO_2	%	64.3	63.1	64.0	63.6	63.1	63.6	65.6	66.4	67.8	67.8	65.4	66.6
Al_2O_3	%	14.8	15.4	14.7	15.0	14.8	14.9	13.7	13.5	12.3	12.5	13.3	13.0
CaO	%	2.2	2.1	2.1	2.1	2.2	2.1	2.0	2.1	2.0	2.0	2.0	2.0
K_2O	%	2.7	2.8	2.8	2.8	2.8	2.8	2.8	2.7	2.6	2.6	2.7	2.7
MgO	%	2.4	2.6	2.3	2.4	2.3	2.4	1.8	1.7	1.5	1.5	1.8	1.6
TiO_2	mg/kg	5702	5744	5524	5690	5533	5639	4482	4461	4097	3956	4656	4330
P_2O_5	mg/kg	2120	2188	2282	2343	2480	2283	1490	1514	1434	1488	1585	1502
S	mg/kg	250	253	246	259	326	267	24	34	57	45	59	44

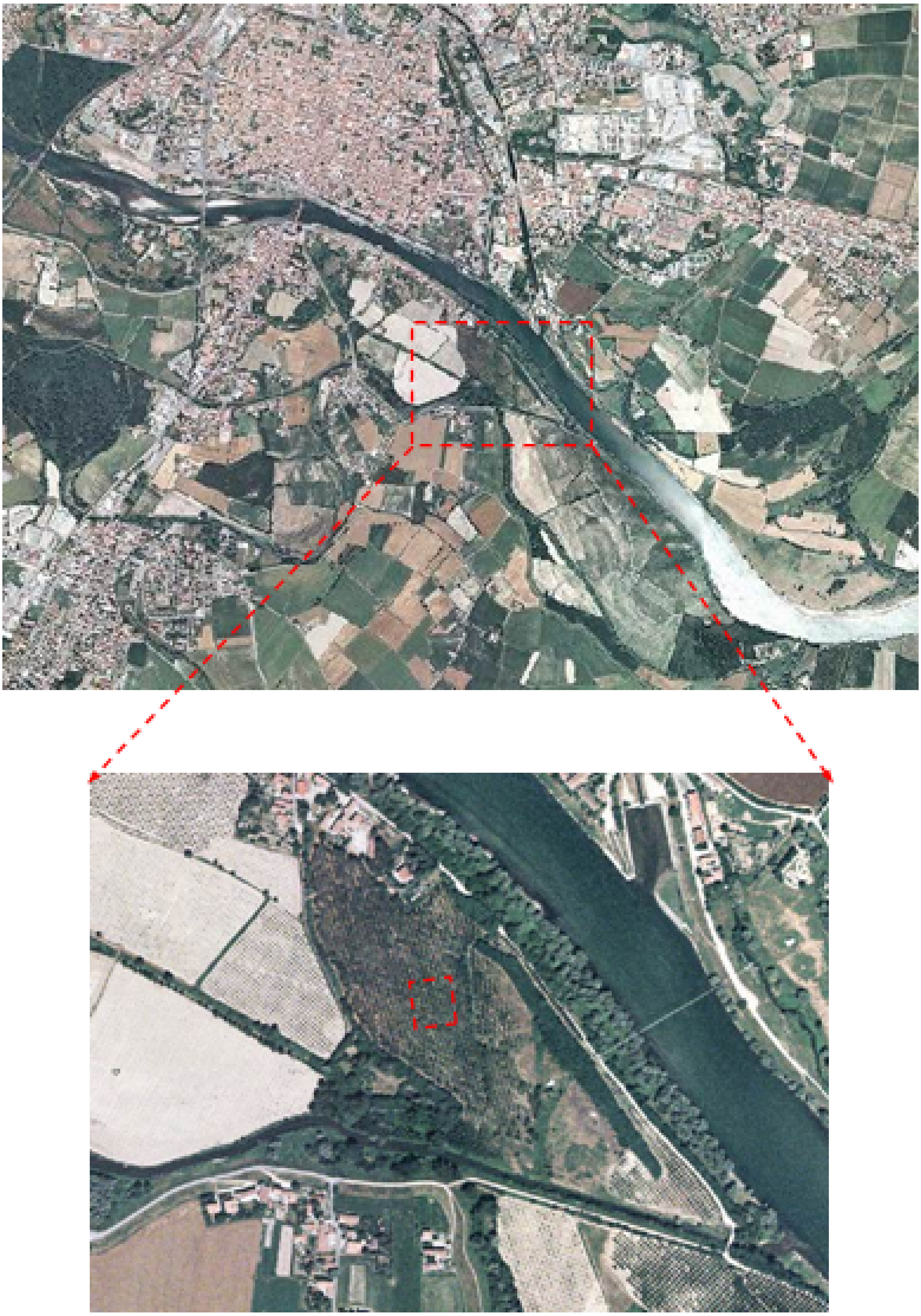
		0÷10 cm depth	10÷60 cm depth	50÷80 cm depth	80÷100 cm depth
Bulk density	g/cm³	1.36	1.41	1.36	1.32
saturated water content	g/cm³	0.54	0.52	0.48	0.51
Porosity		0.488	0.467	0.485	0.501

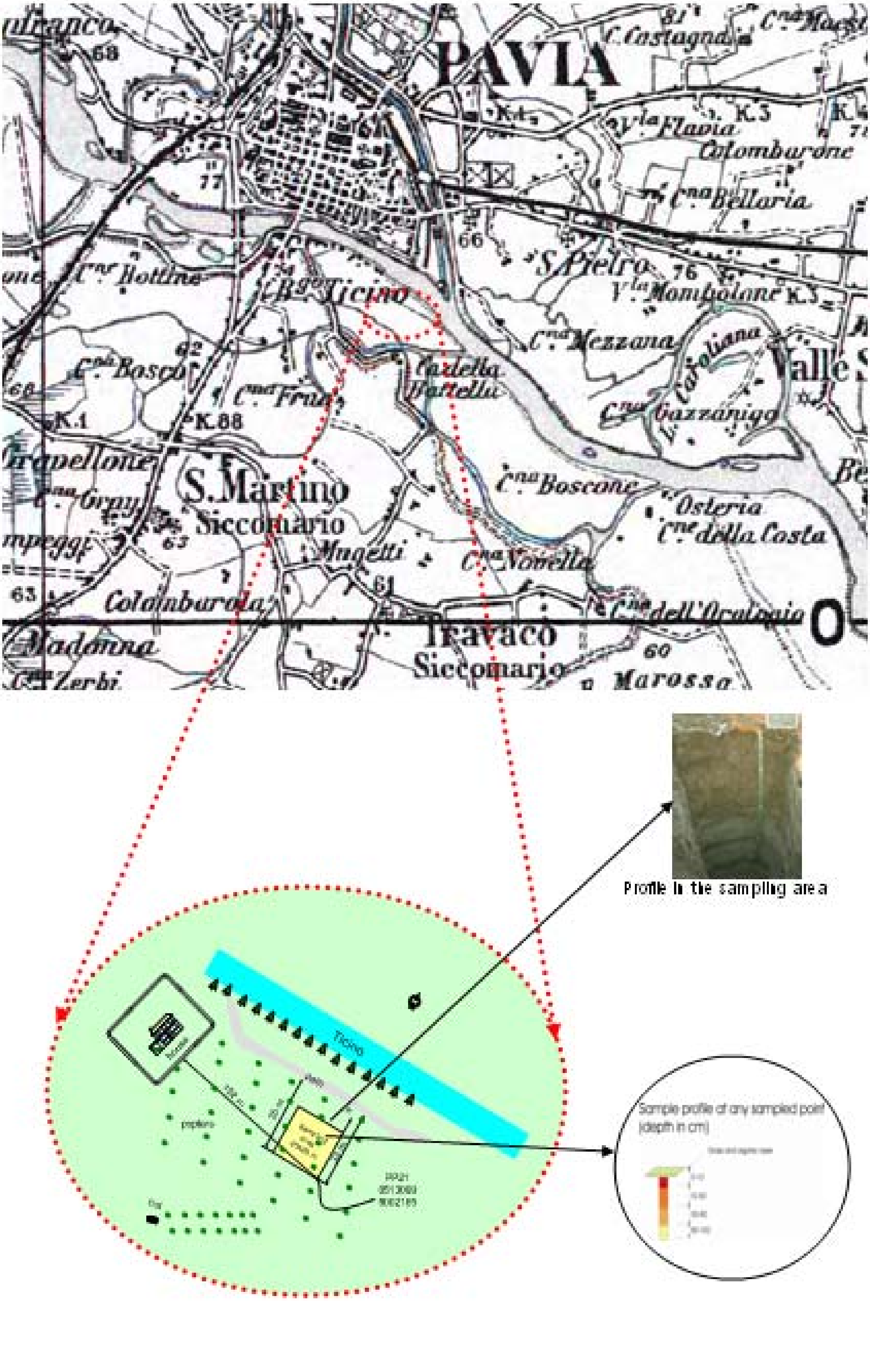




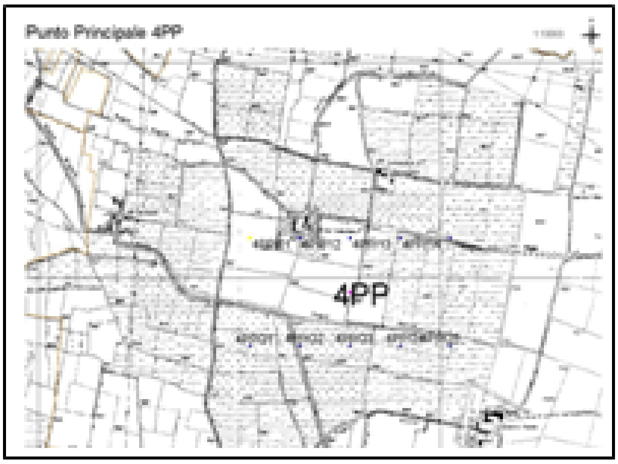
Soil retention curves

Location of PP3 sampling area




PAVIA
S.Martino
Siccomario
Travaco
Siccomario
Ticino
Profile in the sampling area
Sample profile at any sampled point
(depth in cm)
poplars

PP4: Sampling Area Description



Map 1

Phot Nr.1

Phot Nr.2

Phot Nr.3

Location ID: S. Cristina-Bissone – C.na Todeschina

Geographic area: Provincia di Pavia – Low Lombard plain pavese-lodigiana

Sampling date: 26 October 2004

<u>Coordinates</u> Position format: UTM/UPS Map Datum: WGS 84
32T Lat. 0531051
Long. 5002245

Quota and inclination: 70 m; 0%

Area description: pale river beds delimited by terraces' edges or joined to the lowland. Corn's field (harvested), to the right of a small path that brings to the farmhouse, distant about 100 m. Mixed clay soil, compact and wet; stratification of organic matter, due to plowing down to 45 cm.

Land-use: corn (alternation every 5 years with *lolium italicum*)

Applied fertilizers: 2004 150 kg/ha 18N-46P
300 kg/ha KCl
cattle sewages

2003 and prev years: same as above

Stones on surface: absent

Substratum: river sediments not calcareous; particle size mainly loamy sand

Horizons description:

Ap1 (0÷25) 0÷20 cm, damp, brown (10YR5/3), loam, sub-angular polyhedric fragments, medium and moderately developed, frequent thin roots, not calcareous, low limit abrupt-linear.

Ap2 (25÷50) 20÷45 cm, damp, brown yellowish (10YR5/4), loam, sub-angular polyhedric aggregation big and moderately developed, frequent very thin roots, not calcareous, low limit abrupt-linear.

Bt1 (50÷75) 45÷85 cm, damp, mainly strong brown colour (7,5YR5/6), secondarily brown yellowish (10YR5/6), abundant small variegations of strong brown colour (7,5YR4/6) of clean limit, loam, sub-angular polyhedric aggregation big and moderately developed, many small concentrations not cemented of Fe-Mn, a lot of argillans on the aggregate faces, roots absent, not calcareous, low limit abrupt-undulated.

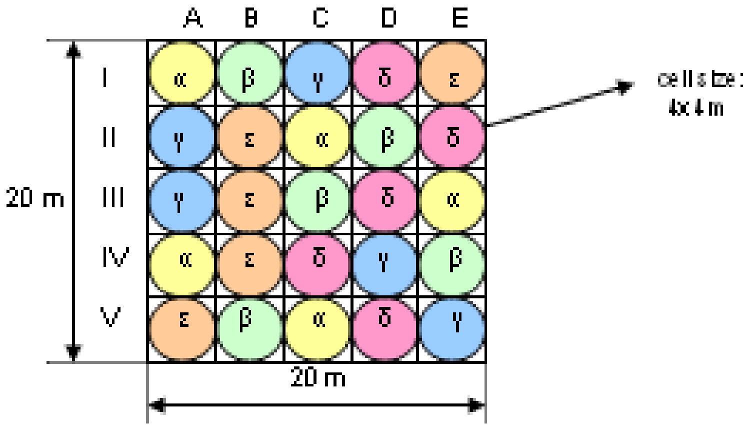
2E/Bt2 (75÷100+) 85÷170 cm, damp, brown yellowish (10YR5/8), incoherent sand with intercalated brown, sub-horizontal thin plates (7,5YR5/4), sandy loam, sub-angular polyhedric aggregation fine and weakly developed, very small concentrations not cemented of Fe-Mn common in the whole horizon, roots absent, not calcareous, low limit abrupt-linear.

2Cg 170÷185 cm and over, wet, brown greyish (10YR5/2), incoherent sand, roots absent, not calcareous, low limit unknown.

Classification: fine loamy, mixed active, mesic (Thapto-lamellic) Ultic Haplustalf

The term "Thapto-lamellic" is linked to the presence of clay thin plates in depth, inside a sunken soil, different and more evolved in comparison to superficial soil.

Sampling scheme:

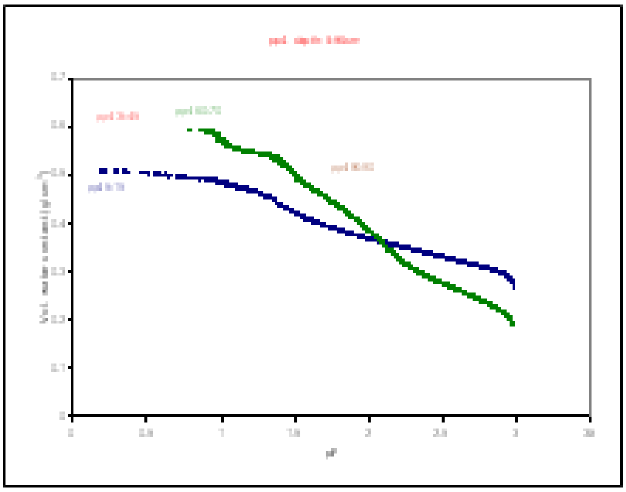


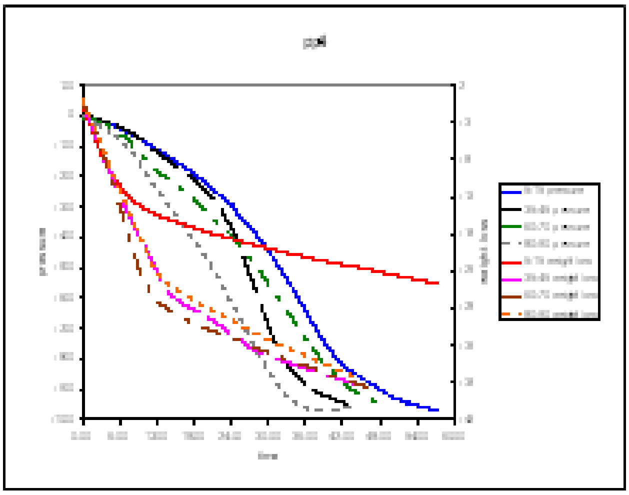
Random-stratified sampling approach for PP4 sampling. A composite sample is obtained by mixing equal aliquots of all 5 sub-samples, for each stratum (same colour)

Analysis Results

Sample		α 0÷25 cm	β 0÷25 cm	γ 0÷25 cm	δ 0÷25 cm	ε 0÷25 cm	Mean value	α 75÷100 cm	β 75÷100 cm	γ 75÷100 cm	δ 75÷100 cm	ε 75÷100 cm	Mean value
Humidity	%	nd	nd	nd	nd	nd	21.4	nd	nd	nd	nd	nd	10.4
Texture	% sand	nd	nd	nd	nd	nd	46	nd	nd	nd	nd	nd	75
	% clay	nd	nd	nd	nd	nd	8	nd	nd	nd	nd	nd	14
	% silt	nd	nd	nd	nd	nd	46	nd	nd	nd	nd	nd	11
pH		6.2	6.2	6.5	6.4	6.3	6.1	6.1	6.1	5.8	6.8	6.9	6.3
C	% total	1.4	1.4	1.3	1.4	1.3	1.3	0.16	0.18	0.15	0.22	0.27	0.20
	% organic	1.1	1.2	1.1	1.2	1.2	1.1	0.12	0.15	0.14	0.21	0.20	0.16
	% $CaCO_3$	2.3	1.7	1.8	1.7	0.8	1.6	0.33	0.25	0.08	0.08	0.58	0.27
H	%	0.49	0.49	0.49	0.45	0.48	0.48	0.33	0.36	0.36	0.29	0.34	0.34
N	%	0.15	0.15	0.14	0.14	0.17	0.15	0.03	0.03	0.03	0.02	0.06	0.03
Mercury	µg/g	0.045	0.046	0.048	0.040	0.042	0.044	0.022	0.021	0.019	0.019	0.020	0.020
Fe_2O_3	%	3.2	3.0	3.0	3.1	3.1	3.1	3.6	3.7	3.6	3.5	3.6	3.6
Na_2O	%	1.8	1.9	2.0	1.9	2.0	1.9	1.9	2.0	2.0	1.9	1.9	1.9
SiO_2	%	68.6	71.3	72.0	70.2	71.8	70.8	67.0	68.9	69.5	68.0	68.1	68.3
Al_2O_3	%	12.8	11.8	11.7	12.3	11.7	12.0	14.4	13.8	13.3	13.7	13.6	13.7
CaO	%	1.7	1.7	1.6	1.7	1.7	1.6	1.6	1.6	1.6	1.7	1.7	1.6
K_2O	%	2.3	2.1	2.1	2.2	2.2	2.2	2.2	2.2	2.1	2.2	2.2	2.1
MgO	%	1.4	1.2	1.1	1.3	1.2	1.2	1.7	1.5	1.4	1.7	1.6	1.6
TiO_2	mg/kg	6345	5906	5955	6289	61	4911	4291	4442	4209	4400	4416	4352
P_2O_5	mg/kg	3606	3734	3238	3719	3380	3535	2106	2042	1914	2090	2245	2079
S	mg/kg	305	275	287	279	267	283	40	30	23	50	70	43

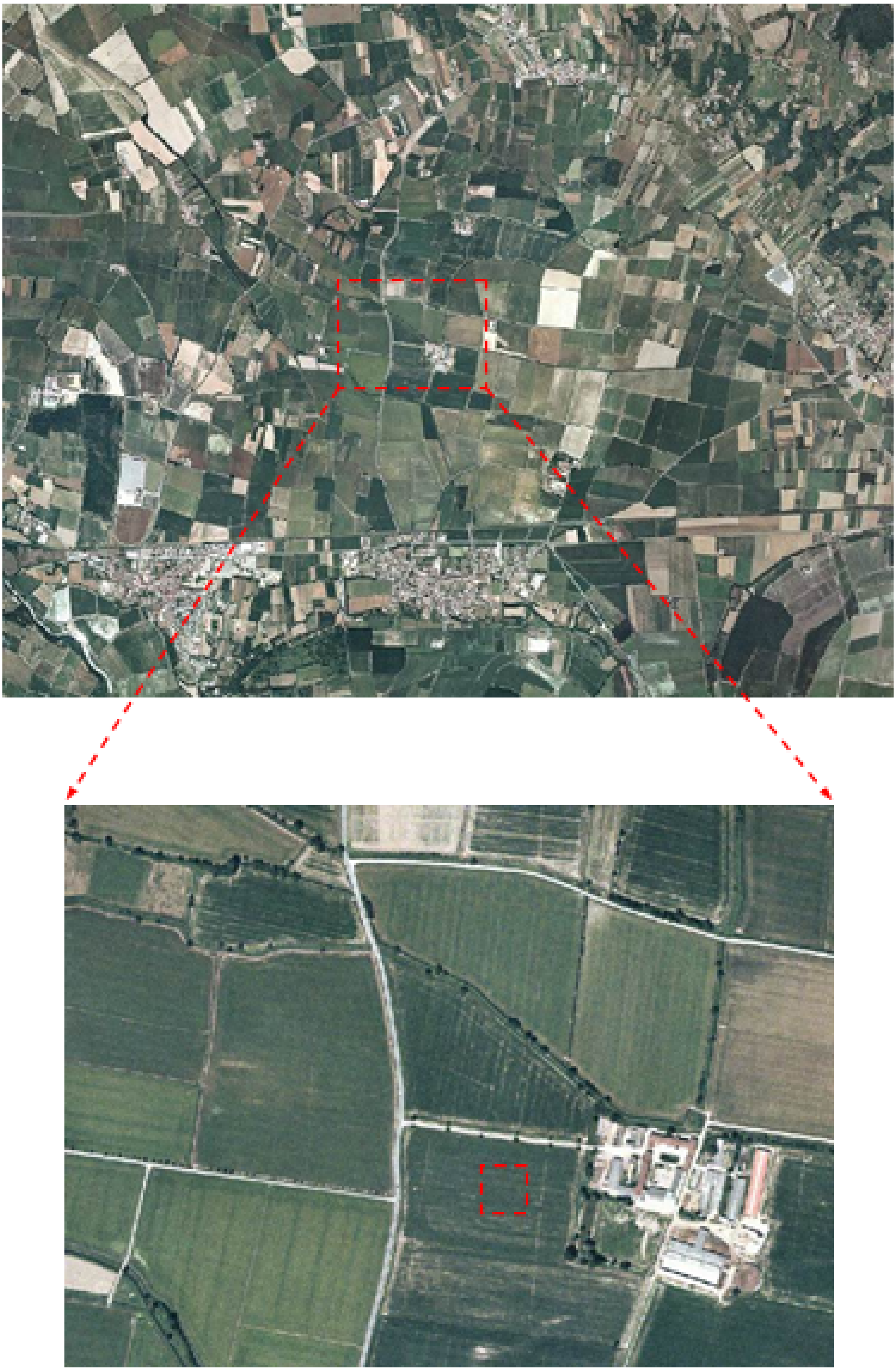
		0÷25 cm depth	25÷50 cm depth	50÷75 cm depth	75÷100 cm depth
Bulk density	g/cm^3	1.40	1.19	1.13	1.22
saturated water content	g/cm^3	0.52	0.59	0.59	0.58
Porosity		0.472	0.550	0.573	0.540

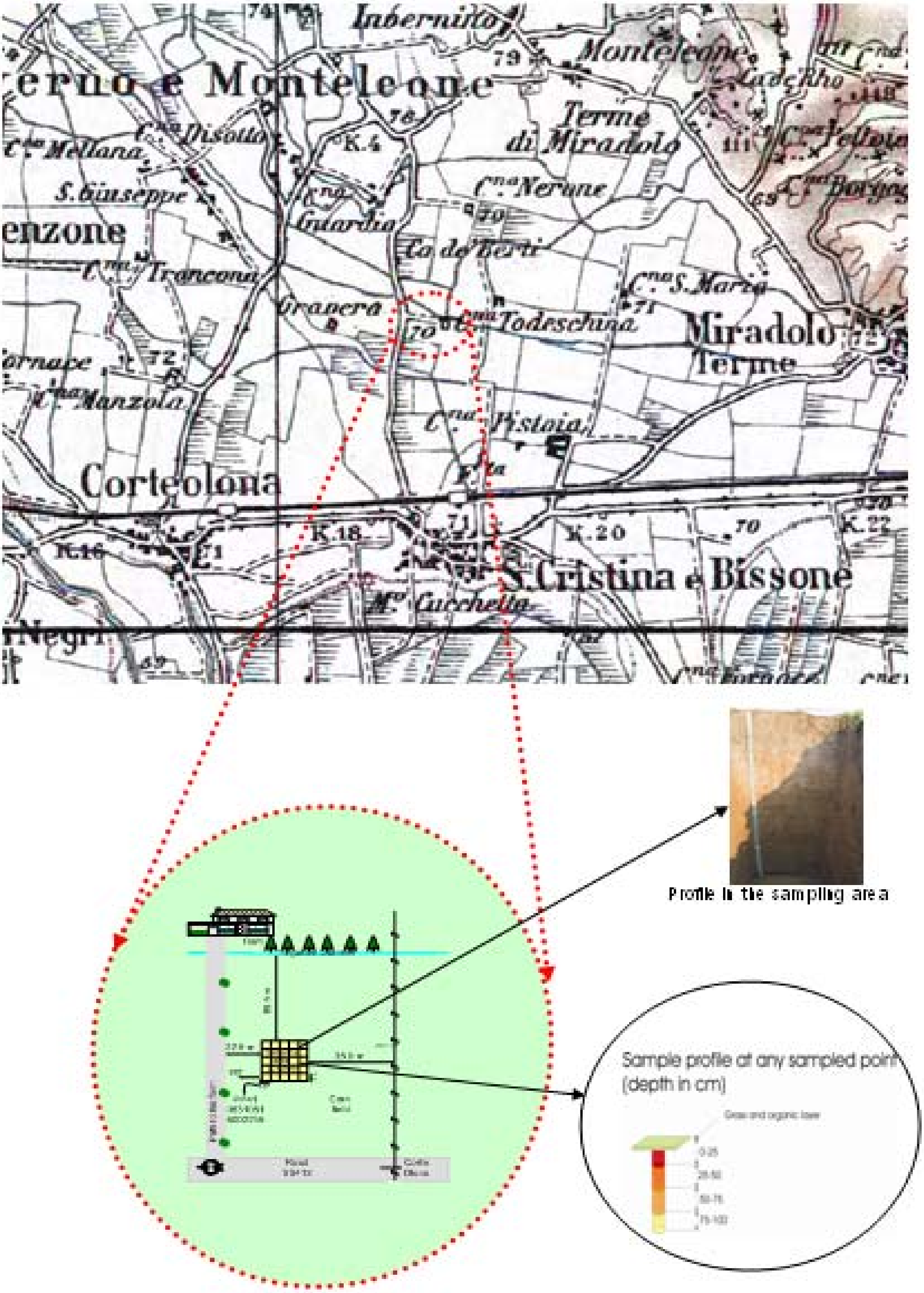




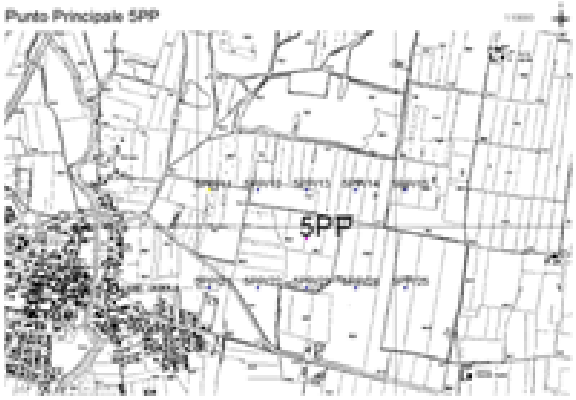
Soil retention curves

Location of PP4 sampling area




Inbernitto
Monteleone
Terme di Miradolo
C.na Nerone
Ca de Berti
C.na S. Maria
Granera
C.na Todeschina
Miradolo Terme
Corteolona
C.na Pistoia
K.18
K.20
K.22
S. Cristina e Bissone
Profile in the sampling area
Sample profile at any sampled point
(depth in cm)
Grass and organic layer
0-25
25-50
50-75
75-100

PP5: Sampling Area Description



Map 1

Phot Nr.1

Phot Nr.2

Phot Nr.3

Location ID: Casei Gerola – Northeast outskirts

Geographic area: Provincia di Pavia – Lowland of the Oltrepo' pavese deriving from Appennino

Sampling date: 9 November 2004

Coordinates Position format: UTM/UPS Map Datum: WGS 84

	32T	Lat.	0495018
		Long.	4984182

Quota and inclination: 79 m; 0 %

Area description: wide hollows artificially drained (recent reclamation), constituted of very thin sediments. Fields of medical grass placed side by side with vineyard (same crop since ten years). Clay mixed land, with small irrigation channels in the borders; level and well flattened land: grey soil at 50 cm depth, calcareous, quite dry and homogeneous, almost floury. Vegetation in the nearby: wheat, walnut-trees and cherries.

Land-use: inter-rows of vineyard sowed with medical grass

Applied fertilizers: nothing since two years; potassium just under vineyards and verdigris on the vineyards

Stones on surface: absent

Substratum: silt and calcareous clays

Horizons description:

Ap1 (0÷10) 0÷20 cm, damp, brown (10 YR5/3), frequent middle-size variegations of strong brown colour (7,5YR5/6) of clean limit, silty clay loam, angular polyhedric fragments, medium size and moderately developed, few very thin macro pores, frequent thin and very thin roots, calcareous, low-limit abrupt-undulated.

Ap2 (20÷40) 20÷45 cm, damp, brown yellowish (10YR5/4), silty clay loam, angular polyhedric aggregation big and moderately developed, few very thin macro pores, few very thin roots, calcareous, low-limit clear undulated.

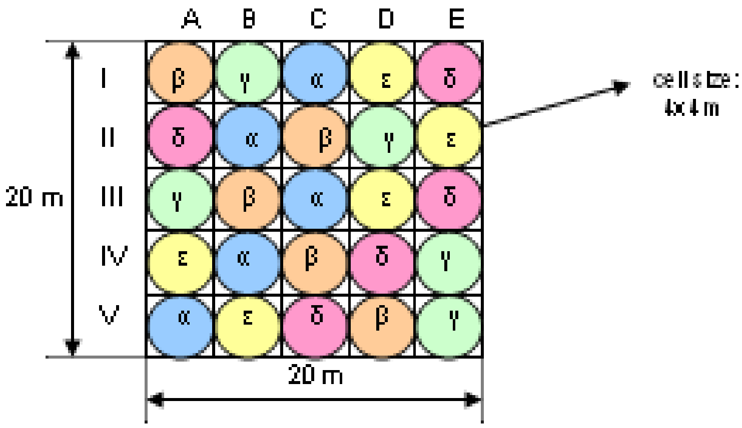
Bss (50÷80) 45÷100 cm, damp, brown yellowish (mainly 10YR5/4, secondarily 10YR5/6), silty clay loam, medium angular polyhedric aggregation strongly developed, common agricutans, few slickenside, few very thin roots, calcareous, low limit clear-linear.

BC (80÷100+) 100÷130 cm, damp, mainly brown yellowish (10YR5/6), secondarily yellow brownish (10YR6/6), silty clay loam, sub-angular polyhedric aggregation big and weakly developed, few very thin roots, calcareous, low limit clear-linear.

C 130÷155 cm and over, damp, yellow brownish (10YR6/6), silty clay loam, massive, roots absent, calcareous, low limit unknown.

Classification: fine, mixed, super active, mesic Vertic Haplustept

Sampling scheme:

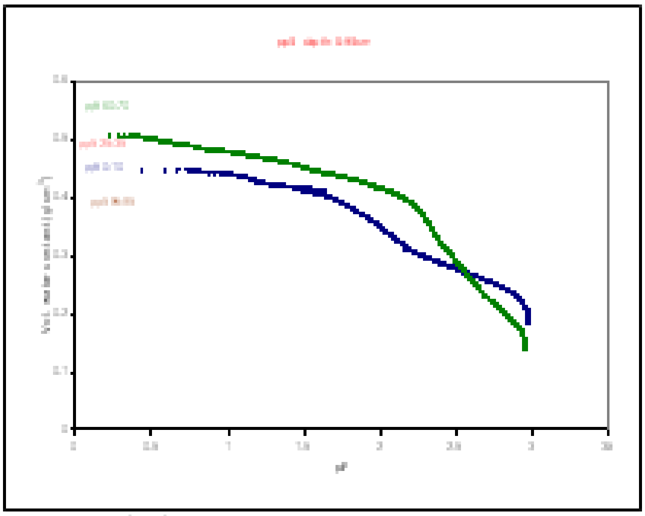


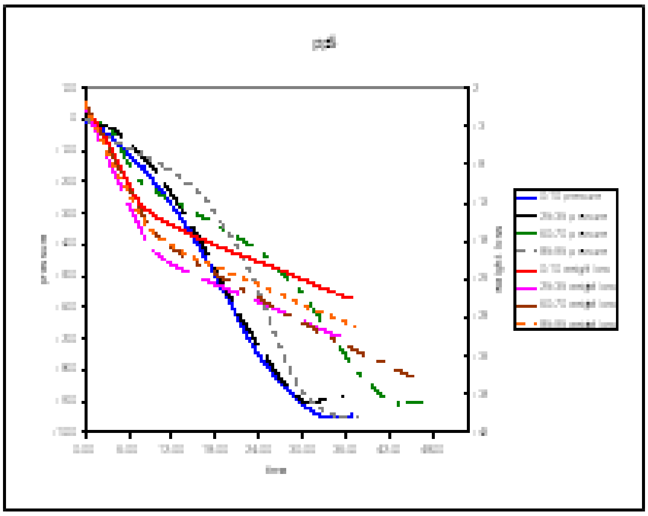
Random-stratified sampling approach for PP5 sampling. A composite sample is obtained by mixing equal aliquots of all 5 sub-samples, for each stratum (same colour)

Analysis Results

Sample		α 0÷10 cm	β 0÷10 cm	γ 0÷10 cm	δ 0÷10 cm	ε 0÷10 cm	Mean value	α 80÷100 cm	β 80÷100 cm	γ 80÷100 cm	δ 80÷100 cm	ε 80÷100 cm	Mean value
Humidity	%	nd	nd	nd	nd	nd	15.6	nd	nd	nd	nd	nd	16.9
Texture	% sand	nd	nd	nd	nd	nd	9	nd	nd	nd	nd	nd	1
	% clay	nd	nd	nd	nd	nd	37	nd	nd	nd	nd	nd	35
	% silt	nd	nd	nd	nd	nd	54	nd	nd	nd	nd	nd	64
pH		7.4	7.3	7.3	7.5	7.5	7.4	7.5	7.6	7.6	7.7	7.3	7.6
C	% total	3.3	3.5	3.4	3.4	3.3	3.4	3.19	3.09	3.36	3.30	3.22	3.23
	% organic	1.1	1.2	1.1	1.0	1.1	1.1	0.52	0.62	0.61	0.66	0.62	0.61
	% CaCO3	18.3	19.6	19.3	19.5	18.9	19.1	22.25	20.58	22.92	22.00	21.67	21.89
H	%	0.62	0.68	0.67	0.69	0.69	0.67	0.57	0.59	0.62	0.61	0.65	0.61
N	%	0.15	0.16	0.15	0.14	0.14	0.15	0.07	0.08	0.08	0.08	0.08	0.08
Mercury	μg/g	0.051	0.049	0.048	0.045	0.044	0.047	0.037	0.034	0.038	0.036	0.036	0.036
Fe2O3	%	5.5	5.5	5.5	5.4	5.3	5.4	5.2	5.5	5.3	5.3	5.3	5.3
Na2O	%	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
SiO2	%	47.8	47.7	47.8	47.5	47.5	47.7	46.1	46.5	45.9	46.1	46.3	46.2
Al2O3	%	14.9	14.8	14.7	14.6	14.2	14.6	13.9	14.4	13.7	13.9	13.9	14.0
CaO	%	9.3	9.7	9.8	9.9	10.1	9.8	11.4	10.9	11.6	11.5	11.2	11.3
K2O	%	2.6	2.6	2.6	2.5	2.5	2.5	2.4	2.5	2.4	2.4	2.4	2.4
MgO	%	4.2	4.3	4.3	4.3	4.3	4.3	4.1	4.1	4.1	4.2	4.2	4.1
TiO2	mg/kg	5766	5779	5787	5682	5546	5712	5563	5789	5538	5561	5494	5589
P2O5	mg/kg	1682	1685	1673	1606	1713	1672	1168	1155	1190	1198	1196	1181
S	mg/kg	310	303	264	249	285	282	109	113	128	133	116	120

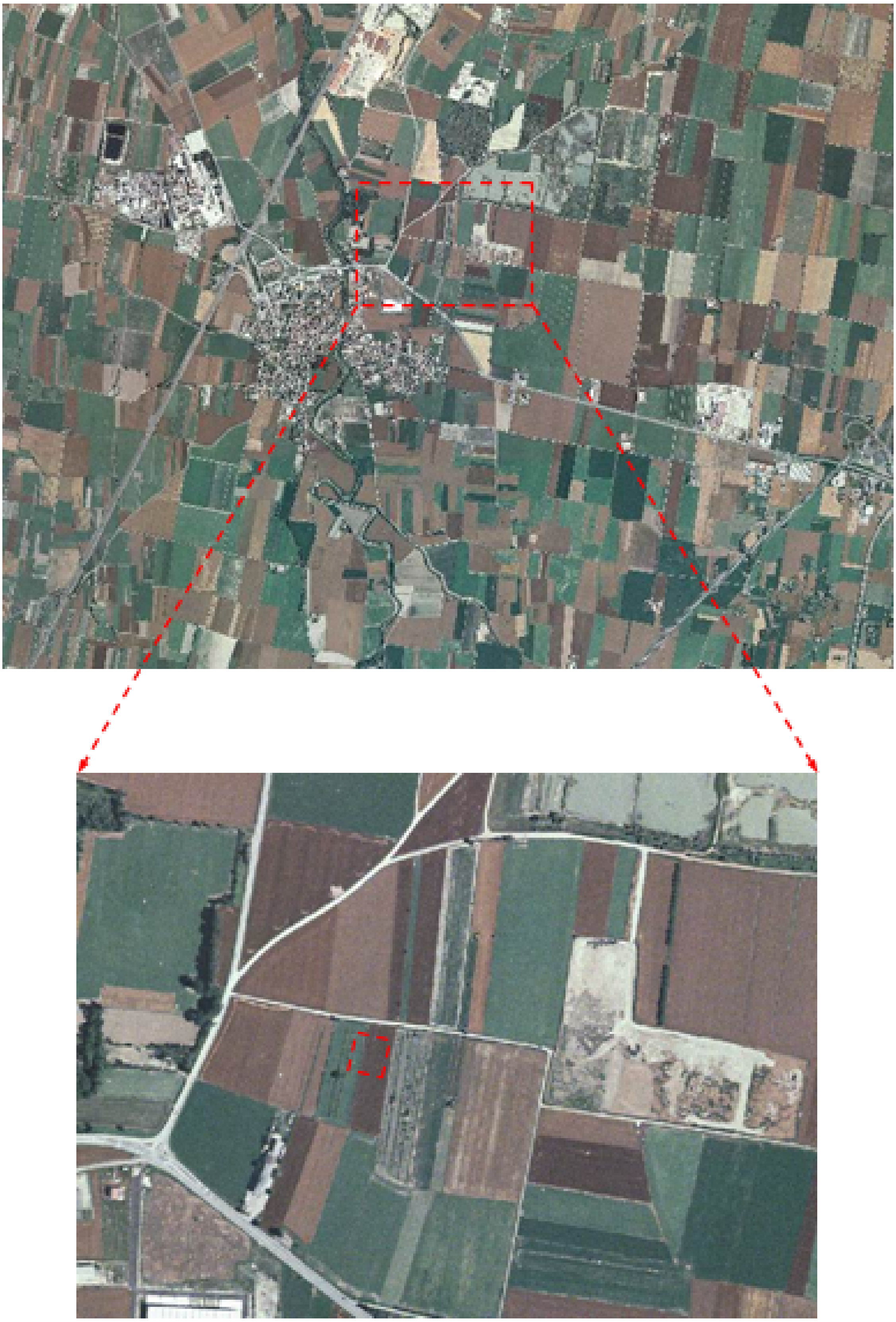
		0÷10 cm depth	20÷40 cm depth	50÷80 cm depth	80÷100 cm depth
Bulk density	g/cm³	1.57	1.43	1.57	1.58
saturated water content	g/cm³	0.45	0.50	0.46	0.44
Porosity		0.407	0.460	0.409	0.405

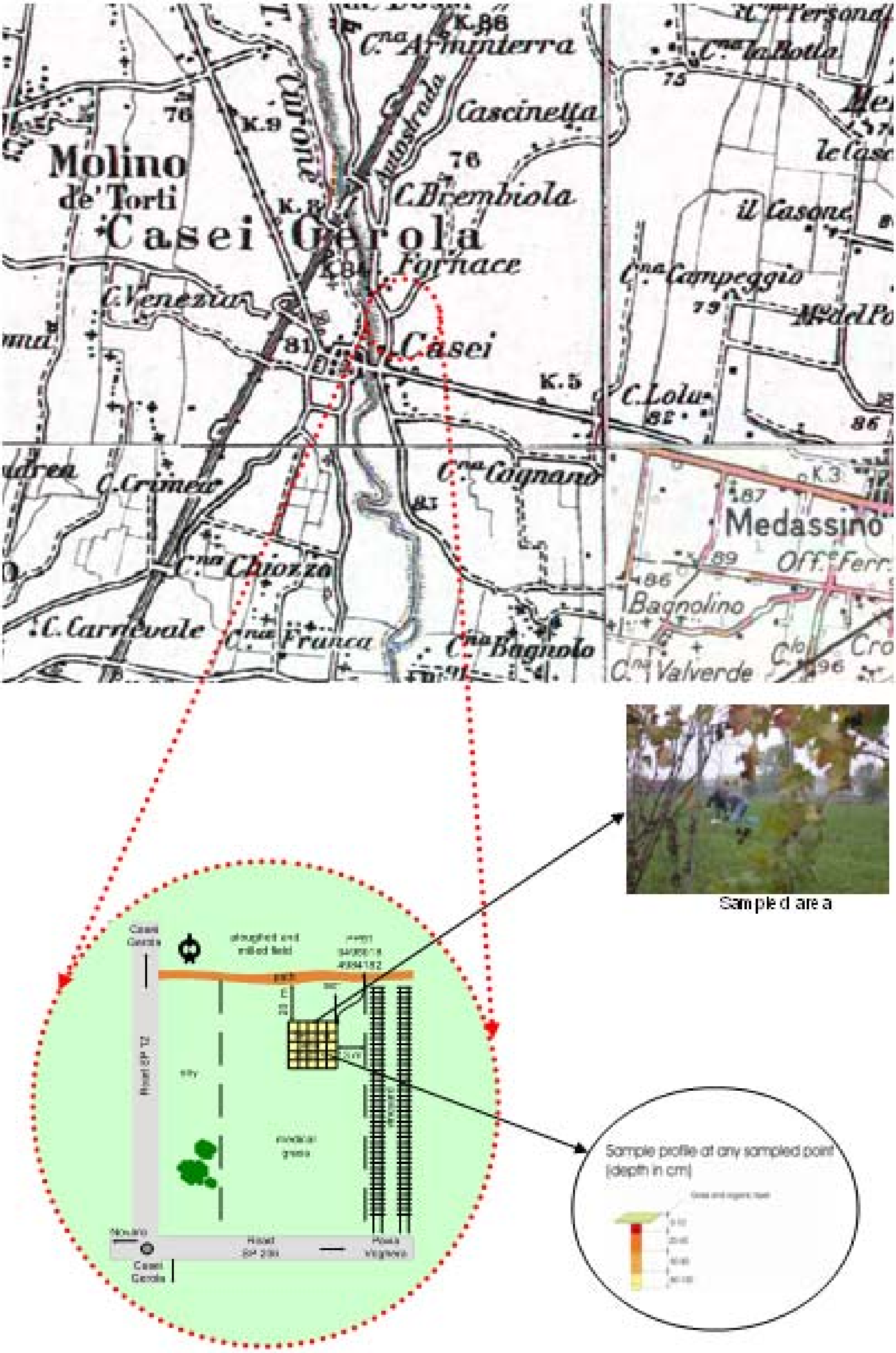




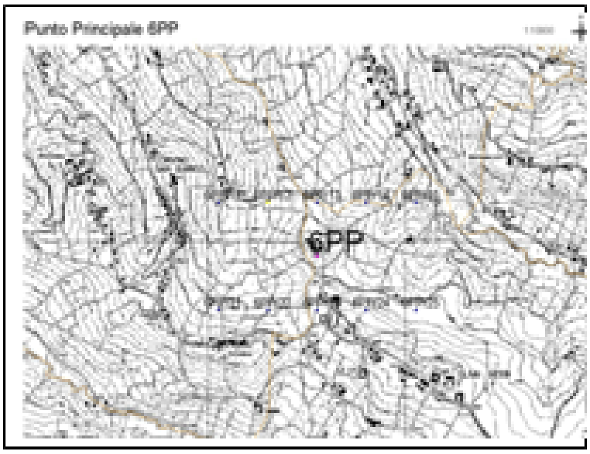
Soil retention curves

Location of PP5 sampling area




Molino
de' Torti
Casei Gerola
Cascinetta
Autostrada
Curone
C.Brembiola
Fornace
C.Venezia
Casei
il Casone
Cna Campeggio
C.Lolu
C.Crimea
Cna Cagnano
Medassino
Cna Chiozzo
Bagnolino
C.Carnevale
Cna Franca
Cna Bagnolo
Cna Valverde
Sampled area
Sample profile at any sampled point
(depth in cm)

PP6: Sampling Area Description



Map 1

Phot Nr.1

Phot Nr.2

Phot Nr.3

Location ID: Corvino S. Quirico – Valle Stroggini

Geographic area: Provincia di Pavia – low hills of Val Versa

Sampling date: 17 November 2004

<u>Coordinates</u> Position format: UTM/UPS Map Datum: WGS 84

32T Lat. 0513337

Long. 4984208

Quota and inclination: 190 m; 15% (varying, but however < 25%)

Area description: slopes with inclination from elevate to extremely elevate; site on the hillside exposed to west. Areas used as pasture, or cultivated as vineyard or orchards on the less sheers surfaces or artificially terraced. Soil very fertile, rich and dark, humus actually down to 80 cm.

Land-use: vineyard, with inter-rows cultivated with medical grass

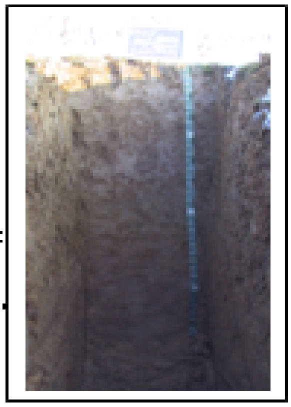
Applied fertilizers: <u>2004</u> organic fertilizer (rarely)
verdigris (small quantities)
S in powder (significant quantities)
pyrethrum as insecticide

<u>2003 and prev years:</u> same as above

Stones on surface: absent

Erosion: absent

Substratum: clays and shales



Horizons description:

Ap1 (0÷15) 0÷20 cm, damp, brown olive (2,5Y4/4), silt loam, sub-angular polyhedric fragments big and moderately developed, few small concretions of $CaCO_3$, frequent middle-size macro pores, frequent thin and very thin roots, poorly calcareous, low limit abrupt-linear.

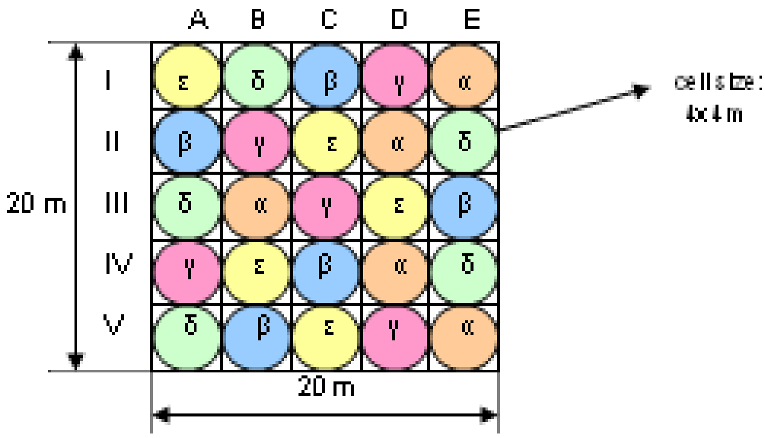
Ap2 (20÷40) 20÷70 cm, damp, brown yellowish (10YR5/6), clay loam, big and moderately developed sub-angular polyhedric aggregation, few small concretions of $CaCO_3$, frequent middle-size macro pores, few thin and very thin roots, poorly calcareous, low limit abrupt- undulated.

Bw (50÷80) 70÷105 cm, damp, brown yellowish (mainly 10YR5/8, secondarily 10YR5/4), silty clay loam, big and strongly developed sub-angular polyhedric aggregation, few very small concentrations not cemented of Fe-Mn, , frequent very thin macro pores, few thin roots, poorly calcareous, low limit clear-linear.

C (80÷100+) 105÷180 cm and over, damp, mainly light brown olive (2,5Y5/6), secondarily brown yellowish (10YR5/8), silt loam, massive, many small concentrations not cemented of Fe-Mn, very few very thin macro pores, roots absent, poorly calcareous, low limit unknown.

Classification: fine silty, mixed, super active, mesic Typic Haplustept

Sampling scheme:

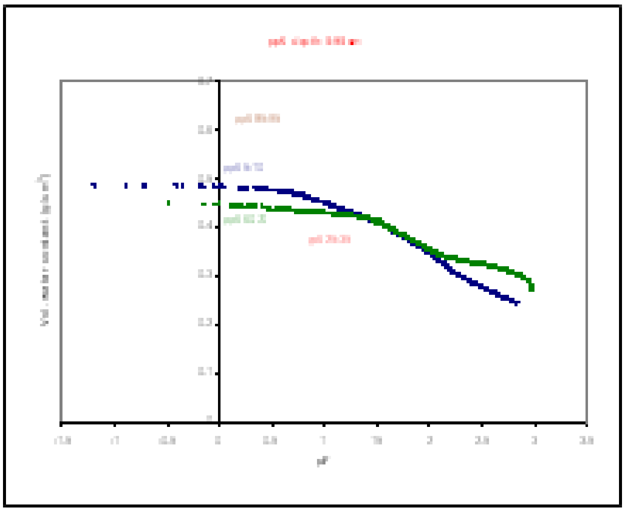


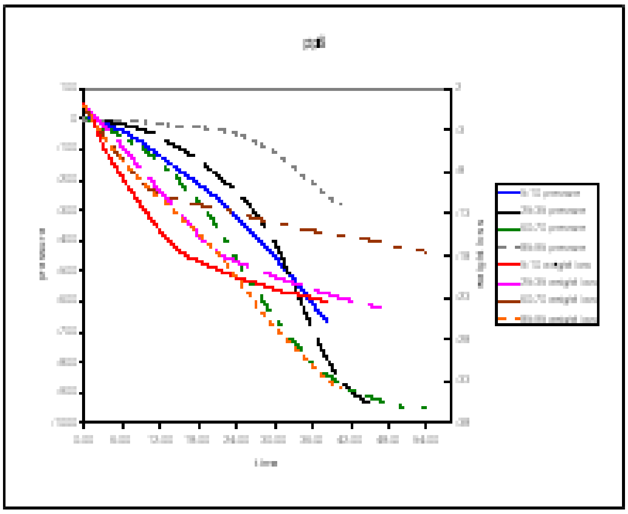
Random-stratified sampling approach for PP6 sampling. A composite sample is obtained by mixing equal aliquots of all 5 sub-samples, for each stratum (same colour)

Analysis Results

Sample		α 0÷15 cm	β 0÷15 cm	γ 0÷15 cm	δ 0÷15 cm	ε 0÷15 cm	Mean value	α 80÷100 cm	β 80÷100 cm	γ 80÷100 cm	δ 80÷100 cm	ε 80÷100 cm	Mean value
Humidity	%	nd	nd	nd	nd	nd	16.5	nd	nd	nd	nd	nd	10.2
Texture	% sand	nd	nd	nd	nd	nd	14	nd	nd	nd	nd	nd	13
	% clay	nd	nd	nd	nd	nd	25	nd	nd	nd	nd	nd	27
	% silt	nd	nd	nd	nd	nd	61	nd	nd	nd	nd	nd	60
pH		7.6	7.5	7.6	7.5	7.4	7.5	7.5	7.5	7.7	7.8	7.8	7.7
C	% total	3.1	2.1	2.1	2.6	1.7	2.3	1.03	0.85	1.16	4.19	3.86	2.22
	% organic	1.4	1.4	1.3	1.0	1.2	1.2	0.41	0.33	0.41	0.22	0.20	0.31
	% CaCO3	14.3	6.2	6.5	13.8	4.1	9.0	5.17	4.33	6.25	33.09	30.50	15.87
H	%	0.58	0.59	0.61	0.62	0.55	0.59	0.55	0.59	0.50	0.60	0.53	0.55
N	%	0.17	0.16	0.16	0.13	0.14	0.15	0.07	0.16	0.06	0.03	0.04	0.07
Mercury	µg/g	0.046	0.037	0.033	0.039	0.039	0.039	0.036	0.035	0.030	0.046	0.030	0.035
Fe2O3	%	5.1	5.3	5.5	5.3	5.9	5.4	5.9	5.4	5.5	4.7	4.6	5.2
Na2O	%	1.0	1.4	1.3	1.0	1.3	1.180	1.2	1.7	1.4	0.6	0.6	1.090
SiO2	%	53.2	56.7	56.8	53.0	57.7	55.5	58.2	59.2	57.2	40.9	43.1	51.7
Al2O3	%	13.3	15.2	15.4	14.0	16.1	14.8	16.2	15.6	15.5	9.8	10.5	13.5
CaO	%	8.3	4.8	4.8	7.9	3.7	5.9	3.9	4.2	5.0	18.9	17.1	9.8
K2O	%	2.5	2.6	2.6	2.4	2.6	2.5	2.6	2.5	2.4	1.7	1.9	2.2
MgO	%	2.5	2.6	2.5	2.5	2.6	2.5	2.6	2.6	2.6	2.0	2.2	2.4
TiO2	mg/kg	5938	6575	6693	6199	7140	6509	7269	6936	6911	4575	4796	6098
P2O5	mg/kg	1651	1712	1579	1375	1409	1545	1215	1478	1340	1111	1048	1238
S	mg/kg	305	299	290	231	237	272	73	37	95	95	46	69

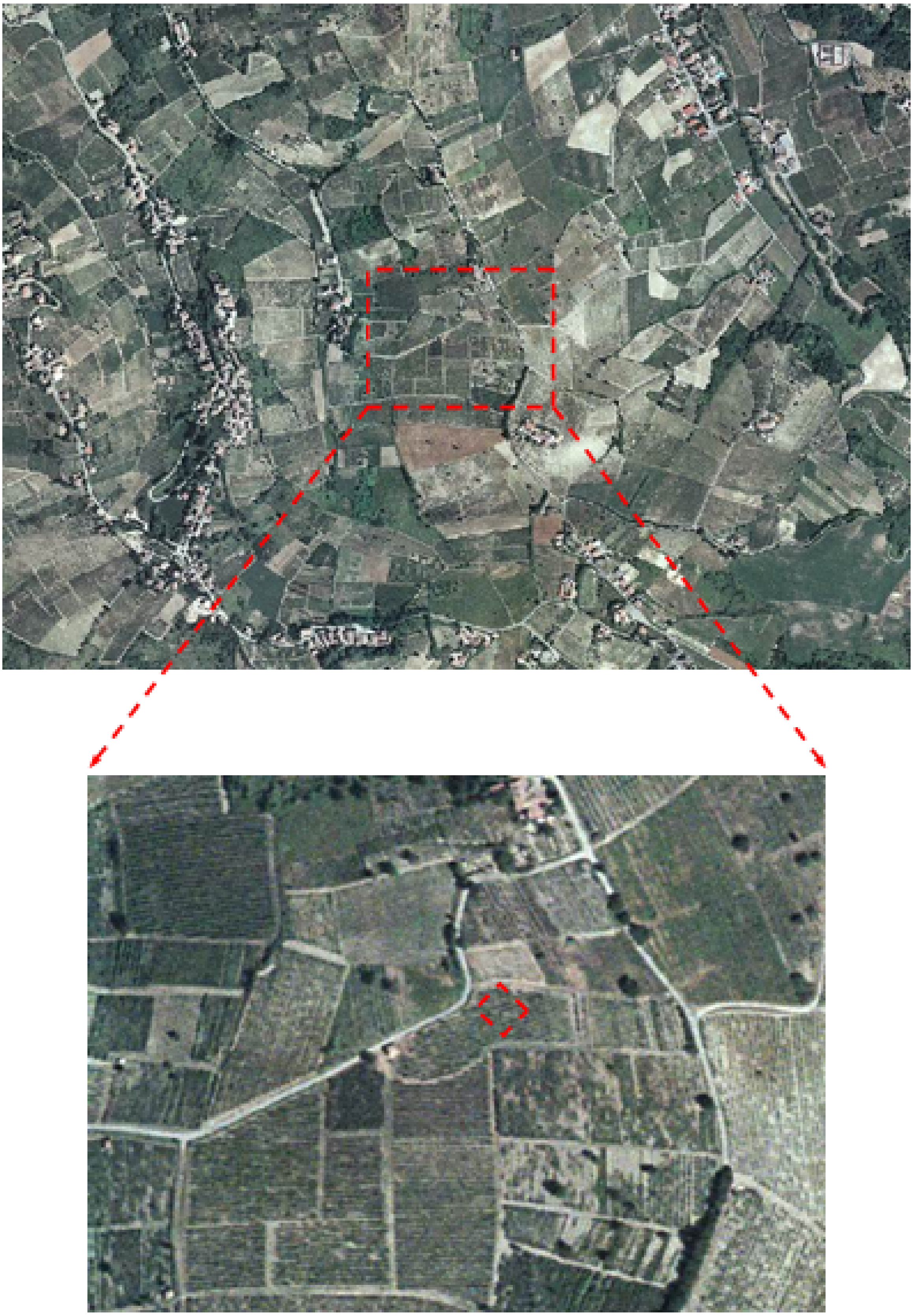
		0÷15 cm depth	20÷40 cm depth	50÷80 cm depth	80÷100 cm depth
Bulk density	g/cm³	1.45	1.50	1.58	1.11
saturated water content	g/cm³	0.46	0.46	0.45	0.58
Porosity		0.453	0.436	0.403	0.583

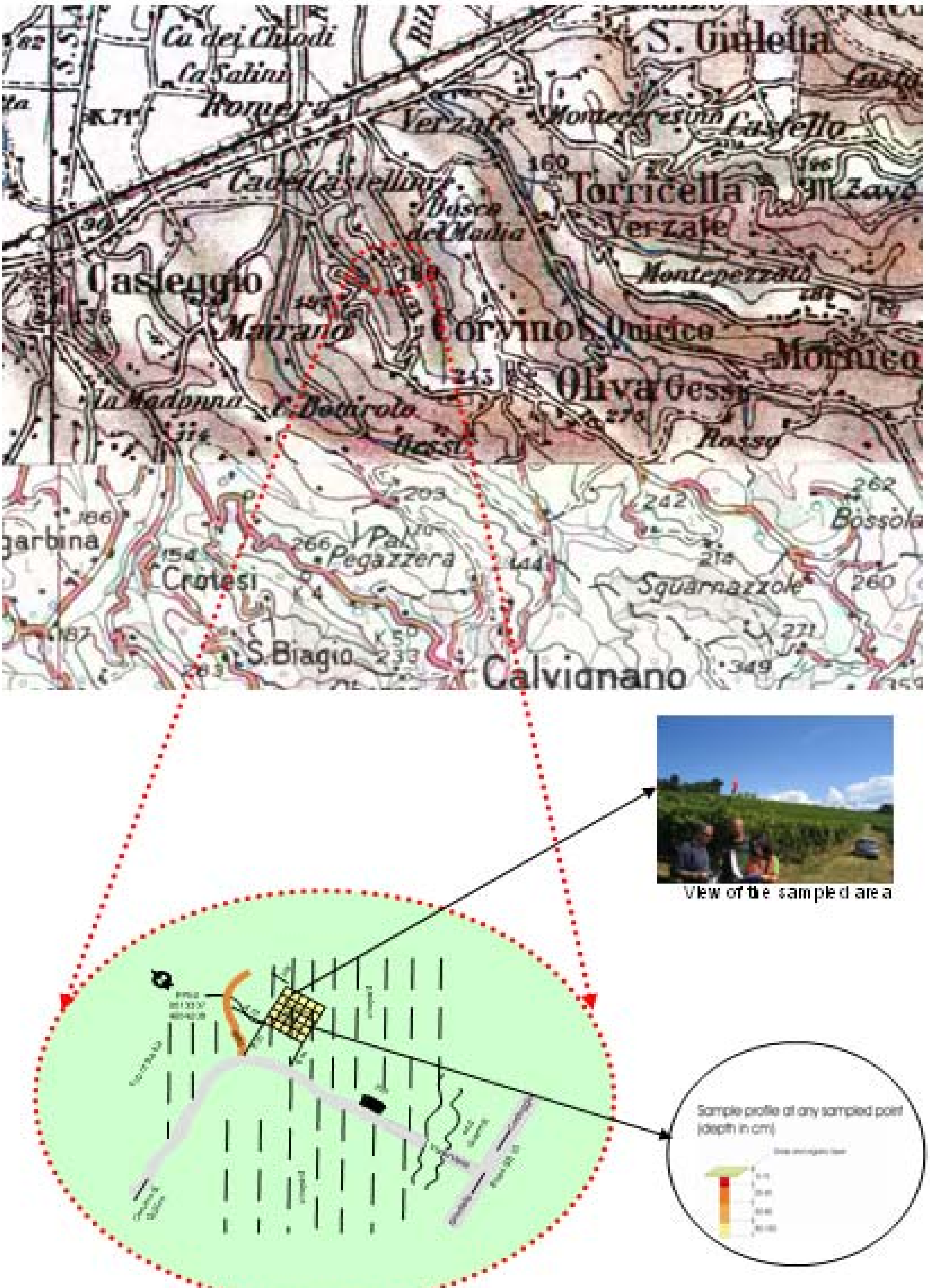




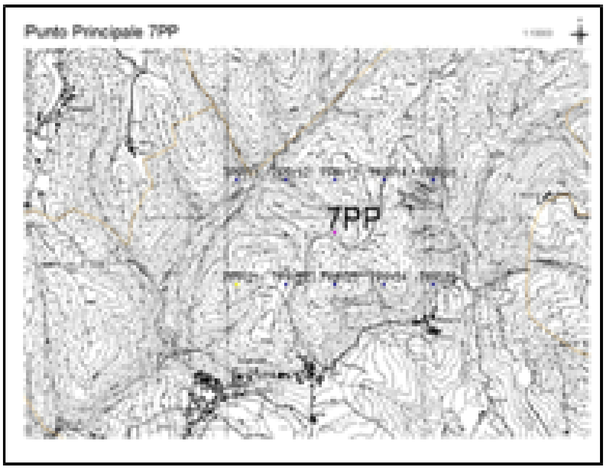
Soil retention curves

Location of PP6 sampling area




Ca dei Chiodi
Ca Salini
Romera
S. Giuletta
Verzate
Montecresino
Castello
Torricella
Verzate
Bosco del Matia
Casteggio
Mairano
Corvino S. Quirico
Montepezzolo
Mornico
Oliva Gessi
La Madonna
C. Bettirolo
Gessi
Rosso
Crotesi
Pegazzera
Squarnazzole
Bossola
S. Biagio
Calvignano
View of the sampled area
Sample profile at any sampled point (depth in cm)

PP7: Sampling Area Description



Map 1

Phob Nr.1

Phob Nr.2

Phob Nr.3

Location ID: Varzi – Sagliano

Geographic area: Provincia di Pavia – high hill and medium mountains of Oltrepò pavese

Sampling date: 15 November 2004

Coordinates	Position format: UTM/UPS		Map Datum: WGS 84
	32T	Lat.	0513206
		Long.	4965619

Quota and inclination: 710 m; 30 %

Area description: high part of a ridge with rounded off slope, inclination from moderate to moderately elevate. Sampling point close to the top of the hill; chestnut and larch forest; small glade, the land presents light inclination in direction WNW ←→ ESE. The area shows soft and humus enriched soil, mixed calcareous - siliceous, good drainage.

Land-use: copse chestnut grove with presence of oak, black hornbeam, flowering ash, hazel and locust.

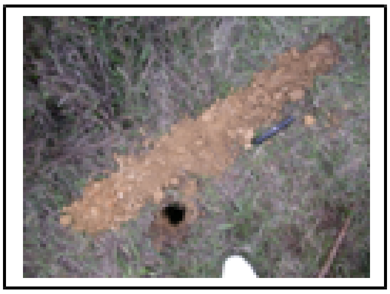
Applied fertilizers: nothing

Stones on surface: absent

Erosion: water, superficial and moderate; it is accented by the copse management

Substratum: heterogeneous complex

Horizons description:



L 5÷0 cm, low limit abrupt-discontinuous.

A 0÷2 cm, damp, dark brown (10Y3/3), sandy loam, granular aggregation medium and moderately developed, frequent middle-size macro pores, frequent very thin roots, not calcareous, low limit abrupt-linear.

Bw1 (0÷10) 2÷30 cm, damp, mainly brown olive (2,5Y4/4), secondarily dark brown yellowish colour (10YR4/6), sandy loam, middle-size and moderately developed sub-angular polyhedric aggregation, frequent thin and middle-size macro pores, many big and thin roots, poorly calcareous, low limit clear-linear.

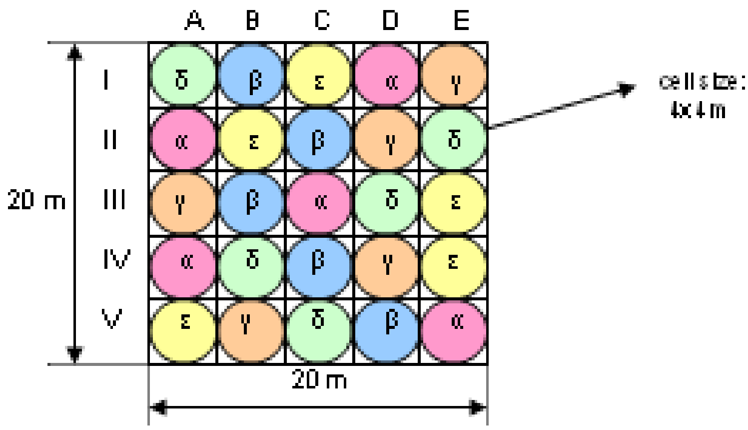
Bw2 (20÷40) 30÷45 cm, damp, brown olive (2,5Y4/4), sandy loam, big and weakly developed sub-angular polyhedric aggregation, frequent thin and middle-size macro pores, frequent medium and big roots, calcareous, low limit abrupt-linear.

C1 (50÷70) 45÷55 cm, damp, light brown yellowish (2,5Y6/4), sandy loam, massive, frequent thin and middle-size macro pores, many medium and thin roots, very calcareous, low limit abrupt-linear.

C2 (70÷100+) 55÷110 cm and over, damp, light brown yellowish (2,5Y6/4), abundant grey dark greenish (5GB4/1) sub-horizontal variegations, medium-size and big and strongly ill-matched, sandy loam, massive, rare very thin macro pores, roots absent, very calcareous, low limit unknown.

Classification: coarse-loamy, mixed, super active, mesic Typic Haplustept

Sampling scheme:

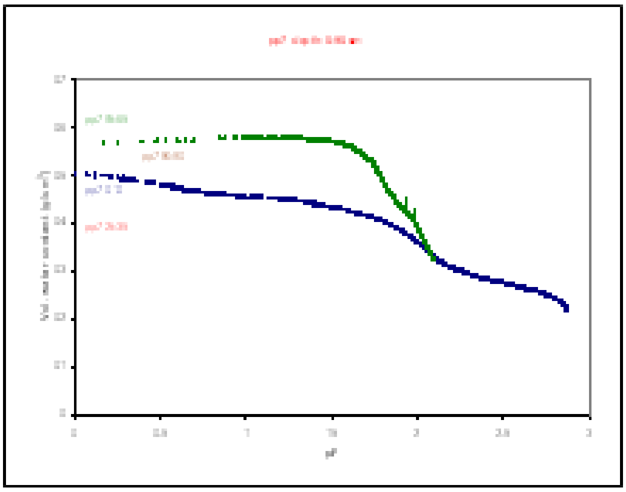


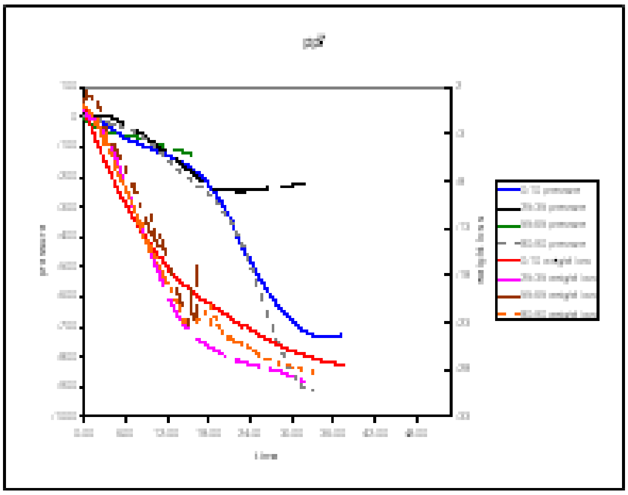
Random-stratified sampling approach for PP7 sampling. A composite sample is obtained by mixing equal aliquots of all 5 sub-samples, for each stratum (same colour)

Analysis Results

Sample		α 0÷10 cm	β 0÷10 cm	γ 0÷10 cm	δ 0÷10 cm	ε 0÷10 cm	Mean value	α 70÷100 cm	β 70÷100 cm	γ 70÷100 cm	δ 70÷100 cm	ε 70÷100 cm	Mean value
Humidity	%	nd	nd	nd	nd	nd	16.9	nd	nd	nd	nd	nd	12.2
Texture	% sand	nd	nd	nd	nd	nd	58	nd	nd	nd	nd	nd	63
	% clay	nd	nd	nd	nd	nd	13	nd	nd	nd	nd	nd	9
	% silt	nd	nd	nd	nd	nd	29	nd	nd	nd	nd	nd	28
pH		7.7	7.7	7.7	7.7	7.8	7.7	7.5	7.7	7.7	7.6	7.8	7.7
C	% total	4.2	4.8	3.7	5.1	5.0	4.6	0.86	4.18	1.21	3.86	4.73	2.97
	% organic	1.6	1.3	1.3	1.0	1.4	1.3	0.1	0.2	0.3	0.2	0.3	0.23
	% CaCO3	21.6	28.8	19.8	34.1	30.3	26.9	6.17	33.17	7.75	30.50	36.67	22.85
H	%	0.59	0.53	0.54	0.52	0.53	0.54	0.46	0.41	0.41	0.45	0.42	0.43
N	%	0.18	0.16	0.15	0.12	0.15	0.15	0.02	0.02	0.05	0.03	0.05	0.03
Mercury	μg/g	0.036	0.031	0.023	0.028	0.036	0.031	0.036	0.022	0.015	0.035	0.025	0.026
Fe2O3	%	4.7	4.0	4.3	3.3	3.6	4.0	6.1	3.4	4.3	3.4	3.0	4.0
Na2O	%	1.0	1.0	1.1	0.9	0.9	1.0	1.2	0.9	1.6	1.0	0.9	1.1
SiO2	%	50.3	46.9	53.0	42.9	44.2	47.4	61.4	42.2	65.5	45.8	41.2	51.2
Al2O3	%	8.8	7.5	9.0	6.9	7.3	7.9	11.3	6.4	9.8	7.4	6.5	8.3
CaO	%	13.5	17.6	12.3	21.5	20.0	17.0	5.1	22.4	5.7	19.8	23.3	15.2
K2O	%	1.8	1.7	1.8	1.5	1.6	1.7	2.3	1.5	2.1	1.6	1.5	1.8
MgO	%	2.1	2.1	2.3	2.0	1.9	2.1	2.0	1.8	1.8	2.0	1.8	1.9
TiO2	mg/kg	3360	2972	3471	2966	3058	3169	4055	2720	3853	2994	2745	3273
P2O5	mg/kg	1897	1842	1740	1558	1682	1744	1283	1326	1207	1250	1308	1275
S	mg/kg	474	471	441	393	432	442	< 20	139	75	143	231	147

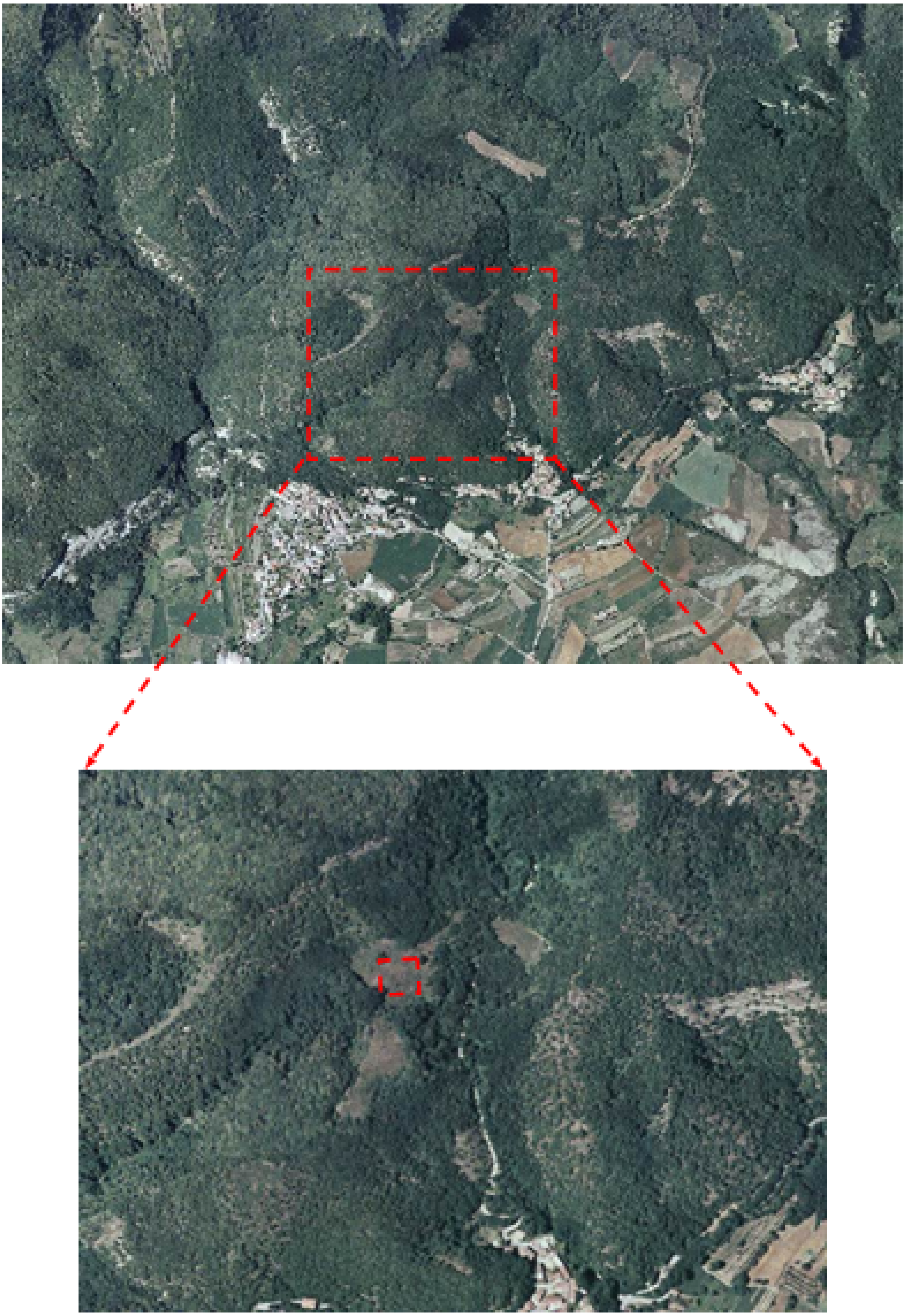
		0÷10 cm depth	20÷400 cm depth	50÷70 cm depth	70÷100 cm depth
Bulk density	g/cm³	1.46	1.41	1.10	1.12
saturated water content	g/cm³	0.48	0.47	0.57	0.56
Porosity		0.451	0.468	0.583	0.576

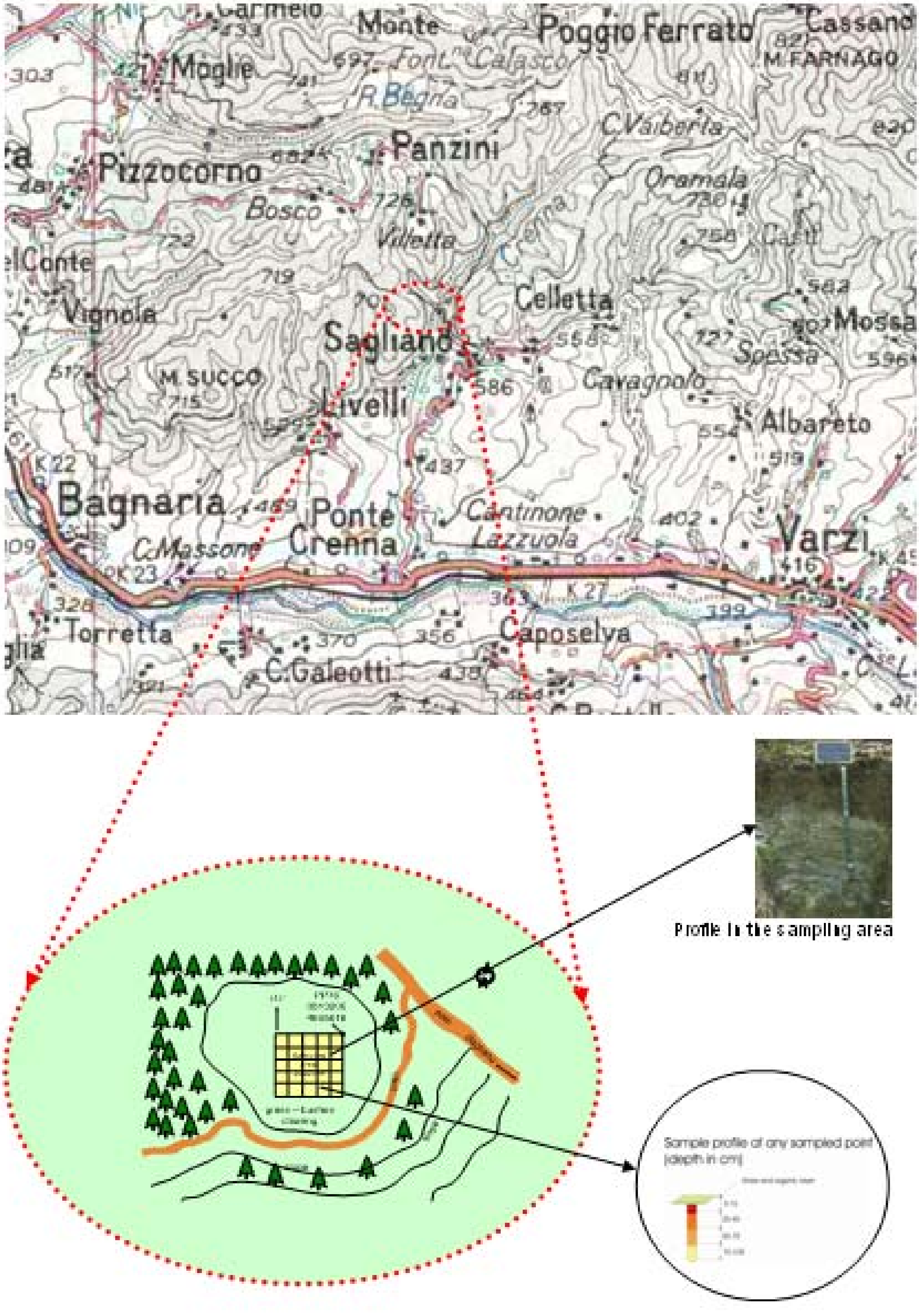




Soil retention curves

Location of PP7 sampling area





Monte
Poggio Ferrato
Cassano
M. FARNAGO
Moglie
R. Begna
C. Valberta
Panzini
Pizzocorno
Oramala
Bosco
Villetta
Casti
Celletta
Vignola
Mossa
Sagliano
Spessa
M. SUCCO
Cavagnolo
Livelli
Albareto
Bagnaria
Ponte
Crenna
Cantinone
Lazzuola
Varzi
C. Massone
Torretta
Caposelva
C. Galeotti
Profile in the sampling area
Sample profile at any sampled point (depth in cm)

1. Punto di campionamento: **PS 09**
2. Coordinate geografiche:
3. Latitudine: **504470**
4. Longitudine: **5010814**
5. Altitudine: **82 m**
6. Località: **Trivolzio – cascina Montagnola**

7. 

Figure: Mappa scala 1/10.000 (alto dx.), particolare del punto di campionamento (sx.), veduta generale dell'area (dx.)

Note

Utilizzo del suolo: campo di riso circondato da altri campi e da pioppeti

Descrizione dell'area:

circa 500 m a N: strada provinciale e paese
circa 200 m a W: pioppeto
circa 50 m a E: laghetto ghiacciato con pioppeto
circa 100 m a S: cascina dietro ad un pioppeto
circa 50 m a S-W: autostrada e provinciale

Muschio (*Rhynchostegium megapolitanum* (Weber & D. Mohr) Bruch & *al.*)

circa 50 m a S dal punto di campionamento del suolo
raccolto lungo uno scalino di divisione tra i due campi
leggera copertura di paglia

Tavola 1. Informazioni relative al **Punto Secondario 09**

Punto di campionamento: **COR 13**
Coordinate geografiche:
Latitudine: **528522**
Longitudine: **5004903**
Altitudine: **64 m**
Località: **Gerenzano**

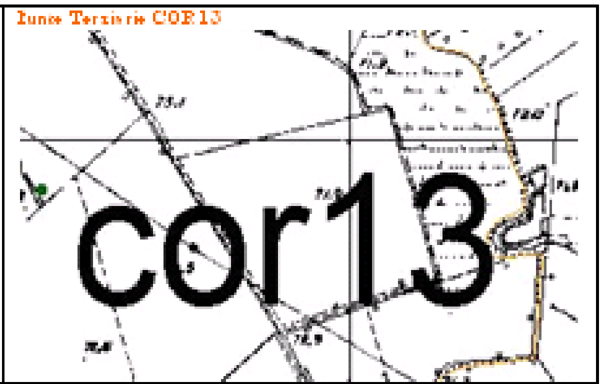


Figure: Mappa scala 1/10.000 (alto dx.), particolare del punto di campionamento (sx.), veduta generale dell'area (dx.)

Note

Utilizzo del suolo: bosco coltivato di latifoglie pregiate (tra cui identificati betulle ed ontani). L'argine tra i vari campi di coltivazione è caratterizzato dalla presenza di querce

Descrizione dell'area:

circa 30 m a N-E: fili della luce
circa 150 m a N-W: strada per Gerenzano
tutto intorno ci sono campi coltivati a latifoglie

Muschio (*Brachythecium rutabulum* (Hedw.) Bruch & *al.*)

circa 10 m a S-E dal punto di campionamento del suolo
raccolto all'interno dell'argine asciutto all'ombra delle querce e al di sotto di una non fitta copertura erbacea
non c'è il diretto percolamento dalle chiome delle querce

Tavola 1. Informazioni relative al **Punto terziario COR 13**

European Commission

EUR 23935 EN – Joint Research Centre – Institute for Environment and Sustainability
Title: DIOXINS, TRACE ELEMENTS, BIOINDICATORS AND BIODIVERSITY IN SOILS
Authors: R. M. Cenci, F. Sena

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ISBN 978-92-79-12793-9
DOI 10.2788/2351

Abstract
Soils of the Province of Pavia have been the object of a biological, physical and chemical survey in order to obtain a detailed assessment of their "quality". For this purpose, standard international methods were used to identify sampling, collection, handling and analysis points. With the use of the Land Use Cover Area from Statistical Survey (LUCAS) network, 7 Primary Points and 34 Secondary Points have been identified. On the basis of the same network, 116 sampling points (Tertiary Points) have been selected within six areas of prevalently industrial nature. A sample of soil being 0-30 cm thick was collected from each Secondary and Tertiary Point, while in the Primary Points the samples were up to approximately 1metre thick. A moss sample was collected in the surroundings of all the 157 points to enhance the information for the study. The moss analysis allowed the evaluation of the soil depositions of inorganic elements.
The bio-physical-chemical analyses of all the soil samples were the following:
• trace elements (As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Ti and Zn)
• macro elements (C tot, Corg, Al, Ca, Fe, K, Mg, N, Na, P and Si)
• dioxins and furans
• pH, water retention, pedological profile
• bacteria
The analysis carried out on moss samples were:
• As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Pt, Rh and Zn.
Besides what is listed, soil belonging to three areas with different management was considered: biological area, area fertilized with manure and area treated with sewage sludges. These areas were also subjected to an analysis carried out four times over a year with the use of bacteria. In two oxbows, sediment cores were collected. The analysis, carried out on 1 cm sections, aimed at evaluating the concentration of trace elements, macro elements, dioxins and furans over time.

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

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