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Soil Organic Matter Map of Europe

Estimates of soil organic matter content of the topsoil of FAO-Unesco soil units

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July 1993

Research carried out in the framework of the project: "The environment in Europe: a global perspective" on request of the GLOBE-Europe organization by, and under the responsibility of, RIVM, the National Institute of Public Health and Environmental Protection and by the direction of the Directorates for International Environmental Affairs and Strategical Planning of the Directorate-General for Environmental Protection.

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Preface

In 1992 the RIVM published the report "The environment in Europe: a global perspective", in which a description is given of the present and future state of the European environment. This study, commissioned by the GLOBE-Europe organization, was carried out by the National Institute of Public Health and Environmental Protection as part of the GLOBE project in the period December 1991 - January 1992.

Organic matter is an important soil constituent influencing such physical properties as bulk density, structure and available moisture, as well as chemical properties such as nutrient availability and retardation of pollutants. This report will provide the background for estimating organic matter content of the dominant soil units on the European soil map. These estimates have been used in calculating the leaching hazard of pesticides in European arable soils.

The report represents an initial attempt to produce a documented map of soil organic matter content for Europe, based on the "Soil organic matter map of the European Communities". Although aware of the imperfection of the current map, we hope that its use will encourage others to help us improve it.

Finally, we wish to thank Mrs. R.E. de Wijs-Christensen for editorial comments.

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Summary

One of the threats to groundwater is the leaching of pesticides. A major factor determining the migration of most pesticides in soil is their organic matter content. Using classification criteria, data on organic matter content in European and American soil profiles described, and common knowledge from textbooks, the organic matter content of the topsoil (upper 30 cm) for each soil unit occurring on the European part of the World Soil Map has been estimated. Outlined are the assumptions used to estimate the organic matter content for soil units and subunits, and the data and references on which these assumptions are based. The results are presented as the Soil Organic Matter Map of Europe (scale 1 : 20 000 000). Recommendations for future improvements are also discussed.

Samenvatting

Een van de bedreigingen van het grondwater is de uitspoeling van bestrijdingsmiddelen. De mate waarin bestrijdingsmiddelen uitspoelen uit de bodem is onder andere afhankelijk van het organische-stofgehalte van de bodem. Gebruik makend van de classificatiecriteria, de organische-stofgegevens van Europese en Amerikaanse bodemprofielen en algemene bodemkundige kennis is voor elke bodemeenheid van het Europese deel van de Wereld-Bodemkaart het organische-stofgehalte voor de bovenste 30 cm van de bodem geschat. De aannamen, die gebruikt zijn om de organische-stofgehalten te schatten, en de gegevens en referenties waarop deze aannamen gebaseerd zijn, worden in dit rapport beschreven. Tevens zijn enkele aanbevelingen gedaan voor toekomstige ontwikkeling van de Europese Organische-Stofkaart. Als bijlage is de Europese Organische-Stofkaart, schaal 1 : 20 000 000 ingesloten.

1. Introduction

Organic matter content is one of the major soil properties influencing the migration of pesticides in the soil. Estimating the threat to groundwater by pesticides in Europe requires a map of organic matter content of soils in Europe. Since an organic matter map on a European scale was neither available nor traceable within the time frame of the project, such a map had to be compiled. The resulting current soil organic matter map of Europe has been derived from the digital Soil Map of the World [1]. The resolution of this soil map is 10 * 10 minutes. For each cell the dominant soil unit is given. The soil unit name conforms to the legend of the FAO-Unesco Soil Map of the World [2]. Organic matter content has been estimated for the upper 30 cm of the soil units occurring as dominant soil; the limitations of this point of departure are discussed under future developments (Chapter 3). Where relevant, estimates refer to arable land, which usually has a lower organic matter content than grassland and is more prone to leaching of solutes. Although an absolute value for the organic matter content of each soil unit is given, it should be stressed that this value be regarded as a tool to rank different soils on the basis of their organic matter content. Most of the organic matter content estimated represents an average value for the soil unit considered. Ranges of organic matter content for different soil units often overlap.

The soil classification used consists of two levels [2]. The highest level is formed by Major Soil Groups (MSGs), in fact, groups of soil units with a similar soil formation, e.g. Fluvisols (soils influenced by floodplain regime), and Gleysols (soils dominated by hydromorphic soil-forming processes). The second level, soil units, is based on knowledge of the formation, properties and distribution of the soils covering the earth's surface, their importance as resources for production and their significance as factors in the environment [2, p.10]. For example, Calcaric Fluvisols are calcareous Fluvisols, at least between 20 and 50 cm from the surface and Dystric Fluvisols are Fluvisols with a base saturation of < 50%, at least in a certain part of the soil between 20 and 50 cm from the surface.

Soil maps show map units and not soil units. The legend of the European soil map [3] comprises several hundred different map units consisting of associations of soil units occurring within the limits of a mappable physiographic entity. Each association is composed of a dominant soil and associated soils. Associated soils cover at least 20% of the map unit area. Important soils covering less than 20% of the area are added as inclusions [3]. A map unit is named after its dominant soil. Associations with the same dominant soil but differing in composition (associated soils and inclusions, textural class(es) and slope class(es) of the dominant soil unit) have the same name but a different map code.

Estimation of organic matter content has been done similarly to the method used to produce the Soil Organic Matter Map of the European Communities [4]. Comparing the EC organic matter map with the EC part of the European organic matter map (Appendix I) will show some significant differences caused by:

(1) The difference in scale of the original soil maps used to derive the organic matter map; the EC soil map has a scale of 1 : 1 000 000 [5] and the European soil map has a scale of 1 : 5 000 000 [3]. Due to differences in scale some areas which can be shown on the EC soil map are too small to be shown on the European soil map and are incorporated in other map units.

(2) (Slight) differences between the original European soil map [3] and the digital soil map on a 10 * 10-minute grid [1]. Minor differences between the original soil map and the digital version for the EC countries are shown in §2.22. The Mollic Solonchak occurs as a dominant soil on the digital map, but only as an associated soil and inclusion on the original map.

(3) Differences in definition of map units between the European soil map [3] and the EC soil map; in some cases a different soil type was assigned a dominant soil status. Differences in definition of map units have been found, for example, in Italy where part of the Mount Etna region which is defined as Vitric Andosols on the European map occurs as Eutric Regosols on the EC map. The former has an

estimated organic matter content of 8%, while the latter has an estimated organic matter content of 1% (see §2.3 for more examples).

(4) Difference in soil classification: the EC soil map has three categorical levels (MSG, soil unit and soil subunit; [5]) and the European soil map has only two levels (MSG and soil unit; [3]). The difference in number of categorical levels between the EC and European soil map will be clearly shown in §2.5 (Cambisols) and §2.8 (Gleysols). Especially in the United Kingdom (UK) and Ireland, and to a lesser extent in the Netherlands and Italy, soil subunits occur which have been estimated to have distinct deviating organic matter content when compared with the overall soil unit estimate. For the non-EC countries this kind of information is not available, but it will be clear that the current approach of using a conservative estimate for the organic matter content may for some areas seriously overestimate the leaching of pesticides.

In the next chapter estimates of organic matter content per MSG will be discussed in alphabetical order. A short description of the soil units occurring on the European soil map [3] is given[1]. The organic matter content of each soil unit occurring as dominant soil on the European soil map, as well as the available data and information on which the estimates are based, are presented.

In estimating the organic matter content of a soil unit we followed these general rules: (1) The information included in the soil unit name has been used as a starting point. Estimates based on the soil name were also founded on the data from the literature data, both profile data and general ranges. (2) Where the soil name did not give information on organic matter content, only data from the literature were used. (3) General knowledge about relationships between organic matter content and soil properties (e.g. wetness, clay content) and climatic conditions (temperature, precipitation) were incorporated in the estimate. (4) In estimating the organic matter content of the upper 30 cm of the soil

[1] The full description or definition of soil scientific terms used below is not always given; only the most important properties are noted. For a complete description see [2].

profile, the distribution of the organic matter in the profile was considered, as is discussed in Chapter 3. (5) Knowledge on associated soils and inclusions occurring in the associations with the same dominant soil unit was used to modify estimates. (6) Estimates of organic matter content for different soil units were checked for consistency.

As stated above information included in the soil name was used in the first phase. In the FAO-Unesco legend [2] organic soils are differentiated from mineral soils on the MSG level.

Organic soils have an H horizon of more than 40 cm thick within 80 cm of the soil surface. The H horizon consists of organic material, which contains more than 30% organic matter if the mineral fraction contains more than 60% clay, and more than 20% organic matter if the mineral fraction contains no clay. An organic matter content of 30% was used for all organic soils (see §2.10 for discussion).

For mineral soils the presence of a certain type of upper horizon for some soil units was either mandatory or excluded. Two types of H horizon, a dystric and an eutric histic H, and three types of A horizon, mollic, umbric and ochric, are described [2]. A histic H horizon, consisting of organic material, is more than 20 cm but less than 40 cm thick. A histic H horizon is dystric when it has a pH (H_2O, 1:5) of less than 5.5 in at least a part of the horizon; it is eutric when the pH is 5.5 or more throughout. Soils with an ochric A horizon contain less than 1% organic matter, or if finely divided lime is present, less than 4%. Exceptions to this general rule exist. A surface horizon may be too light in colour (high value[2]), have too high a chroma[3], be too thin to classify as mollic or umbric, or be both hard and massive when dry. For all mineral soil units with a specified A horizon,

[2] Value refers to the relative lightness of colour [8, p.464], a low value indicating dark colours and a high value indicating light colours.

[3] Chroma (sometimes called saturation) is the relative purity or strength of the spectral colour and increases with decreasing greyness [8, p.464].

mollic and umbric horizons were assigned an organic matter content of 4% in the upper 30 cm, and ochric horizons 1%.

These initial assumptions were compared and/or corrected with available data in the second phase, as discussed in [4]. The A horizon of the Andosols occurring in the EC is ochric, pointing to an organic matter content of 1%. The 25-cm-thick A horizon of an Ochric Andosol profile described (To, [3, p.186]) contains 14% organic matter. Although this A horizon has more than 1% organic matter, it does not classify as mollic, because it has a colour value of 4. This is too light to classify as mollic (maximum allowed is 3.5). The data used for testing the assumptions come from European [3,5,6,7] and American [8] sources, which give detailed description of soil profiles. Appendix IV presents the American data file derived from Soil Taxonomy [8]. Textbooks in soil science [9,10,11] were used to find ranges of organic matter contents for different soil units.

Knowledge about the relationship between organic matter content and climate was used to improve estimates of organic matter content of, for example, the Chernozems and Chernozem-like soils (§2.6) and the soil units of Cambisols [4]. Knowing the relationship between wetness and organic matter content, and familiarity with associated soils and inclusions, enabled estimation of the organic matter content of, for example, the Gleyic Podzoluvisols (§2.10) and the Placic Podzols [4].

Appendix II gives the data file containing all the estimates of organic matter content. For each soil unit the abbreviation, full name and estimated organic matter content are given. The data file contains all soil units of the FAO-Unesco legend, placed in alphabetical order by soil unit code. The original data set was compiled by FAO-Unesco [12] in a grid resolution of 2 minutes and reprocessed and resampled by NOAA and UNEP/GRID to a 10-minute grid [1]. The data set in this 10-minute resolution is distributed as a part of the "Global Ecosystems Database" [13] on Compact Disk in IDRISI raster format. This raster data set is converted to a vector data set in Arc/Info, using a Lambert Azimuthal projection. The interpretation of the soil data to create the Soil Organic Matter Map of Europe

(Appendix I) is carried out in Arc/Info. Appendix III contains a listing of the other files used to create this European Soil Organic Matter Map.

2. Description of the Major Soil Groups

2.1 General

In this chapter the Major Soil Groups (MSGs) occurring on the European part of the digital World Soil Map [1] are discussed. For each of the MSGs a short description is given of the properties of the soils. The classification of soil units is based on the FAO-Unesco legend of 1974 [2]. The revised legend of the FAO-Unesco of 1988 [14] could not be used since the European soil maps available [1,3] are based on an old legend [2] in which a number of significant changes have been made after compilation of the map. The areas where the different soil units occur as dominant soil are outlined, with the extent of the units' occurrence expressed as their relative occurrence as dominant soil unit on the digital European soil map [1]. The organic matter content of the upper 30 cm of the soil has been estimated. Also included is an account of this estimate and the information used to estimate the organic matter content of the soil units. Detailed references are given in the heading of each section. Where relevant, proposed improvements appear at the end of the section under *remarks*.

As stated in Chapter 1, the estimates refer to arable land. Arable land usually has a lower organic matter content than grassland and it is more prone to the leaching of solutes. Estimates are presented as integers, representing an average value for common ranges of the organic matter content. Nine possible values for the estimated organic matter content for the 75 soil units and 12 non-specified soil units are: 1, 2, 3, 4, 5, 8, 10, 14 and 30. Fourteen is the highest estimate of organic matter for a mineral soil, according to FitzPatrick [11], who states that normally upper horizons of mineral soils contain less than 15% organic matter and a large number contain less than 2%.

In calculating the organic matter content of described profiles [3,5,6, and 8] histic epipedons are included but litter layers are not because organic matter in surface litter is assumed to degrade soon after forest clearing and conversion to agricultural land. Histic horizons are assumed to be related to excess wetness due to their physiographic position (groundwater) or soil properties (perched water table), rather than to vegetation type. Cultivation of these soils is assumed not to change organic matter content drastically, although it is well known that under natural conditions the organic matter content of a virgin soil is usually higher than in adjacent cultivated areas. This is caused by a higher rate of addition of organic matter by natural vegetation accompanied by a lower rate of biological activity and lower temperatures [11].

When organic carbon content is given, the organic matter content is calculated using a factor of 1.72 (an organic carbon content of the organic matter of 58%). This is the figure used in the Dutch evaluation studies on environmental impact of pesticides.

In the final stage of this report an error in the documentation file has been found. Category 22 with code D is described in this file as Podzoluvisols. Comparing the digital European soil map [1] with the printed European soil map [3] showed that the areas coded with "D" on the digital map [1] show on the printed map as "dunes and shifting sands". Implication for the estimated organic matter content are discussed in section 2.18.

2.2 Acrisols (A)

([2]:pp.19,40,51-52; [3]:pp.73-74; [9]:pp.161-165; [11]:pp.183-186)

Acrisols are acidic soils with an illuvial clay B horizon. These soils occur mainly in the equatorial tropics. Five soil units are distinguished, and only the Orthic Acrisol (Ao) occurs on the digital Soil Map of Europe [1], covering about 0.2% of the land area. Orthic Acrisol occurs mainly in the Black Sea zone of northern Turkey, and in the Black Sea hinterland of Georgia in the former USSR, extending northward into Krashnodar [3].

No data for European Acrisols are available. American Acrisols [8] contain between 0.6 and 8.4% organic matter (o.m.) (average 3.2%); Af: 1.0%, Ag: 1.2, 2.7, and 6.0%, Ah: 8.4%, Ao: 0.6, 2.0, 2.5, 2.7, and 3.3%, Ap: 5.0%. The average for the Ao units is 2.2% o.m.

The upper mineral horizon of Orthic Acrisols varies in thickness from < 10 cm to > 30 cm and may contain up to 10% o.m. [11]. The Ao has an ochric horizon often due to an A horizon which is too light in colour, even if the o.m. content is greater than 1%. In addition, since the Ao unit can be compared with the Orthic Luvisol, which has an estimated o.m. content of 2%, an o.m. content of 2% is also used for the Ao unit.

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
Ao	Orthic Acrisol	0.22	none of the properties of other Acrisols	2

2.3 Andosols (T)

([2]:pp.16,34,45; [3]:pp.88,184-189]; [9]:pp.43-54; [11]:pp.186-189)

Andosols are soils formed in volcanic material in volcanic regions. The total area covered by Andosols is about 0.1%, with all soil units distinguished occurring in Europe [1]. Humic Andosols (Th) occur in the Carpathian mountains, Mollic Andosols (Tm) are confined to Italy, and Vitric Andosols (Tv) occur mainly in Iceland and to a small extent in Sardinia [3]. The Orthic Andosols (To) occur in Greece.

European Andosols [3] have an o.m. content of 9.4 up to 19% (average 14%); Th: 19%, To: 14%, Tv: 9.4%. American Andosols [8] have o.m. content ranging from 4.5 to 26% (average 12%); Tm: 8.7 and 26%; Th: 6.1, 12, and 17%, Tv: 4.5%. FitzPatrick [11] states that Th are high in o.m. content, with values of greater than 20% common in the upper horizon.

The average o.m. content for Tm and Th is 13.5 and 17.4%, respectively, and the overall average is 14.8%. The Th units have a very humose A_h horizon under natural conditions which may be up to 30 cm thick [11].

Considering the uncertainty it has been decided to place Andosol units in the same class as the Luvic Chernozems (see §2.6) and that is why an o.m. content of 14% is used for Humic and Mollic Andosols. For Ochric (To) and Vitric Andosols (Tv) the same o.m. content is used as in [4], i.e. 8%.

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
Tm	Mollic Andosols	0.06	have a mollic A horizon	14
Th	Humic Andosols	0.03	have an umbric A horizon	14
To	Ochric Andosols	<0.01	ochric A, smeary consistency and/or silt loam or finer texture	8
Tv	Vitric Andosols	0.01	ochric A, none of the properties of To	8

Remarks:

(1) The Mollic Andosols (14% o.m.) on the European soil map [3] do occur on the EC soil map [5] as Ando-Eutric Cambisols for which an o.m. content of 5% has been used [4].

(2) Part of the Tv unit on Sardinia (Mount Etna region) with an estimated o.m. content of 8% occurs on the EC soil map as Eutric Regosols for which an estimated o.m. content of 1% has been used [4].

(3) A relatively large area classified as To (8% o.m.) with Th as associated soils on the EC soil map (south of Clermont Ferrand, France) is classified on the European soil map as Humic Cambisols (with Th as associated soils) and Dystric Cambisols with an estimated o.m. content of 5 and 3%.

2.4 Arenosols (Q)

([2]:pp.15,34,45-46; [3]:pp.87,176-179; [5]:pp.89; [9]:pp.55-64; [11]:pp.189-191)

Arenosols are soils formed in coarse-textured unconsolidated materials (excluding recent alluvial deposits - see Fluvisols §2.7) consisting of albic material or showing properties of Luvisols, Cambisols or Ferralsols. However, these types of soils do not qualify as Luvisols, Cambisols or Ferralsols because of textural requirements. Arenosols can, by definition [2], only have an ochric A horizon. The two Arenosol units occurring on the European soil map cover almost 0.4% of the area. Mainly Cambic Arenosols (Qc) occur: 0.33% versus 0.03% for Luvic Arenosols (Ql) [1]. Qc units are confined to Poland, the UK, Spain and former Czechoslovakia. Ql units are confined mainly to Hungary [3].

At present, the same estimate has been used for the Qc and Ql units as [4], i.e. 1%. In [11] cambic arenosols are described as having a thin upper mineral A_h horizon usually not more than 10 to 15 cm thick which has less than 2% o.m.

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
Qc	Cambic Arenosols	0.33	none of the properties of other Arenosols	1
Ql	Luvic Arenosols	0.03	showing lamellae of clay accumulation	1

2.5 Cambisols (B)

([2]:pp.18,37-38,52-53; [3]:pp.74-77,94-103; [5]:pp.101-109; [9]:pp.125-132; [11]:191-195)

Cambisols are soils with a development of the B horizon that is too weak to classify as another MSG or soils with an umbric A horizon of more than 25 cm (e.g. Humic sub-group). Seven soil units of the Cambisols occur on the Soil Map of Europe [1]. This MSG covers over 11% of the land area [1]. Chromic Cambisols (Bc) occur mainly in France, with associated Chromic Luvisols, in the mountainous region of former Yugoslavia and to a small extent in the trans-Danubian region of Hungary. These soils occur as well in Azerbaijan and Dagestan in the Caspian Sea zone. Dystric Cambisols (Bd) occur extensively throughout Europe. Eutric Cambisols (Be) occur extensively in southern Europe, but they also as far north as the UK and southern Sweden. Gleyic Cambisols (Bg) occur in Spain, the UK and Austria. Humic Cambisols occur extensively in Spain; Calcic Cambisols (Bk) are largely confined to Spain, Portugal and Turkey, and Vertic Cambisols (Bv) are mainly confined to southern Finland and southern Sweden [3].

Estimates of o.m. content for all these units are available [4]. On the EC soil map subunits with distinctly different o.m. contents occur. The subunit with the lowest o.m. content is used to represent the o.m. content of the soil unit to avoid underestimation of pesticide leaching.

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
Bc	Chromic Cambisols	0.52	strong brown to red B horizon	2
Bd	Dystric Cambisols	3.75	base saturation of < 50% in part of B	3
Be	Eutric Cambisols	3.25	no properties of other Cambisols	3
Bg	Gleyic Cambisols	0.63	hydromorphic properties within 100 cm	3
Bh	Humic Cambisols	0.44	an umbric A horizon, thicker than 25 cm	5
Bk	Calcic Cambisols	2.35	calcic or gypsic horizon or powdery lime	3
Bv	Vertic Cambisols	0.33	vertic properties (like Vertisols)	3

Remark: Three subunits on the EC soil [4] map have considerably higher o.m. content but do not show on the European soil map [3]. These are: (1) the Spodo-subunit of the Dystric Cambisols (Bds), with an estimated o.m. content of 10%; (2) the Ando-subunit of the Eutric Cambisols (Bea) and (3) the Fluvi-subunit of the Calcic Cambisols (Bkf), both with an estimated o.m. content of 5%. The Bds units cover a considerable part of Wales, and occur in eastern and southern Ireland, and eastern Bavaria (Germany). The Bea units occur as a small area in the Eiffel (Germany) and in larger areas in the western part of *middle Italy and northeastern Sardinia (see remark §2.3). The Bkf units only occur in the Netherlands (eastern part of the Rhine basin).*

2.6 Chernozems (C)

([2]:pp.17,36,49; [3]:pp.77-78,104-109; [9]:pp.211-214,219-226; [11]:pp.195-199)

Chernozems are soils with a thick upper horizon (mollic A) rich in organic matter. Apart from the Glossic Chernozems (Cg, tonguing of A horizon in cambic B or C horizon) all different soil units occur as dominant soil on the European soil maps [1,3]. These fertile soils, confined to eastern Europe, occupy almost 8% of the area.

From the available literature [9,10,11] we have devised the following concept regarding the influence of climate on the organic matter content of soils developed in loess such as the Chernozems.

The loess deposits belt extends from France, across Belgium, the southern Netherlands, Germany and a large part of Eastern Europe into the vast steppes of the former USSR, and further east to Siberia and China. A belt of aeolian sand deposits occurs north of the loess belt in which mainly Podzols (§2.17) and Podzoluvisols (§2.18) have developed. In eastern Europe, going from the northern to the southern fringe of the loess belt, different soils have developed mainly due to differences in the steppe climate, with cold winters and hot summers. From north to south temperature increases from an annual temperature of about 4 °C in the Luvisols zone to 13-17 °C in the Xerosols zone. Precipitation decreases from an annual rainfall of over 650 mm to less than 200 mm [10, p.455]. This affects the vegetation type which under natural conditions changes from deciduous forest via grass steppe to open vegetation and thus organic matter production and decomposition. Because of the continental influence the ground is frozen everywhere for at least one month, and so the main soil development takes place in the summer months when evapotranspiration is highest. It is assumed that both o.m. production and decomposition rates increase with

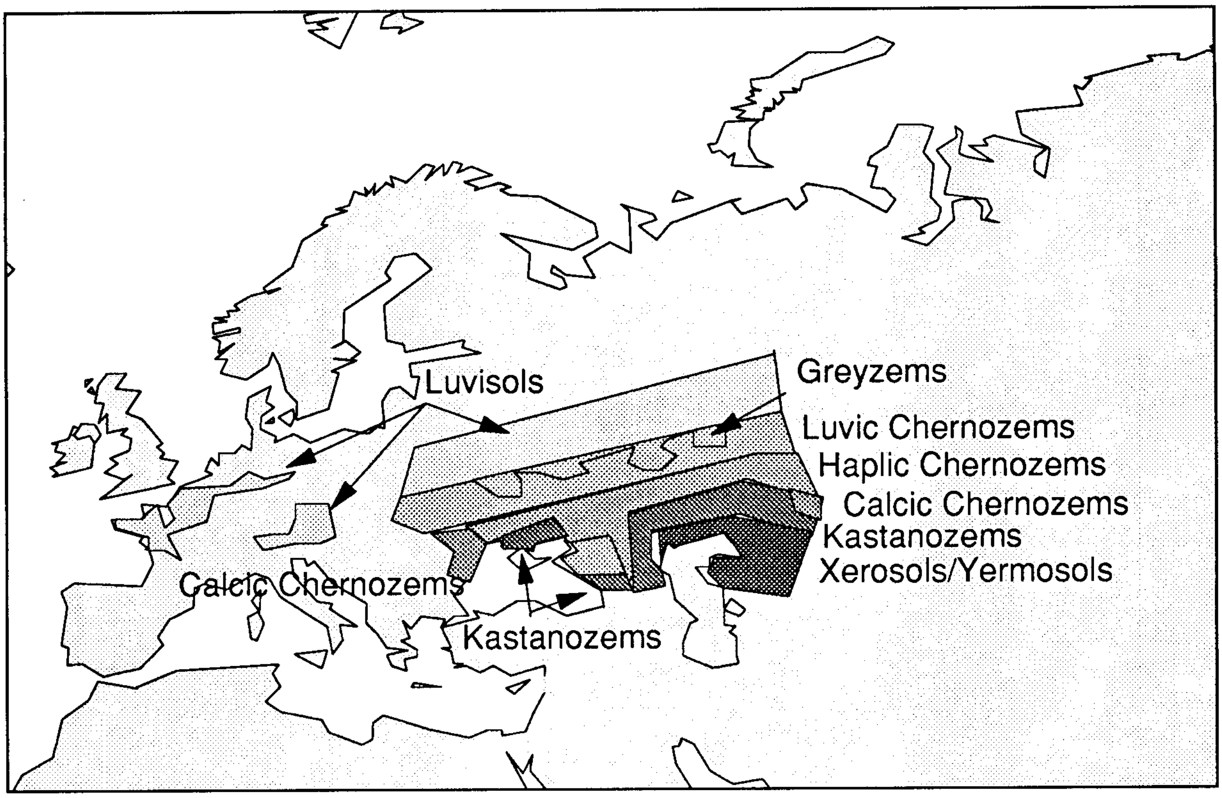

***Figure 1:** Occurrence of the major belts of the Luvisols, Chernozems, Kastanozems and Xerosols/Yermosols in Europe.*
Source: European soil map [3]

increasing temperature, but the former increases faster and the equilibrium o.m. level will be higher as long as there is sufficient soil moisture [15, p.179]. This trend is changed when a precipitation deficit occurs. Although o.m. decomposition will be hampered during periods of drought, o.m. production falls faster as a result of the moisture stress [16, pp.42-43]. The annual precipitation sum and evaporation in the central Chernozems belt are in approximate equity [9]. Soil types found from north to south are given in *Figure 1.*

The organic matter content increases from 2-3% in Luvisols, 3-5% in Greyzems and 5-10% in Luvic Chernozems to 10-16% in Haplic Chernozems. Going further south the o.m. content decreases: 5-10% in Calcic Chernozems, 2-5% in Kastanozems, to 1-2% in Xerosols/Yermosols (derived from [9]). Schachtschabel et al. [10, p.455] present a soil unit sequence of Phaeozems-Chernozems-Kastanozems-Xerosols with a similar climatic change and an accompanying o.m. sequence of 1.5-3.5% for Phaeozems, 5-8.5% for Luvic Chernozems, 7-10% for Haplic Chernozems, 3.5-5% Calcic Chernozems, 1.5-3.5% Kastanozems, and 1-1.5% for Xerosols. The thickness of the o.m.-containing horizon follows a similar trend with a maximum thickness of about 1 m for Haplic Chernozems. The o.m. content of topsoils given in [10] is for all units presented here somewhat lower than those derived from [9]. Buol et al. [17] give estimates of o.m. content of the A_p (plough layer) and B horizon of the Phaeozem-Chernozem-Kastanozem-Xerosol sequence (see *Table 1*). Their figures are remarkably lower than those presented by the other authors [9,10]. FitzPatrick [11] describes Calcic Chernozems as soils having a dark-coloured upper A_h horizon which may exceed 2 m in thickness but is normally 50 to 100 cm thick. The o.m. content of the top of the upper horizon varies from about 3 to 15%. The o.m. content decreases steadily With depth to less than 1% in the horizon with carbonate accumulation.

Table 1: *Estimated percentage of organic matter of Chernozem topsoils and related soils provided by several authors*

Soils		Buol et al. [17]			Schachtschabel et al. [10]	Driessen and Dudal [9]
MSG	Unit	Depth A_p	A_p	B	A_h	A
Luvisols						2-3
Phaeozems		30	2.0-4.5	1.0-1.5	1.5-3.5	
Greyzems						3-5
Chernozems	Luvic				5-8.5	5-10
	Haplic	20*	4*	2-3*	7-10	10-16
	Calcic				3.5-5	5-10
Kastanozems		20	3	2-3	1.5-3.5	2-5
Xerosols Yermosols		7-10	1.3-2	1.3-1.5	1-1.5	1-2

* average for all Chernozem units

Organic matter content in European Chernozem profiles [3] is much lower than in the figures given above based on general soil science textbooks; Ch: 5%, Ck: 2.5%, Cl: 3.5%. The same holds for American data [8] where o.m. content ranges from 1.6 up to 6.6% (average 3.8%); Ch: 1.6 and 2.1, Ck: 2.4, 3.6 and 6.0%, Cl: 3.0, 5.5, and 6.6%.

Given the thick A horizons of Chernozems and the need for consistency in ranking MSG and soil units, the o.m. contents as derived from general textbooks [9,10,11] have been used as point of departure. The Cl and Ck units fall in the same o.m. class. An average of 8% was taken from the range provided. The Ch unit should be higher in o.m. content than the Ck and Cl units. An o.m. content of 14% was used instead of the average of 13% to restrict the number of o.m. classes (see §2.3, Andosols). In the digital European soil map [1] some of the cells contain only the MSG name as dominant soil and no further specification is provided about the dominant soil unit. The lowest estimate (8%) is used for these grid cells to avoid underestimation of pesticide leaching.

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
C	n.s. Chernozems	0.25	not specified on map	8
Cl	Luvic Chernozems	2.12	have an argillic B horizon	8
Ck	Calcic Chernozems	0.88	have calcic or gypsic horizon, no argillic B	8
Ch	Haplic Chernozems	3.15	none of the properties of other Chernozems	14

n.s., non-specified

2.7 Fluvisols (J)

([2]:pp.14-15,32-33,44; [3]:pp.81-82,134-139; [5]:pp.30-31,82-83; [9]:pp.83-104; [11]:pp.210-214)

Fluvisols are soils developed from recent alluvial deposits (see [2] for definition of alluvial sediments). Fluvisols can have an ochric, umbric or histic horizon. Organic matter content may thus range from less than 1 up to 30% and even more in the upper 30 cm [2]. Fluvisols occur all over Europe. On the European soil maps [1,3] the same soil units occur as on the EC soil map [5]. Fluvisols cover about 3.5% of the European land area, with the Eutric Fluvisol (Je) the most common soil unit of this MSG (1.86%) [1].

The o.m. estimates for the soil units are the same as in [4].

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
Jc	Calcaric Fluvisols	1.01	calcareous, at least between 20-50 cm	5
Jd	Dystric Fluvisols	0.59	base saturation < 50% between 20-50 cm	5
Je	Eutric Fluvisols	1.86	base saturation > 50% between 20-50 cm	5

2.8 Gleysols (G)

([2]:pp.15,33,44-45; [3]:pp.80,122-125; [5]:pp.31-33,84-85; [9]:pp.83-92,105-110; [11]:pp.214-223)

Gleysols are formed from unconsolidated materials (excluding recent alluvial deposits - see Fluvisols §2.7). Gleysols cover about 2.7% of the European land area. The Dystric Gleysols (0.7% coverage) are confined to Ireland. Eutric Gleysols (Ge) are largely confined to the UK, but also occur in the western Po Valley in Italy. Mollic Gleysols (Gm) occur extensively in the eastern part of the Baltic Republics, in northern and southern Russia and western Georgia. Gelic Gleysols (Gx) only occur in the permafrost zone of Russia. Humic Gleysols (Gh) are largely confined to the U.K. and Ireland. The Calcaric Gleysols (Gc) occur on the digital European soil map as dominant unit [1], but not on the printed European soil map [3]. The only soil unit of this MSG which does not occur either on the printed European soil map or the digital version is the Plinthic Gleysol (Gp; plinthite within 125 cm of the surface).

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
Gc	Calcaric Gleysols	0.24	calcic or gypsic horizon or calcareous between 20-50 cm	5
Gd	Dystric Gleysols	0.74	base saturation < 50% between 20-50 cm	5
Ge	Eutric Gleysols	0.57	base saturation > 50% between 20-50 cm	4
Gh	Humic Gleysols	0.13	an umbric A or dystric histic H horizon	10
Gm	Mollic Gleysols	0.51	a mollic A or eutric histic H horizon	4
Gx	Gelic Gleysols	0.49	permafrost within 200 cm of the surface	10

The estimates given in [4] for the soil units have been used for all Gleysols, except the Gelic Gleysols, which do not occur on the EC soil map. A general description of Gelic Gleysols is given in [11]: at the surface there is a thin litter layer which rests on a partially humified O horizon that may be up to 15 cm thick. The organic matter is underlaid by a cambic B horizon about 25 cm thick. There is often an o.m. rich horizon just above or just within the permafrost. An o.m. content of 10% has been used for the Gx unit: this percentage is based on the assumption that bog forming conditions are present in areas where this soil unit occurs. This is - in addition to the general description given above - supported by the occurrence of Dystric Histosols and Placic Podzols in the same area.

Remarks:

On the EC soil map four subunits (third categorical level) occur of which three are assumed to have an o.m. content deviating from the o.m. content of the soil unit. These are the Stagno subunit of the Dystric Gleysols (Gds, o.m. = 10%) and the Fluvi-subunits of the Eutric and Mollic Gleysols (Gef and Gmf, o.m. = 5%). The Gds subunits occur in Dartmoor, Wales and middle and northern England as well as in northern and eastern Ireland. The Gef subunits occur in northeastern Italy (Po basin) and the Gmf units occur mainly in the western part of the Netherlands (old polders) and in Cambridge county (England). This information is lost on the European scale. The Gc unit occurs, according to the legend, as associated soil in the map units Ge17, K3, and Vc48 of the printed European soil map [3].

2.9 Greyzems (M)

([2]:pp.17-18,37,48; [3]:pp.154-156; [9]:pp.211-214,231-236; [11]:pp.223-224)

Greyzems are soils with a mollic A horizon which meets the colour requirements of the Chernozems but shows bleached coatings on structural pad surfaces [3]. Greyzems form a non-continuous belt between the Luvisols and the Chernozems (see *Figure 1*, §2.6). This MSG, which does not occur on the EC soil map, covers ca. 0.5% of the land area in Europe. Only one soil unit is shown on the European soil map, i.e. the Orthic Greyzems (Mo). Gleyic Greyzems (Mg, with hydromorphic properties within 50 cm of the surface[4] [2]) are not shown on the European soil map [1,3].

No profile data are available. Driessen and Dudal [9] give a range of 3-5% o.m. in the upper soil. An o.m. content of 4% has been used in this study.

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
Mo	Orthic Greyzems	0.48	no hydromorphic properties within 50 cm	4

2.10 Histosols (O)

([2]:pp.20,41,43; [3]:pp.72,156-159; [5]:pp.52-53,122-123, [9]:pp.19-34; [11]:pp.224-230)

Histosols are soils with a high organic matter content (at least 40 cm of organic material in the upper 80 cm). Organic material contains at least 20% o.m. if the mineral fraction contains no clay and 30% organic matter if the mineral fraction contains 60% clay. All

4 According to the revised FAO-Unesco legend [14] the hydromorphic properties should be within 100 cm instead of 50 cm.

three soil units of the Histosol group occur on the European soil map. Histosols cover about 3.9% of the land area. Most of them are Dystric Histosols (Od, 2.9%), which occur extensively in Finland, Russia and the UK, and to a lesser extent in the Netherlands, Germany, and Rumania. Eutric Histosols (Oe) occur in Germany, The Netherlands, Poland and France. The Gelic Histosols (Ox), occurring in the permafrost zone of Russia, are characterized by permafrost within 200 cm of the surface. (These are not shown on the EC soil map).

A conservative o.m. content of 30% has been used for all soil units of this MSG as suggested by Fraters and Bouwman [4].

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
Od	Dystric Histosols	2.90	a pH(H_2O, 1:5) < 5.5 in a certain part between 20-50 cm not Gelic	30
Oe	Eutric Histosols	0.30	not Gelic or Dystric	30
Ox	Gelic Histosols	0.67	permafrost within 200 cm of the surface	30

2.11 Kastanozems (K)

([2]:pp.17,36,49; [3]:pp.82-83,140-143; [9]:pp.211-214; [11]:pp.230-234)

Kastanozems are soils with a mollic A which is not as dark as the mollic A horizon of the Chernozems or Greyzems (moist chroma of more than 2, [3]). This MSG covers more than 5% of the land area in Europe. Kastanozems form a more-or-less continuous belt between the Chernozems and the soils of the arid regions (Yermosols and Xerosols; see *Figure 1*, §2.6). The predominant soil unit is the Haplic Kastanozem (Kh: 3.5%).

The A_h horizon of the Kastanozems (a humus accumulation horizon about 25 cm thick) contains between 2 and 4% o.m. and seldom exceeds 5% [9]. Darker topsoils occur in the northern part of the Kastanozems belt (bordering the Chernozems) whereas soils with shallower and lighter coloured horizons are more abundant in the south [9]. According to FitzPatrick [11] Kastanozems have a mollic A horizon which is about 50 cm in thickness and with a content of o.m. which varies from 3 to 6% in the uppermost part of the soil.

Only two European profiles are available with 2.1 (Kk) and 3.0% o.m. (Kl), respectively [3]. In the American data [8] three Kl profiles have an o.m. content of 1.7, 1.7, and 2.0%, with an average of 1.8%.

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
K	n.s. Kastanozems	0.01	not specified on map	3
Kh	Haplic Kastanozems	3.54	not being Luvic or Calcic	5
Kk	Calcic Kastanozems	0.39	calcic or gypsic horizon but not Luvic	3
Kl	Luvic Kastanozems	1.41	an argillic B horizon	3

n.s., non-specified

On the European soil map [3] mainly the Haplic Kastanozems border the Chernozems. Both Luvic and Calcic Kastanozems seem to occur south of the Haplic units. Therefore Kh units are assumed to have a higher o.m. content than the Kk and Kl units. For Kh units an o.m. content of 5% has been used, the same as for the Phaeozems. For the Kl and Kk units 3% has been used, the average in the range given by Driessen and Dudal [9].

Remarks: At present, an o.m. content of 3% has been used for Kl and Kk units, which is higher than the average for the five profiles (2.1% o.m.). Based on the available data, an o.m. content of 4% seems more applicable to Kh and Phaeozem units and a 2% o.m. content to Kl and Kk units.

2.12 Lithosols[5] (I)

([2]:pp.15,34,43; [3]:p.81; [9]:pp.111-118; [11]:p.234)

Lithosols are soils limited in depth to within 10 cm of the surface by continuous hard rock. They may contain high organic matter content but leaching of solutes from the upper layer is relatively easy because of their limited thickness. Lithosols cover a rather large area of Europe (about 9%) but due to their limited depth, usually accompanied by steep slopes, they are of no agricultural interest. On the European map no soil units are differentiated and grid cells are marked with the MSG name if this is the dominant soil [1].

The same o.m. content as for the soil units on the EC soil map is used (1%, [4]).

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
I	n.s. Lithosols	9.04	continuous hard rock within 10 cm of the surface	1
	n.s., non-specified			

2.13 Luvisols (L)

([2]:pp.18,38.52; [3]:pp.83-85,144-153; [5]:pp.46-50,110-117; [9]:pp.237-247; [11]:pp.234-239)

Luvisols are soils with a horizon containing illuvial clay and a base saturation of more than 50%. They may have an umbric or ochric A horizon, so differentiation on unit level based on o.m. content is not easy. Six of the eight Luvisol units distinguished occur on the

[5] In the revised FAO-Unesco legend [14] soils which are limited in depth by continuous hard rock within 10 cm of the surface do not form an MSG but are the Lithic Soil Unit of the Leptosols.

European soil map [1,3]. Plintic Luvisols (Lp), with plinthite within 125 cm of the surface, and Calcic Luvisols (Lk), with a calcic horizon or soft powdery lime within 125 cm of the surface, do not occur on the European soil map. Calcic Luvisols occur on the EC soil map, but due to the scale difference is not shown on the European soil map. This MSG covers 8.1% of the land area. Luvisols occur all over Europe, except for Scandinavia and northern Russia. The Orthic Luvisol (Lo) is the most abundant unit (4.3%) occurring throughout Europe. Gleyic units (Lg) are most extensive in the former USSR, France, Rumania, Poland, former Yugoslavia and former Czechoslovakia. Chromic Luvisols (Lc) occur most extensively in Greece, Italy, Spain and Albania. Vertic Luvisols (Lv) are confined to Spain [3].

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
La	Albic Luvisols	0.03	an albic E horizon	2
Lc	Chromic Luvisols	1.40	strong brown to red B horizon	2
Lf	Ferric Luvisols	0.02	ferric properties	2
Lg	Gleyic Luvisols	2.30	hydromorphic properties within 50 cm of surface	3
Lo	Orthic Luvisols	4.33	none of the properties of other Luvisols	2
Lv	Vertic Luvisols	0.06	vertic properties	2

Data are available from [4], except for the La unit for which no estimate had been provided. According to FitzPatrick [11] the La unit has 5 to 10% o.m. in its upper mineral horizon and a very low o.m. content throughout the rest of the soil due to the advanced state of decomposition. In the generalized profile the o.m. content in the upper 30 cm is 4% [11]. Two American La profiles [8] formed in alluvium and calcareous till have respective percentages of 0.70 and 1.1% organic matter in the upper 30 cm of the mineral horizon.

The estimates are taken from [4], except for the La units. A conservative estimate of 2% has been used for this unit. Although general textbooks indicate a higher o.m. content, the profile data are significantly lower. In addition, we felt that there was no logic in giving a "leached" profile a higher o.m. content than the other Luvisol units.

2.14 Nitosols (N)

([2]:pp.19,40,51; [3]:-; [5]:-; [9]:pp.133-138,157-160; [11]:pp.239-240)

Nitosols are soils having an argillic B horizon, like Luvisols, but with a clay distribution where the percentage of clay does not decrease by as much as 20% from its maximum within 150 cm of the surface: it is also lacking plinthite within 125 cm of the surface [2]. These are typically soils of the tropical areas with a wet and dry season [9]. Only the Eutric Nitosols (Ne) occur in the legend of the European soil map and these occur in a mere 0.01% of the map [1]. Other units are Humic Nitosols (Nh, base saturation of less than 50%, at least in a part of the B horizon, with an umbric A or a high o.m. content in the B horizon) and Dystric Nitosols (Nd, other Nitosols with a base saturation of less than 50%, at least in a part of the B horizon) [2].

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
Ne	Eutric Nitosols	0.01	base saturation > 50% throughout B horizon	2

No information is available for Eutric Nitosols in the northern hemisphere. Two profiles from Puerto Rico and one from the USA have an average o.m. content of 4%: Nd showing 2.7 and 3.2% and Nh, 6.1%.

We have used the estimate for Orthic Luvisols of 2% o.m. (see §2.13).

2.15 Phaeozems (H)

([2]:pp.17,36-37,49-50; [3]:pp.39-40,81; [5]:pp.43-44,80-81,126-133; [9]:pp.211-214,227-230; [11]:pp.240-243)

Phaeozems are soils with a dusky red mollic A horizon. They are similar to Chernozems, but occur in slightly more humid areas west of the Greyzem/Chernozem/Kastanozem belts (see *Figure 1*). Although only 0.54% of the map is occupied by Phaeozems, they are from an agricultural point of view important because of their high natural fertility. All units of this MSG occur on the European soil map [1,3]. Calcaric Phaeozems (Hc) are largely confined to Hungary, former Czechoslovakia and former Yugoslavia. Gleyic units (Hg) occur mainly in Hungary and former Czechoslovakia; Haplic units (Hh) are most extensive in Rumania and Hungary and Luvic Phaeozems (Hl) are confined to Rumania and Bulgaria.

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
Hc	Calcaric Phaeozems	0.18	calcareous, at least between 20 and 50 cm	5
Hg	Gleyic Phaeozems	0.08	hydromorphic properties within 50 cm of the surface	5
Hh	Haplic Phaeozems	0.14	none of the properties of the other Phaeozems	5
Hl	Luvic Phaeozems	0.13	an argillic B horizon	5

For Hc, Hh, and Hl units an estimate has been provided by Fraters and Bouwman [4]. No estimate was available for the Hg unit. A Polish profile contains about 3.8% o.m. in the topsoil [3]. Two American profiles contain 3.3 and 4.2% o.m., respectively, in the upper 30 cm [8].

Estimates of 5% given in [4] for Hc, Hh, and Hl units have been used. Although the average o.m. content of these units is 3.8%, 5% has been used because of the comparatively thicker humus-rich horizon. There is no reason to assign a deviating o.m. content to Hg units.

2.16 Planosols (W)

([2]:pp.19,39-40,48; [3]:pp.65,88,195; [5]:pp.52,121;[9]:pp.237-239,253-258; [11]:pp.243-244)

Planosols are soils with an eluvial horizon from which clays and free iron have been leached. They show hydromorphic properties in at least a part of the eluvial horizon, indicating saturation with surface water, at least during part of the year. The eluvial horizon abruptly overlays a slowly permeable horizon [2,9].

The European soil map shows three Planosol units occupying 0.14% of the area. The Gelic Planosols (Wx, permafrost within 200 cm of the surface) and Humic Planosols (Wh, umbric A or dystric histic H) are not shown on this map. Mollic Planosols (Wm, mollic A or Eutric histic H) only occur as associated soils [3]. Solodic Planosols (Ws, see table below) are on the digital European soil map [1], but not as dominant soil on the FAO-Unesco soil map [3] (see remark). Eutric Planosols (We) are confined to Rumania and the former USSR, the Distric unit (Wd) mainly occurs in former Yugoslavia and Spain [3].

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
Wd	Dystric Planosols	0.08	base saturation < 50% in part of B horizon	1
We	Eutric Planosols	0.05	none of the properties of the other Planosols	1
Ws	Solodic Planosols	0.02	> 6% sodium in exchange complex of B horizon	3

Estimates of o.m. content for Wd and We units are given in [4]. No data are available for Wg units.

Dystric and Eutric Planosols have an ochric A horizon; therefore an estimate of 1% has been used [4]. Solodic Planosols, which do not occur in the EC, may have all types of A horizons. They usually have an ochric A horizon 5 to 10 cm thick containing up to 20%

o.m. [11]. Below is the clay-depleted albic E horizon, which may be 20 to 50 cm thick and in extreme cases over a metre in thickness [11]. Because salt and water logging hamper organic matter decomposition, the same estimate has been used as for Gleyic Solonetz, i.e. 3%.

Remark: On the FAO-Unesco soil map [3] Ws units occur as inclusions in the units Vp69-3a (sodic phase) in Hungary and Rumania, Lc107-2/3a (sodic phase) in Bulgaria and possibly as inclusion in Lo77 in Bulgaria [3].

2.17 Podzols (P)

([2]:pp.19,39,47; [3]:pp.58-62,85-87,162-175; [5]:pp.50-52,118-120;[9]:pp.237-239,259-266; [11]:pp.244-256)

Podzols are soils with an illuvial horizon rich in organic matter and/or sesquioxides. Podzols are the largest MSG, occupying over 16% of the European land area [1]. The Ferric Podzol (Pf, ratio free iron/carbon > 6) does not occur on the European soil map. The major unit is the Orthic Podzol (Po). The Po unit covers an extensive area in Scandinavia and in Russia north of the Dystric Podzoluvisol belt (see *Figure 1*, §2.18), but this unit occurs all over western and middle Europe. The Gleyic unit (Pg) is mainly confined to Russia, north of the Po belt and south of the permafrost zone. The Leptic unit (Pl) is most extensive in Poland, Rumania and the former western USSR. The Humic Podzols (Ph) are confined to Belgium, The Netherlands, Germany and Denmark. The Placic unit (Pp) occurs in the UK and Ireland [3].

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
Pg	Gleyic Podzols	2.71	hydromorphic properties within 50 cm of the surface	4
Ph	Humic Podzols	0.71	lacking enough free iron in B horizon	4
Pl	Leptic Podzols	0.77	very thin eluvial E horizon	4
Po	Orthic Podzols	11.87	none of the properties of the other Podzols	4
Pp	Placic Podzols	0.20	a thin iron pan over spodic B horizon	10

The estimates used for all Podzol units are those given in [4].

2.18 Podzoluvisols (D)

([2]:pp.18-19,39,50; [3]:pp.39-40,78-79,110-117; [5]:p.50; [9]:pp.237-239,247-252; [11]:pp.256-259)

Podzoluvisols are characterized by deep tonguing of an eluvial E horizon into the argillic B horizon. Podzoluvisols are mainly concentrated in a broad belt extending from Poland eastward into central Siberia. North of this belt Podzols occur, south of it mostly Luvisols are found. A schematic sequence from north to south is given in *Figure 2*.

Gleyic Podzoluvisols (Dg) mainly occur west of this belt, with Dystric (Dd) and Eutric (De) units in Poland and Croatia [3].

On the EC map only the Dd units occur as dominant soils; an o.m. content of 2% has been used in [4]. European data of o.m. contents in Podzoluvisol vary from 1.1 to 2.6% (average 1.7%); Dd: 1.5%, De: 2.6%, Dg: 1.1% [7]. The Gleyic (Dg) units described in [8] for the USA contain about 4% o.m. (Dg: 3.8, 3.9 and 3.9%). In [11] a general Dg profile is described. The ochric A usually contains less than 10% o.m. and the content decreases sharply to about 2 to 3% in the albic eluvial horizon. The A horizon of

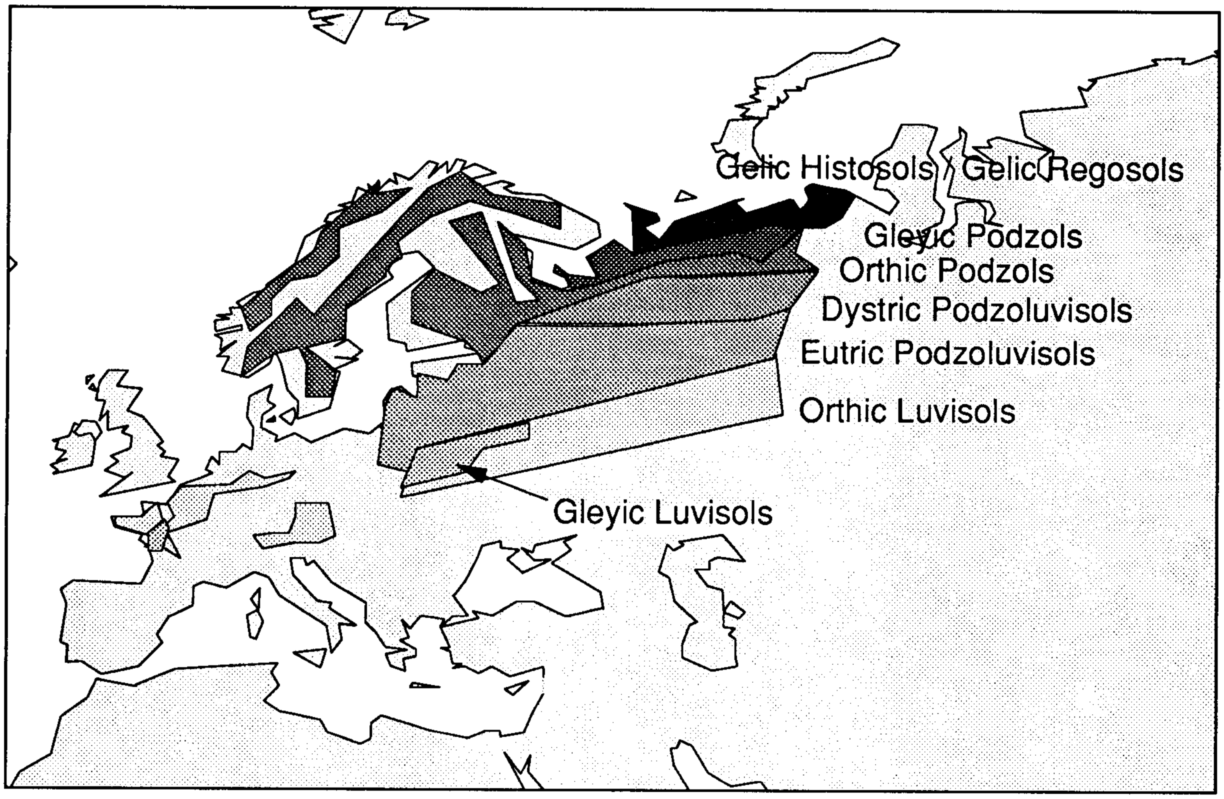

***Figure 2:** Occurrence of the major belts of the Permafrost soils, Podzols, Podzoluvisols and Luvisols in Europe.*
Source: European soil map [3]

Podzoluvisols can contain between 1 and 10% organic carbon (1.7 and 17% o.m.) [9]. The eluvial horizon rarely contains more than 1% organic carbon; a similar amount is present in the Bt horizon (argillic or illuvial clay horizon).

Based on these data De units should be given a somewhat higher o.m. content than Dd units; we used an o.m. content of 3%. The Dg units are assumed to have a much higher o.m. content based on the wetness: see, for example, Gleysols (§2.8). An o.m. content of 8% has been assumed.

For those polygons in the database [1] marked as D without unit identification code is was assumed that it concerned non-specified Podzoluvisols. The the non-specified Podzoluvisols were assigned an o.m. content of 2%. This figure has been used in the

GLOBE-project [18]. Later work showed that this D-code concerns "dunes and shifting sands" and it now has been assigned an o.m. content of 1%; i.e. it has been classified in the group of soils with the lowest o.m. content.

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
Dd	Dystric Podzoluvisols	2.65	base saturation < 50% in part of the B horizon	2
De	Eutric Podzoluvisols	8.91	none of the properties of the other Podzoluvisols	3
Dg	Gleyic Podzoluvisols	0.57	hydromorphic properties within 50 cm of the surface	8

Remark: The estimate for the Dg unit might be too high, especially for the map unit Dg6 occurring in Croatia. This unit includes Gleyic Luvisols as associated soils and Orthic Luvisols and Dystric Planosols as inclusions, all having a much lower estimated o.m. content. The Polish Dg5 map unit includes the Eutric Podzoluvisols as associated soils and the Gleyic Luvisols and Humic Gleysols as inclusions, the latter with an estimated o.m. content of 10%.

2.19 Rankers (U)[6]

([2]:pp.16,34,46; [3]:pp.63-64,88; [5]:pp.57-58,90; [9]:pp.111-118; [11]:pp.259-260)

Rankers are usually shallow soils [11] which have developed over siliceous materials. The MSG contains only one soil unit having an umbric A horizon [3]. Rankers cover 0.17% of the European land area and are found mainly under forest or used for rough grazing. Rankers occur in Spain, former Yugoslavia and the UK.

[6] In the revised FAO-Unesco legend [14] Rankers are no longer an MSG but the Umbric Soil Unit of the Leptosols, see [9] as well.

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
U	n.s. Rankers	0.17	thin umbric A, no other diagnostic horizons	3
	n.s., non-specified			

The estimate of 3% o.m. [4] has been adopted.

2.20 Regosols (R)

([2]:pp.15,33-34,46; [3]:pp.62-63,87; [5]:pp.56-57,86-88; [9]:pp.111-114,119-121; [11]:pp.260-261)

Regosols are soils from unconsolidated materials, excluding recent alluvial deposits (see Fluvisols, §2.7) and having no diagnostic horizon other than an ochric A [3]. All units of this MSG occur on the European soil map. As a group they cover 2% of the land area in Europe: the Gelic Regosols (Rx) are predominant, occurring mainly in the permafrost taiga zone of northern Russia [3].

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
Rc	Calcic Regosols	0.56	calcareous, at least between 20-50 cm	1
Rd	Dystric Regosols	<0.01	base saturation of < 50% between 20-50 cm	1
Re	Eutric Regosols	0.19	none of the properties of the other Regosols	1
Rx	Gelic Regosols	1.26	permafrost within 200 cm of the surface	10

For Rc, Rd, and Re units estimates are given [4]. No data are available for the Rx unit.

The Rx unit has Gelic Gleysols (10% o.m.) and Gelic Histosols (30% o.m.) as associated soils. In cold climates the A horizon contains poorly decomposed organic matter [9].

Assuming that temperature limits the organic matter decomposition an o.m. content of 10% is assumed for Rx which is equal to the Gelic Gleysols.

2.21 Rendzinas (E)[7]

([2]:pp.15,34,46; [3]:pp.40-41,68,118; [5]:57; [9]:pp.111-118; [11]:pp.261-263)

Rendzinas are relatively shallow soils developed in calcareous materials with a calcium carbonate content of more than 40% and a mollic A horizon rich in o.m. The MSG contains only one unit, which covers about 1.2% of the area; it is found throughout Europe over carbonate rock.

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
E	Rendzinas	1.22	mollic A over calcareous	5

For the Rendzinas we adopted the estimate given in [4].

2.22 Solonchaks (Z)

([2]:pp.16,35,44; [3]:pp.66,89,198; [5]:pp.58,95; [9]:pp.177-190; [11]:pp.263-270)

The soils of the Solonchak MSG are characterized by a high salinity. Solonchaks are subdivided only partly on the basis of the type of A horizon. Except for the Takyric Solonchaks (Zt), showing takyric features (e.g. crack into polygonal elements when dry), all units are seen on the European soil map. Solonchaks occupy about 1% of the land area. The Mollic Solonchak (Zm) does not occur on the FAO-Unesco soil map (see remarks), but does occur on the digital European soil map [1] as dominant soil. The Gleyic unit (Zg)

[7] In the revised FAO-Unesco legend [14] Rendzinas are the Rendzic Soil Unit of the Leptosols.

occurs around the Caspian Sea, in Spain, France and Portugal. The Orthic unit (Zo) occurs in Kalmytskaya (former USSR).

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
Z	n.s. Solonchaks	9.04	not specified on map	1
Zg	Gleyic Solonchaks	0.13	hydromorphic properties within 50 cm of the surface	3
Zm	Mollic Solonchaks	0.64	a mollic A horizon	4
Zo	Orthic Solonchaks	0.07	none of the properties of the other Solonchaks	1

n.s., non-specified

The estimate given in [4] has been used for the Zg unit. Fraters and Bouwman [4] reported data of three Zo units with an average of 0.6% o.m. We therefore assumed an o.m. content of 1% for this unit. According to the classification key [2, p.35] Zo units have an ochric A horizon, while the Zm unit has a mollic A horizon. Many Zm units have the appearance of Chernozems, Kastanozems or Phaeozems [9]. Therefore 4% o.m. has been assumed for Zm units. This is lower than for Chernozems, for example, because the high salt concentration hampers the faunal activity, and in severely saline soils the vegetation is sparse, resulting in low o.m. production. For the non-specified Solonchaks a conservative estimate of 1% has been used (conservative from the point of view of the groundwater threat).

Remarks: on the FAO-Unesco European soil map [3] the Zm unit does not appear as dominant soil. It does appear as associated soil in the map units Jc38, Jc40, Kh32, Kk18, Zg9, Zo22, and Zo23. In addition, it occurs in several map units as inclusion.

2.23 Solonetz (S)

([2]:pp.16,35,48; [3]:pp.63,68,87,180-183; [5]:-; [9]:pp.177-180,191-196; [11]:pp.270-274)

Solonetz are soils having a natric B horizon, i.e. having an argillic horizon with more than 15% exchangeable sodium and often a columnar or prismatic structure. This MSG does not appear on the EC soil map [5]. The Mollic Solonetz (Sm) units are mainly found in Hungary and Rumania, the Orthic units (So) mainly in the former USSR, north of the Caspian Sea. West of this area smaller areas of So and Gleyic (Sg) units are found within the Kastanozem belt [3].

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
S	n.s. Solonetz	0.24	not specified on map	2
Sg	Gleyic Solonetz	0.07	hydromorphic properties within 50 cm of the surface	3
Sm	Mollic Solonetz	0.25	a mollic A horizon	4
So	Orthic Solonetz	1.04	none of the properties of the other Solonetz	2

n.s., non-specified

Two European Solonetz units have 3.4 (Sg) and 2.6% (So) o.m., respectively, in the upper 30 cm [3]. American Solonetz units [8] have an o.m. content ranging from 0.59 up to 3.84% (average 1.9% o.m.): Sg: 0.90 and 1.20%, Sm: 1.78, 3.51, and 3.84%, So: 0.59, 1.33 and 2.12%. The So units have an ochric A horizon [2, p.35] up to about 15 cm thick and under natural conditions overlaid by black humified material 2 to 3 cm thick [11]. According to FitzPatrick [11] the amount of o.m. in the surface mineral horizons varies but is usually less than 10%; the upper 30 cm of the provided generalized profile contains 2% o.m. The average for the So units is 1.7% o.m. We therefore assumed an o.m. content of 2%. Sg units may have all types of A horizons. Because of wetness the o.m. content is assumed to be somewhat higher than for the So units. Although the average of 1.8% for the profiles described disagrees with this assumption, we adopted a tentative o.m. content of 3%, i.e. the same as the Gleyic Solonchaks. The Sm units have a mollic A horizon. In addition the o.m. content of the described profiles is clearly higher than for the other Solonetz units. That is why we used an estimate of 4% o.m., identical to the Mollic Solonchaks. For the non-specified Solonetz, the lowest estimate has again been used, i.e. 2%.

2.24 Vertisols (V)

([2]:pp.16,35,43; [3]:pp.64-65,88,190-193; [5]:pp.5,38-39,5891-94; [9]:pp.65-82; [11]:pp.274-279)

Vertisols are clay soils rich in montmorillonite. They typically show cracks to a depth of at least 50 cm when dry. Vertisols cover 0.45% of the European land area [1]. The Chromic Vertisols (Vc) occur in the Mediterranean, whereas the Pellic Vertisols (Vp) are confined to Bulgaria, Rumania, former Yugoslavia and Hungary [3].

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
V	n.s. Vertisols	0.01	not specified on map	2
Vc	Chromic Vertisols	0.23	non Pellic Vertisols	2
Vp	Pellic Vertisols	0.20	moist chromas[a] of less than 1.5 in soil matrix	2

n.s., non-specified
a) see footnote 3, page 4

For Vc, Vp, and the non-specified Vertisols we assumed an o.m. content of 2% following [4].

2.25 Xerosols (X)[8]

([2]:pp.17,36,50; [3]:pp.65-66,88-89,196-197; [5]:pp.39,97; [9]:-; [11]:pp.279-282)

Xerosols are desert and semi-desert soils with a weak ochric A. A weak ochric A horizon has a content of o.m. which is intermediate to that of the very weak ochric A horizon and that required for the mollic A horizon[9]. Xerosols occupy over 5% of the land area [1] and are found mainly south of the Kastanozem belt in eastern Europe and in the northeastern and southeastern part of Spain [3].

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
X	n.s. Xerosols	0.11	not specified on map	1
Xh	Haplic Xerosols	0.79	none of the properties of the other Xerosols	1
Xk	Calcic Xerosols	2.48	a calcic horizon within 125 cm of the surface	1
Xl	Luvic Xerosols	1.62	an argillic B horizon	1
Xy	Gypsic Xerosols	0.12	a gypsic horizon within 125 cm of the surface	1

n.s., non-specified

In [4] estimates are given for only Calcic and Gypsic Xerosols (Xk and Xy, respectively). There are no indications to assume that other Xerosol units have higher o.m. contents and therefore an estimate of 1% is used for all units, including the non-specified Xerosols.

8 In the revised FAO-Unesco legend [2] Xerosols and Yermosols, previously classified on the basis of an aridic soil moisture regime, are now incorporated in other groups and a yermic phase is indicated where appropriate.

9 For definitions see [2]. Roughly summarized, ochric A horizons may have any o.m. content valid for mineral soils. Based on o.m. content three types of ochric A horizons can be distinguished: (1) ochric A horizons with an o.m. content required for a mollic A horizon; these horizons do not qualify as mollic (or umbric) because of structure, colour or depth requirements (see Chapter 1); (2) very weak ochric A horizons with very low contents of o.m., depending on sand/clay ratios less than 0.5-1% o.m. and (3) weak ochric A horizons with an intermediate o.m. content.

2.26 Yermosols (Y)[8]

([2]:pp.16-17,35-36,50-51; [3]:-; [5]:-; [9]:-; [11]:pp.282-283)

Yermosols are soils with a very weak ochric A horizon[9] occurring under an aridic moisture regime.

American data [8] show o.m. content ranging from 0.07 up to 1.33% (average 0.50%): Yh: 0.22, 0.42, and 0.60% (average: 0.41%); Yk: 0.07, 0.18, and 0.37% (average: 0.21%); Yl: 0.28, 0.49, 0.57, 0.62, and 0.87% (average: 0.57%); Yy: 1.33%. It is clear from the available data that the o.m. contents of these soils are very low. For the present project it was not necessary to distinguish these soils from the Xerosols, therefore an estimate of 1% has been used for all Yermosol units.

code	Soil Unit	Occurrence % of total	Main Criterion	Estimated o.m. (%)
Y	n.s. Yermosols	0.05	not specified on map	1
Yh	Haplic Yermosols	0.43	none of the properties of the other Yermosols	1
Yk	Calcic Yermosols	2.42	a calcic horizon within 125 cm of the surface	1
Yl	Luvic Yermosols	0.04	an argillic B horizon	1
Yt	Takyric Yermosols	0.53	takyric features (crack into polygonal elements)	1
Yy	Gypsic Yermosols	0.49	a gypsic horizon within 125 cm of the surface	1

n.s., non-specified

Remarks: although trends within this MSG suggest an increase in organic matter content, i.e. Yk < Yh < Yl < Yy variability in the amount of data available is too high.

8,9 See previous page

3. Future developments

3.1 More detailed geographic information

The literature available to be able to make generalizations as in this report is scarce. In future, more information from national and regional soil maps and reports will have to be collected. Another approach is to relate the organic matter content of the dominant soil unit in the map unit to the estimated organic matter content of the associated and/or included soil units. This is suggested in the text and already in practice for several major soil groups and soil units.

A point of focus is the calculation of organic matter content from the organic carbon content. The multiplication factor of 1.72 or 1.724 has been widely used in the past to calculate organic matter content from organic carbon data [10,11,17]. In [17] a factor of 1.8 to 2.0 (approximately 1.9) is given as a more appropriate factor for surface soils. In [10] a factor of 2.0 is given as alternative. In addition, data from De Leenheer [10] which show a relationship between the carbon content of organic matter and the carbon content of the soil horizon are presented. The higher the organic carbon content of the soil the lower the organic carbon content of the organic matter, e.g. for an organic carbon content of the soil of less than 2.5% the multiplication factor would be 1.82, 2.5-5%: 1.94, 5-10%: 2.21, and of more than 10%: 2.01. It would be possible to present all data as organic carbon since most profile data are presented in that capacity. Nevertheless, general textbooks usually present organic matter and not organic carbon, which poses the problem of reverse translation.

At presentl, only minor assumptions have been used to estimate organic matter content for arable topsoils from topsoils of profiles under different land use types. We are aware of the vast amount of literature on the influence of land use and management on the organic matter content of the topsoil, which might led to more elaborate methods for organic matter estimation.

3.2 Different estimation approaches

In the current organic matter map of Europe (Appendix I) the organic matter content of the upper 30 cm has been estimated. Implicitly the organic matter content of that layer was assumed to be the most important factor in controlling leaching of pesticides to groundwater reservoirs and that content and distribution below 30 cm had a negligible influence. Because large differences exist in organic matter distribution in profiles of different soil units the approach used in Soil Taxonomy [8] offers an interesting alternative. Not the percentage of a layer is estimated but the total amount of organic matter in $kg \cdot m^{-2}$ over the depth of the profile. In Soil Taxonomy the maximum depth is usually 100 to 150 cm, including a part of the C horizon.

Note that for Lithosols, Chernozems and Chernozem-like soils this approach was explicit when estimating the organic matter content of the upper 30 cm. For other MSGs it was implicit.

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APPENDIXES

Appendix I: Soil organic matter map of Europe

Appendix II: Listing of data file with organic matter content of topsoils

File: SOMEUR_2.DAT
Content: Organic matter contents in per cent for FAO/Unesco Soil Units in Europe

author: Dico Fraters
date: May 24 1993

comments:
- An error has been discovered in the database description of NOAA global FAO soil units (1991, file: GFAOSOIL.DOC): unit 22 (code: D) covers "Dunes and shifting sands" and not Podzoluvisols, therefore the o.m.% has been changed from 2 to 1%.
- A zero (0) indicates that either the legend unit is not a soil or the soil unit does not occur on the digital Soil Map of Europe
- A total of 9 o.m. classes are differentiated (1, 2, 3, 4, 5, 8, 10, 14, and 30).
- The colour codes advised for the classes are (using the Ostwald colour system):

class	colour code
1	101
2	199
3	297
4	317
5	331
8	2
10	94
14	49
30	51

image title : UNESCO/FAO Soil Units - Europe
data type : byte
file type : binary
rows : 228
columns : 486
minimum : 0.0000000000E+00
maximum : 1.3300000000E+02
cell x : 1.6666666667E-01
cell y : 1.6666666667E-01
legend : 133

category 1 :	1	A	Acrisols	0
category 2 :	2	Af	Ferric Acrisols	0
category 3 :	3	Ag	Gleyic Acrisols	0
category 4 :	4	Ah	Humic Acrisols	0
category 5 :	5	Ao	Orthic Acrisols	2
category 6 :	6	Ap	Plinthic Acrisols	0

category 7 :	7	B	Cambisols	0
category 8 :	8	Bc	Chromic Cambisols	2
category 9 :	9	Bd	Dystric Cambisols	3
category 10 :	10	Be	Eutric Cambisols	3
category 11 :	11	Bf	Ferralic Cambisols	0
category 12 :	12	Bg	Gleyic Cambisols	3
category 13 :	13	Bh	Humic Cambisols	5
category 14 :	14	Bk	Calcic Cambisols	3
category 15 :	15	Bv	Vertic Cambisols	3
category 16 :	16	Bx	Gelic Cambisols	0
category 17 :	17	C	Chernozems	8
category 18 :	18	Cg	Glossic Chernozems	0
category 19 :	19	Ch	Haplic Chernozems	14
category 20 :	20	Ck	Calcic Chernozems	8
category 21 :	21	Cl	Luvic Chernozems	8
category 22 :	22	D	Dunes and shifting sands	1
category 23 :	23	Dd	Dystric Podzoluvisols	2
category 24 :	24	De	Eutric Podzoluvisols	3
category 25 :	25	Dg	Gleyic Podzoluvisols	8
category 26 :	26	E	Rendzinas	5
category 27 :	27	F	Ferralsols	0
category 28 :	28	Fa	Acric Ferralsols	0
category 29 :	29	Fh	Humic Ferralsols	0
category 30 :	30	Fo	Orthic Ferralsols	1
category 31 :	31	Fp	Plinthic Ferralsols	0
category 32 :	32	Fr	Rhodic Ferralsols	0
category 33 :	33	Fx	Xanthic Ferralsols	0
category 34 :	34	G	Gleysols	0
category 35 :	35	Gc	Calcaric Gleysols	5
category 36 :	36	Gd	Dystric Gleysols	5
category 37 :	37	Ge	Eutric Gleysols	4
category 38 :	38	Gh	Humic Gleysols	10
category 39 :	39	Gm	Mollic Gleysols	4
category 40 :	40	Gp	Plinthic Gleysols	0
category 41 :	41	Gx	Gelic Gleysols	10
category 42 :	42	H	Phaeozems	0
category 43 :	43	Hc	Calcaric Phaeozems	5
category 44 :	44	Hg	Gleyic Phaeozems	5
category 45 :	45	Hh	Haplic Phaeozems	5
category 46 :	46	Hl	Luvic Phaeozems	5
category 47 :	47	I	Lithosols	1
category 48 :	48	J	Fluvisols	0
category 49 :	49	Jc	Calcaric Fluvisols	5
category 50 :	50	Jd	Dystric Fluvisols	5
category 51 :	51	Je	Eutric Fluvisols	5

category 52 :	52	Jt	Thionic Fluvisols	0
category 53 :	53	K	Kastanozems	3
category 54 :	54	Kh	Haplic Kastanozems	5
category 55 :	55	Kk	Calcic Kastanozems	3
category 56 :	56	Kl	Luvic Kastanozems	3
category 57 :	57	L	Luvisols	0
category 58 :	58	La	Albic Luvisols	2
category 59 :	59	Lc	Chromic Luvisols	2
category 60 :	60	Lf	Ferric Luvisols	2
category 61 :	61	Lg	Gleyic Luvisols	3
category 62 :	62	Lk	Calcic Luvisols	0
category 63 :	63	Lo	Orthic Luvisols	2
category 64 :	64	Lp	Plinthic Luvisols	0
category 65 :	65	Lv	Vertic Luvisols	2
category 66 :	66	M	Greyzems	0
category 67 :	67	Mg	Gleyic Greyzems	0
category 68 :	68	Mo	Orthic Greyzems	4
category 69 :	69	N	Nitosols	0
category 70 :	70	Nd	Dystric Nitosols	0
category 71 :	71	Ne	Eutric Nitosols	2
category 72 :	72	Nh	Humic Nitosols	0
category 73 :	73	O	Histosols	0
category 74 :	74	Od	Dystric Histosols	30
category 75 :	75	Oe	Eutric Histosols	30
category 76 :	76	Ox	Gelic Histosols	30
category 77 :	77	P	Podzols	0
category 78 :	78	Pf	Ferric Podzols	0
category 79 :	79	Pg	Gleyic Podzols	4
category 80 :	80	Ph	Humic Podzols	4
category 81 :	81	Pl	Leptic Podzols	4
category 82 :	82	Po	Orthic Podzols	4
category 83 :	83	Pp	Placic Podzols	10
category 84 :	84	Q	Arenosols	0
category 85 :	85	Aq	Albic Arenosols	0
category 86 :	86	Qc	Cambic Arenosols	1
category 87 :	87	Qf	Ferralic Arenosols	0
category 88 :	88	Ql	Luvic Arenosols	1
category 89 :	89	R	Regosols	0
category 90 :	90	Rc	Calcaric Regosols	1
category 91 :	91	Rd	Dystric Regosols	1
category 92 :	92	Re	Eutric Regosols	1
category 93 :	93	Rx	Gelic Regosols	10
category 94 :	94	S	Solonetz	2
category 95 :	95	Sg	Gleyic Solonetz	3
category 96 :	96	Sm	Mollic Solonetz	4

category 97 :	97	So	Orthic Solonetz	2
category 98 :	98	T	Andosols	0
category 99 :	99	Th	Humic Andosols	14
category100 :	100	Tm	Mollic Andosols	14
category101 :	101	To	Ochric Andosols	8
category102 :	102	Tv	Vitric Andosols	8
category103 :	103	U	Rankers	3
category104 :	104	V	Vertisols	2
category105 :	105	Vc	Chromic Vertisols	2
category106 :	106	Vp	Pellic Vertisols	2
category107 :	107	W	Planosols	0
category108 :	108	Wd	Dystric Planosols	1
category109 :	109	We	Eutric Planosols	1
category110 :	110	Wh	Humic Planosols	0
category111 :	111	Wm	Mollic Planosols	0
category112 :	112	Ws	Solodic Planosols	3
category113 :	113	Wx	Gelic Planosols	0
category114 :	114	X	Xerosols	1
category115 :	115	Xh	Haplic Xerosols	1
category116 :	116	Xk	Calcic Xerosols	1
category117 :	117	Xl	Luvic Xerosols	1
category118 :	118	Xy	Gypsic Xerosols	1
category119 :	119	Y	Yermosols	1
category120 :	120	Yh	Haplic Yermosols	1
category121 :	121	Yk	Calcic Yermosols	1
category122 :	122	Yl	Luvic Yermosols	1
category123 :	123	Yt	Takyric Yermosols	1
category124 :	124	Yy	Gypsic Yermosols	1
category125 :	125	Z	Solonchaks	1
category126 :	126	Zg	Gleyic Solonchaks	3
category127 :	127	Zm	Mollic Solonchaks	4
category128 :	128	Zo	Orthic Solonchaks	1
category129 :	129	Zt	Takyric Solonchaks	1
category130 :	130	RO	Rock	0
category131 :	131	SA	Salt	0
category132 :	132	WA	Water	0
category133 :	133	--	no name	0

Appendix III: Listing of files with mapping parameters

Projection characteristics (Arc/Info):

```
INPUT
        projection geographic
        units dd

OUTPUT
        projection lambert_azimuth
        spheroid bessel
        unit metres
        parameters
        0
        25 0 0
        50 0 0
        0
        0
```

Map-design file:

```
/*****************************************************
/*
/* KAART METAFILE:
/*
/* Project: globe
/* Naam:    /projecten/project4/datacrash/globe/krt/orgmatter.krt
/* Nummer:
/* Versie:  1.0
/* Datum:   Januari 26, 1993
/*
/*****************************************************

&setvar .titel          := Organic matter of the soil
&setvar .subtitel       :=
&setvar .kaartnr        :=
&setvar .versie         := 1.0
&setvar .coverage       := /projecten/project1/globe/basis/eurogrid.cov
&setvar .item           := stdrel//percorg
&setvar .legendatitel1  := percentage per grid
&setvar .legendatitel2  :=
&setvar .legendatitel3  :=
&setvar .legenda1 := 101 1 '    1'
&setvar .legenda2 := 199 2 ' <  2'
&setvar .legenda3 := 297 3 ' <  3'
&setvar .legenda4 := 317 4 ' <  4'
&setvar .legenda5 := 331 5 ' <  5'
&setvar .legenda6 := 2 8 ' <  8'
&setvar .legenda7 := 94 10 ' < 10'
&setvar .legenda8 := 49 14 ' < 14'
&setvar .legenda9 := 51 30 ' < 30'
&setvar .legenda10 := ' ' ' ' ' '
&setvar .tekst1         :=
&setvar .tekst2         :=
&setvar .tekst3         :=
&setvar .tekst4         :=
&setvar .tekst5         :=
&setvar .tekst6         :=
&setvar .tekst7         :=
&setvar .tekst8         :=
&setvar .tekst9         :=
&setvar .tekst10        :=
```

```
&setvar .achtergrond     := .true.
&setvar .altmapex        :=
&setvar .bos             :=
&setvar .boskleur        := 440
&setvar .bron            := UNESCO/FAO, RIVM
&setvar .buitenlandkleur := 415
&setvar .concept         := .false.
&setvar .datum           := .true.
&setvar .feature         := vlak
&setvar .lijnencoverage  :=
&setvar .postaml         :=
&setvar .postcommando1   :=
&setvar .postcommando2   :=
&setvar .postcommando3   :=
&setvar .postcommando4   :=
&setvar .postcommando5   :=
&setvar .preaml          :=
&setvar .precommando1    :=
&setvar .precommando2    :=
&setvar .precommando3    :=
&setvar .precommando4    :=
&setvar .precommando5    :=
&setvar .reldb           := INFO
&setvar .relitem1        := RECNUM
&setvar .relitem2        := RECNUM
&setvar .reltabel        := /PROJECTEN/PROJECT1/GLOBE/DATA/PEST:PEST.INF
&setvar .reltype         := LINK
&setvar .rivieren        := .FALSE.
&setvar .rivierkleur     := cyan
&setvar .rivmcomp        := .true.
&setvar .rivmlogo        := .true.
&setvar .steden          := .false.
&setvar .stedenkleur     := 348
&setvar .symbolnrerbij   := .FALSE.
&setvar .taal            := engels
&setvar .zeekleur        := 6
```

Appendix IV: Classification of Soil Taxonomy profiles and calculation of organic matter content

Appendix IV

Calculations of organic matter content of the upper 30 cm of the profiles described in Soil Taxonomy [8], including their classification according to the FAO/Unesco legend [2]. Classification has been carried out in two steps: (1) an initial classification based on the translation key provided in [2, p14-20], (2) a final classification using profile description [2] and the classification key to the soil units of the FAO\Unesco [2, p43-53] and the key to sub-unit level of the European Communities [5, p5-6].

Table headings

Soil Taxonomy:	classification of pedon according to Soil Taxonomy [8]
FAO/Unesco:	classification of pedon using the FAO/Unesco legend [2]
code:	classification code of FAO/Unesco legend [2]
Landuse:	type of land use as given by [8]
Parentmat:	parent material in which pedon developed [8]
Depth:	depth of described soil layer in cm
OC:	organic carbon content of horizon [8]
OM:	organic matter content of horizon, calculated using factor 1.72
Pedon:	pedon number [8]
Layer:	layer/horizon number
OM-cont:	organic matter content of upper 30 cm of pedon, litter layers excluded.

Soil Taxonomy	FAO/UNESCO	code	Landuse	parentmat	depth	OC	OM	Pedon	layer	OM-cont 0-30 cm
Typic Haplustult	Ochric Acrisol	Ao	arable	?	0-23	1.64	2.83	121	1	2.49
		Ao			23-46	0.8	1.38	121	2	
Typic Haploxerult	Ochric Acrisol	Ao	forest	schist	0- 5	4.22	7.28	122	1	3.28
		Ao			5-23	1.71	2.95	122	2	
		Ao			23-56	0.75	1.29	122	3	
Oxic Plinthaquult	Plinthic Acrisol	Ap	arable	coastal	0-25	3.25	5.60	114	1	5.01
		Ap			25-33	1.18	2.03	114	2	
Typic Dystrochrept	Dystric Cambisol	Bd	forest	siltstone	0- 5	5.48	9.45	29	1	2.65
		Bd			5-18	1.13	1.95	29	2	
		Bd			18-33	0.33	0.57	29	3	
Andic Dystrochrept	Ando-Dystric Cambisol	Bda	forest	fluvial	0-15	8.05	13.88	10	1	9.25
		Bda			15-38	2.68	4.62	10	2	
Typic Xerochrept	Eutric Cambisol	Be	grass	tonalite	0- 8	0.96	1.66	79	1	1.06
		Be			8-23	0.56	0.97	79	2	
		Be			23-48	0.34	0.59	79	3	
Typic Eutropept	Eutric Cambisol	Be	bush	andesite	0- 3	2.26	3.90	81	1	2.24
		Be			3-15	1.77	3.05	81	2	
		Be			15-33	0.73	1.26	81	3	
Typic Eutrochrept	Calcaro-Eutric Cambisol	Bec	grass	glacial	0-23	1.46	2.52	78	1	2.05
		Bec			23-38	0.29	0.50	78	2	
Typic Dystropept	Ando-Humic Cambisol *1	Bha	grass	volcanic	0-15	2.28	3.93	80	1	3.13
		Bha			15-33	1.35	2.33	80	2	

Soil Taxonomy	FAO/UNESCO	code	Landuse	parentmat	depth	OC	OM	Pedon	layer	OM-cont 0-30 cm
Typic Haploboroll	Haplic Chernozem	Ch	grass	alluvium	0-10	1.24	2.14	86	1	1.57
		Ch			10-30	0.75	1.29	86	2	
Entic Haplustoll	Haplic Chernozem	Ch	grass	alluvium	0-15	1.43	2.47	94	1	2.11
		Ch			15-38	1.02	1.76	94	2	
Aridic Calcixeroll	Calcic Chernozem	Ck	bush	alluvium	0-10	3.69	6.36	37	1	5.99
		Ck			10-18	3.46	5.97	37	2	
		Ck			18-38	3.31	5.71	37	3	
Typic Calciustoll	Calcic Chernozem	Ck	grass	Loess?	0-20	1.56	2.69	93	1	2.40
		Ck			20-56	1.05	1.81	93	2	
Pachic Calcixeroll	Calcic Chernozem	Ck	grass	shale	0-10	3.9	6.72	97	1	3.57
		Ck			10-41	1.16	2.00	97	2	
Udic Argiustoll	Luvic Chernozem	Cl	grass	limestone	0-08	4.35	7.50	4	1	6.56
		Cl			8-33	3.61	6.22	4	2	
Typic Argiboroll	Luvic Chernozem	Cl	grass	glacial	0-04	4.68	8.07	18	1	2.95
		Cl			4-08	2.6	4.48	18	2	
		Cl			8-20	1.26	2.17	18	3	
		Cl			20-28	1.2	2.07	18	4	
		Cl			28-58	0.77	1.33	18	5	
Typic Palexeroll	Luvic Chernozem	Cl	brush	loess	0-18	4.35	7.50	101	1	5.47
		Cl			18-33	1.41	2.43	101	2	
Aeric Glossaqualf	Gleyic Podzoluvisol	Dg	Forest	loess	0-10	5.54	9.55	11	1	3.80
		Dg			10-23	0.76	1.31	11	2	
		Dg			23-36	0.13	0.22	11	3	
Aeric Glossaqualf	Gleyic Podzoluvisol	Dg	grass	silt	0- 8	7.2	12.41	45	1	3.89
		Dg			8-15	0.89	1.53	45	2	
		Dg			15-25	0.3	0.52	45	3	
		Dg			25-36	0.18	0.31	45	4	
Typic Rendoll	Orthic Rendzina	Eo	brush	limestone	0-15	2.16	3.72	88	1	2.28
		Eo			15-23	0.9	1.55	88	2	
		Eo			23-58	0.022	0.04	89	3	
Typic Acrutox	Acric Ferralsol	Fa	cerrado	slates	0-10	3.42	5.90	32	1	4.38
		Fa			10-30	2.1	3.62	32	2	
Typic Acrorthox	Acric Ferralsol	Fa	bush	serpentin	0-28	6.04	10.41	102	1	9.95
		Fa			28-46	2.04	3.52	102	2	
Haplic Acrorthox	Acric Ferralsol	Fa	forest	clayey	0- 4	2.76	4.76	103	1	1.98
		Fa			4-19	1.13	1.95	103	2	
		Fa			19-87	0.58	1.00	103	3	
Tropeptic Umbriorthox	Humic Ferralsol	Fh	grass	basalt	0-23	4.39	7.57	106	1	6.49
		Fh			23-53	1.72	2.97	106	2	
Typic Gibbsiorthox	Orthic Ferralsol	Fo	grass	igneous	0-38	3.88	6.69	105	1	6.69
Tropeptic Haplorthox	Rhodic Ferralsol	Fr	grass	andesite	0-15	4.3	7.41	33	1	5.22
		Fr			15-33	1.75	3.02	33	2	
Tropepric Eutrorthox	Rhodic Ferralsol	Fr	grass	colluvium	0-20	2.73	4.71	104	1	3.68
		Fr			20-46	0.94	1.62	104	2	

Soil Taxonomy	FAO/UNESCO	code	Landuse	parentmat	depth	OC	OM-cont OM	Pedon	layer	0-30 cm
Typic Torrox	Rhodic Ferralsol	Fr	arable	igneous	0-15	1.92	3.31	107	1	3.35
		Fr			15-38	1.97	3.40	107	2	
Typic Fragiaquept	Dystric Gleysol	Gd	grass	glacial	0-15	3.5	6.03	77	1	3.10
		Gd			15-36	0.1	0.17	77	2	
Histic Humaquept	Humic Gleysol	Gh	gr/for	marine	30-00	29	50.00	8	1	0.28
		Gh			0-10	0.27	0.47	8	2	
		Gh			10-25	0.13	0.22	8	3	
		Gh			25-58	0.06	0.10	8	4	
Typic Haplaquoll	Mollic Gleysol	Gm	arable	alluvium	0-15	1.51	2.60	28	1	2.53
		Gm			15-30	1.42	2.45	28	2	
Typic Calciaquoll	Mollic Gleysol	Gm	?	?				38	1	
Typic Haplaquoll	Mollic Gleysol	Gm	arable	glacial	0-15	4.2	7.24	84	1	5.72
		Gm			15-33	2.44	4.21	84	2	
Mollic Andaquept	Ando-Mollic Gleysol	Gma	grass	alluvium	0- 4	7.71	13.29	76	1	3.61
		Gma			4-13	2.6	4.48	76	2	
		Gma			13-23	0.88	1.52	76	3	
		Gma			23-38	0.34	0.59	76	4	
Typic Argiaquoll	Gleyic Phaeozem	Hg	arable	glacial	0-18	2.09	3.60	17	1	3.29
		Hg			18-25	2.04	3.52	17	2	
		Hg			25-41	1.08	1.86	17	3	
Typic Argiaquoll	Gleyic Phaeozem	Hg	grass	loess	0-18	2.78	4.79	83	1	4.17
		Hg			18-33	1.88	3.24	83	2	
Typic Hapludoll	Haplic Phaeozem	Hh	gr/for	loess	0-20	2.86	4.93	30	1	3.78
		Hh			20-41	0.85	1.47	30	2	
Typic Cryoboroll	Haplic Phaeozem	Hh	bush	sandstone	0-13	10	17.24	85	1	11.18
		Hh			13-23	4.93	8.50	85	2	
		Hh			23-38	2.18	3.76	85	3	
Typic Hapludoll	Haplic Phaeozem	Hh	arable	loess	0-18	2.2	3.79	90	1	3.57
		Hh			18-33	1.87	3.22	90	2	
Pachic Haploxeroll	Haplic Phaeozem	Hh	grass	glacial	0-10	1.55	2.67	99	1	2.34
		Hh			10-25	1.37	2.36	99	2	
		Hh			25-61	0.92	1.59	99	3	
Typic Haploxeroll	Haplic Phaeozem	Hh	brush	limestone	0- 8	2.99	5.16	130	1	4.24
		Hh			8-23	2.36	4.07	130	2	
		Hh			23-41	2.06	3.55	130	3	
Aquic Argiudoll	Luvic Phaeozem	Hl	arable	loess	0-18	2.17	3.74	2	1	3.08
		Hl			18-38	1.21	2.09	2	2	
Typic Argiudoll	Luvic Phaeozem	Hl	arable	loess	0-18	2.35	4.05	89	1	3.71
		Hl			18-28	1.95	3.36	89	2	
		Hl			28-43	1.42	2.45	89	3	
Typic Paleudoll	Luvic Phaeozem	Hl	arable	limestone	0-15	0.87	1.50	91	1	1.41
		Hl			15-23	0.82	1.41	91	2	
		Hl			23-46	0.7	1.21	91	3	

Soil Taxonomy	FAO/UNESCO	code	Landuse	parentmat	depth	OC	OM	Pedon	layer	OM-cont 0-30 cm
Pachic Argiustoll	Luvic Phaeozem	Hl	grass	loess	0-13	2.54	4.38	92	1	3.50
		Hl			13-25	1.8	3.10	92	2	
		Hl			25-41	1.24	2.14	92	3	
Typic Argixeroll	Luvic Phaeozem	Hl	arab_irr	alluvium	0-18	0.89	1.53	96	1	1.40
		Hl			18-53	0.7	1.21	96	2	
Typic Udifluvent	Calcic Fluvisol	Jc	?	alluvium	0-14	1.28	2.21	66	1	1.55
		Jc			14-31	0.57	0.98	66	2	
Typic Torrifluvent	Calcic Fluvisol	Jc	arable	alluvium	0-30	0.92	1.59	67	1	1.59
Typic Argiustoll	Luvic Kastanozem	Kl	arable	loess	0-15	1.17	2.02	1	1	1.72
		Kl			15-30	0.83	1.43	1	2	
Aridic Argiboroll	Luvic Kastanozem	Kl	grass	glacial	0-05	2.06	3.55	3	1	2.04
		Kl			5-13	1.29	2.22	3	2	
		Kl			13-23	0.97	1.67	3	3	
		Kl			23-33	0.74	1.28	3	4	
Aridic Durixeroll	Luvic Kastanozem	Kl	brush	alluvium	0- 5	2.24	3.86	98	1	1.71
		Kl			5-10	1.05	1.81	98	2	
		Kl			10-20	0.75	1.29	98	3	
		Kl			20-30	0.58	1.00	98	4	
Ultic Hapludalf	Albic Luvisol	La	grass	loess	0-13	0.96	1.66	9	1	1.20
		La			13-23	0.64	1.10	9	2	
		La			23-33	0.28	0.48	9	3	
Ultic Hapludalf	Albic Luvisol	La	arable	loess	0-15	0.86	1.48	14	1	1.15
		La			15-23	0.85	1.47	14	2	
		La			23-33	0.046	0.08	14	3	
Typic Cryoboralf	Albic Luvisol	La	forest	alluvium	0-18	0.84	1.45	48	1	1.11
		La			18-30	0.35	0.60	48	2	
Typic Eutroboralf	Albic Luvisol	La	forest	till	5- 0			49	1	0.70
		La			0-13	0.47	0.81	49	2	
		La			13-25	0.38	0.66	49	3	
		La			25-38	0.3	0.52	49	4	
Mollic Haploxeralf	Chromic Luvisol	Lc	grass	tonalite	0-08	2.1	3.62	12	1	2.01
		Lc			8-33	0.83	1.43	12	2	
Typic Durixeralf	Chromic Luvisol	Lc	grass	granitic	0-28	0.3	0.52	53	1	0.50
		Lc			28-38	0.16	0.28	53	2	
Typic Rhodoxeralf	Rhodo-Chromic Luvisol	Lcr	arable	limestone	0-15	1.68	2.90	13	1	2.71
		Lcr			15-23	1.57	2.71	13	2	
		Lcr			23-41	1.34	2.31	13	3	
Typic Albaqualf	Dystric Planosols *2	Lg	forest	clay till	0- 8	6.5	11.21	20	1	4.10
		Lg			8-19	1.11	1.91	20	2	
		Lg			19-28	0.63	1.09	20	3	
		Lg			28-43	0.69	1.19	20	4	

Soil Taxonomy	FAO/UNESCO	code	Landuse	parentmat	depth	OC	OM	Pedon	layer	OM-cont 0-30 cm
Typic Ochraqualf	Gleyic Luvisol	Lg	grass	loess	0-10	1.82	3.14	46	1	1.67
		Lg			10-28	0.57	0.98	46	2	
		Lg			28-38	0.29	0.50	46	3	
Aeric Tropaqualf	Gleyic Luvisol	Lg	grass	alluvium	0-18	1.48	2.55	47	1	2.35
		Lg			18-30	1.19	2.05	47	2	
Typic Paleustalf	Calcic Luvisol	Lk	?	?	0-18	0.87	1.50	52	1	1.42
		Lk			18-41	0.75	1.29	52	2	
Typic Hapludalf	Orthic Luvisol	Lo	grass	glacial	0-18	1.25	2.16	16	1	1.86
		Lo			18-25	1.08	1.86	16	2	
		Lo			25-36	0.45	0.78	16	3	
Psammentic Hapludalf	Orthic Luvisol	Lo	orchard	delta	0-23	1.42	2.45	19	1	2.00
		Lo			23-38	0.31	0.53	19	2	
Typic Agrudalf	Orthic Luvisol	Lo	arable	loess	0-23	1.02	1.76	22	1	1.50
		Lo			23-43	0.37	0.64	22	2	
Glossic Fragiudalf	Orthic Luvisol?	Lo	grass	loess	0-15	0.96	1.66	34	1	1.06
		Lo			15-33	0.27	0.47	34	2	
Typic Hapludalf	Orthic Luvisol	Lo	grass	loess?	0-10	1.74	3.00	50	1	1.80
		Lo			10-28	0.74	1.28	50	2	
		Lo			28-36	0.31	0.53	50	3	
Typic Paleudalf	Orthic Luvisol	Lo	grass	limestone	0-13	1.79	3.09	51	1	1.93
		Lo			13-36	0.61	1.05	51	2	
Typic Palexeralf	Orthic Luvisol	Lo	arable	alluvium	0-18	0.69	1.19	55	1	0.96
		Lo			18-36	0.36	0.62	55	2	
Typic Rhodudult	Dystric Nitosol	Nd	forest	sandstone	0-13	3.36	5.79	119	1	3.22
		Nd			13-23	0.92	1.59	119	2	
		Nd			23-41	0.44	0.76	119	3	
Typic Tropudult	Dystric Nitosol	Nd	grass	volcanic	0-15	2.4	4.14	120	1	2.65
		Nd			15-41	0.67	1.16	120	2	
Typic Tropohumult	Humic Nitosol	Nh	grass	andesite	0-15	5.2	8.97	116	1	6.14
		Nh			15-28	2.01	3.47	116	2	
		Nh			28-48	1.34	2.31	116	3	
Aeric Haplaquod	Gleyic Podzol	Pg	forest	sandy col	0- 8	1.12	1.93	108	1	0.55
		Pg			8-41	0.03	0.05	108	2	
Typic Cryohumod	Humic Podzol	Ph	forest	volcanic	10- 0	42.52	73.31	109	1	12.63
		Ph			0- 5	9.98	17.21	109	2	
		Ph			5-13	11.77	20.29	109	3	
		Ph			13-23	6.66	11.48	109	4	
		Ph			23-33	1.31	2.26	109	5	
Typic Cryorthod	Leptic Podzol	Pl	forest	volcanic	0- 1	5.31	9.16	111	1	1.89
		Pl			1-20	1.22	2.10	111	2	
		Pl			20-43	0.44	0.76	111	3	

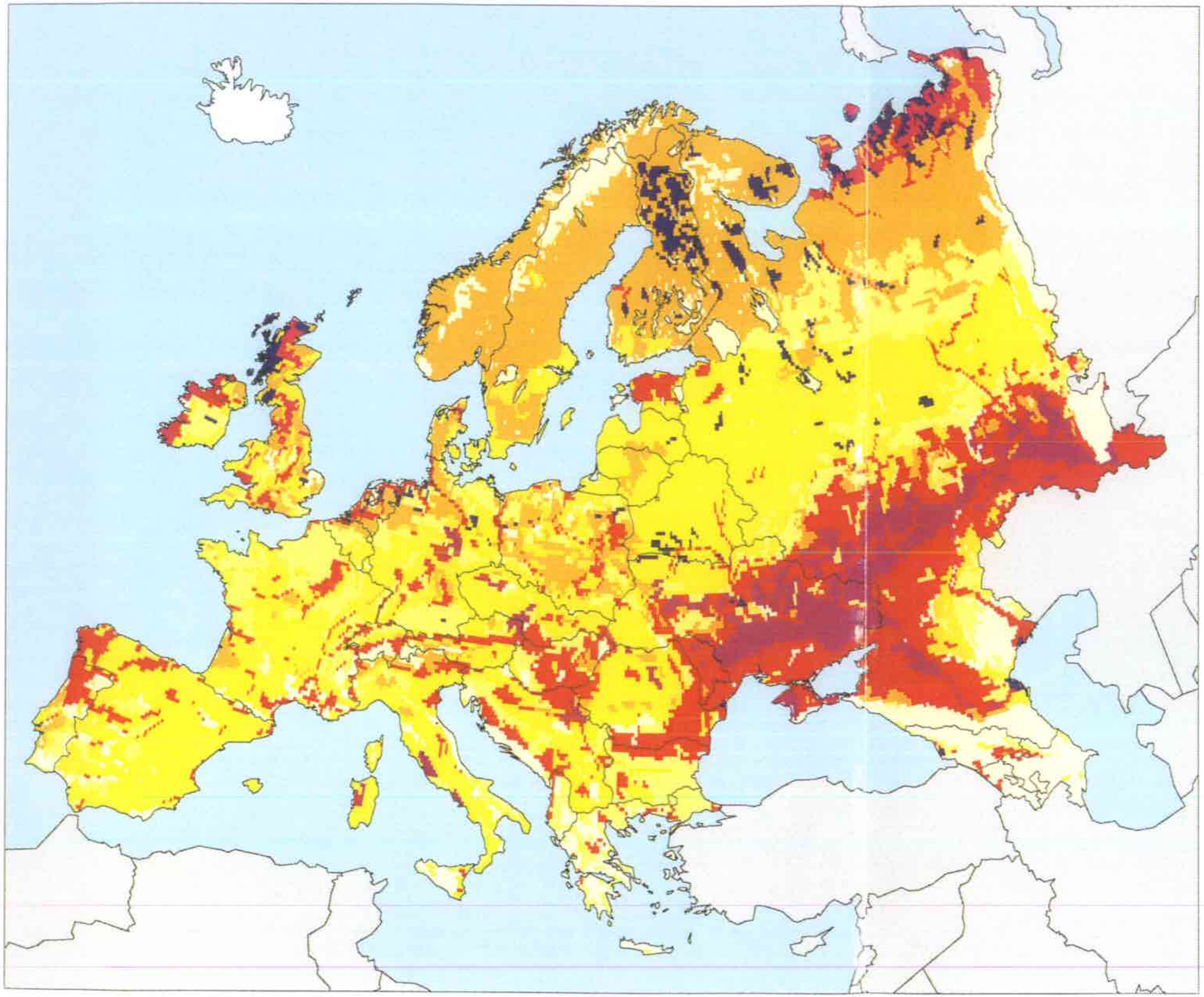
Soil Taxonomy	FAO/UNESCO	code	Landuse	parentmat	depth	OC	OM	Pedon	layer	OM-cont 0-30 cm
Typic Haplorthod	Orthic Podzol	Po	grass	glacial	0-20	3.54	6.10	25	1	5.25
		Po			20-25	3.34	5.76	25	2	
		Po			25-36	0.76	1.31	25	3	
Typic Fragiorthod	Orthic Podzol	Po	forest	glacial	4-00	23	39.66	26	1	3.14
		Po			0- 4	2.16	3.72	26	2	
		Po			4-18	2.34	4.03	26	3	
		Po			18-33	1.5	2.59	26	4	
Alfic Haplorthod	Orthic Podzol	Po	forest	glacial	0-20	2.08	3.59	44	1	3.28
		Po			20-36	1.55	2.67	44	2	
Cryic Placohumod	Placic Podzol	Pp	forest	volcanic	25- 8	50.69	87.40	27	1	25.08
		Pp			8- 0	49.03	84.53	27	2	
		Pp			0- 5	5.11	8.81	27	3	
		Pp			5- 8	6.86	11.83	27	4	
		Pp			8-20	18.12	31.24	27	5	
		Pp			20-30	17.28	29.79	27	6	
Typic Placohumod	Placic Podzol	Pp	bush	aeolian	0-23	0.32	0.55	110	1	1.75
		Pp			23-28	3.46	5.97	110	2	
		Pp			28-33	1.75	3.02	110	3	
Typic Udorthent	Calcaric Regosol	Rc	bush	loess	0- 5	1.16	2.00	68	1	1.20
		Rc			5-25	0.68	1.17	68	2	
		Rc			25-61	0.29	0.50	68	3	
Typic Torripsamment	Eutric Regosol	Re	bush	eolian	0-28	0.15	0.26	69	1	0.26
		Re			28-58	0.15	0.26	69	2	
Typic Ustipsamment	Eutric Regosol	Re	bush	?	0-13	0.3	0.52	70	1	0.32
		Re			13-25	0.11	0.19	70	2	
		Re			25-61	0.07	0.12	70	3	
Typic Natraqualf	Gleyic Solonetz	Sg	arable	loess	0-25	0.51	0.88	24	1	0.90
		Sg			25-36	0.57	0.98	24	2	
Aquic Natrixeroll	Gleyic Solonetz	Sg	brush	alluvium	0- 8	0.77	1.33	100	1	1.20
		Sg			8-20	0.98	1.69	100	2	
		Sg			20-43	0.29	0.50	100	3	
Udic Natriboroll	Mollic Solonetz	Sm	arable	lacutrine	0-15	2.71	4.67	5	1	3.51
		Sm			15-18	2.11	3.64	5	2	
		Sm			18-24	1.25	2.16	5	3	
		Sm			24-30	1.09	1.88	5	4	
Typic Natriboroll	Mollic Solonetz	Sm	grass	alluvium	0- 8	1.82	3.14	87	1	1.78
		Sm			8-18	0.93	1.60	87	2	
		Sm			18-25	0.68	1.17	87	3	
		Sm			25-30	0.47	0.81	87	4	
Typic Natrustoll	Mollic Solonetz	Sm	grass	Loess?	0-13	3.27	5.64	95	1	3.84
		Sm			13-36	1.43	2.47	95	2	

Soil Taxonomy	FAO/UNESCO	code	Landuse	parentmat	depth	OC	OM	Pedon	layer	OM-cont 0-30 cm
Borollic Natrargid	Orthic Solonetz	So	grass	glacial	0- 8	2.82	4.86	23	1	2.12
		So			8-13	0.97	1.67	23	2	
		So			13-18	0.92	1.59	23	3	
		So			18-23	0.54	0.93	23	4	
		So			23-43	0.31	0.53	23	5	
Typic Natrixeralf	Orthic Solonetz	So	grass	alluvium	0-15	1.13	1.95	54	1	1.33
		So			15-36	0.41	0.71	54	2	
Typic Natrargid	Orthic Solonetz	So	grass	alluvium	0- 5	0.4	0.69	58	1	0.59
		So			5-13	0.29	0.50	58	2	
		So			13-28	0.38	0.66	58	3	
		So			28-61	0.13	0.22	58	4	
Typic Cryandept	Humic Andosol	Th	bush	volcanic	0-12	3.56	6.14	71	1	6.10
		Th			12-23	3.68	6.34	71	2	
		Th			23-32	3.28	5.66	71	3	
Oxic Dystrandept	Humic Andosol	Th	grass	volcanic	0-20	8.87	15.29	72	1	12.21
		Th			20-41	3.51	6.05	72	2	
Typic Hydrandept	Humic Andosol	Th	forest	volcanic	0-18	11.7	20.17	74	1	16.62
		Th			18-36	6.55	11.29	74	2	
Hydric Dystrandept	Humic Andosol	Tm	grass	volcanic	0-10	15.43	26.60	6	1	25.84
		Tm			10-30	14.77	25.47	6	2	
Typic Eutrandept	Mollic Andosol	Tm	grass	volcanic	0-23	5.81	10.02	73	1	8.71
		Tm			23-41	2.55	4.40	73	2	
Typic Vitrandept	Vitric Andosol	Tv	forest	volcanic	0-10	5.27	9.09	75	1	4.51
		Tv			10-20	2.12	3.66	75	2	
		Tv			20-41	0.46	0.79	75	3	
Aquentic Chromudert	Chromic Vertisol	Vc	orchard	alluvial	0-18	1.96	3.38	124	1	2.83
		Vc			18-38	1.17	2.02	124	2	
Udic Chromustert	Chromic Vertisol	Vc	grass	alluvial	0-18	1.64	2.83	126	1	2.59
		Vc			18-36	1.29	2.22	126	2	
Typic Chromoxerert	Chromic Vertisol	Vcc	brush	sandstone	0-10	1.85	3.19	128	1	1.91
		Vcc			10-25	0.78	1.34	128	2	
		Vcc			25-36	0.59	1.02	128	3	
Entic Pelludert	Pellic Vertisol	Vp	grass	coastal?	0-18	1.44	2.48	125	1	2.12
		Vp			18-33	0.91	1.57	125	2	
Udic Pellustert	Pellic Vertisol	Vp	arable	alluvial	0-15	1.05	1.81	127	1	1.66
		Vp			15-56	0.87	1.50	127	2	
Typic Torrert	Pellic Vertisol	Vpc	grass	igneous	0- 5	0.58	1.00	123	1	0.74
		Vpc			5-23	0.45	0.78	123	2	
		Vpc			23-48	0.26	0.45	123	3	
Chromic Pelloxerert	Pellic Vertisol	Vpc	grass	tonalite	0-10	1.59	2.74	129	1	1.53
		Vpc			10-46	0.54	0.93	129	2	

Soil Taxonomy	FAO/UNESCO	code	Landuse	parentmat	depth	OC	OM	Pedon	layer	OM-cont 0-30 cm
Typic Albaquult	Dystric Planosol	Wd	forest	?	0-10	2.2	3.79	112	1	2.08
		Wd			10-18	1.17	2.02	112	2	
		Wd			18-25	0.54	0.93	112	3	
		Wd			25-38	0.22	0.38	112	4	
Typic Argialboll	Mollic Planosol	Wm	grass	loess	0-18	2.69	4.64	82	1	3.90
		Wm			18-30	1.62	2.79	82	2	
Typic Camborthid	Haplic Yermosol	Yh	grass	alluvium	0- 8	0.33	0.57	31	1	0.60
		Yh			8-25	0.35	0.60	31	2	
		Yh			25-43	0.38	0.66	31	3	
Typic Camborthid	Haplic Yermosol	Yh	bush	alluvium	0- 3	0.18	0.31	62	1	0.42
		Yh			3-10	0.3	0.52	62	2	
		Yh			10-20	0.26	0.45	62	3	
		Yh			20-28	0.22	0.38	62	4	
		Yh			28-58	0.19	0.33	62	5	
Typic Durorhtid	Haplic Yermosol	Yh	bush	alluvium	0- 3	0.11	0.19	63	1	0.22
		Yh			3-10	0.08	0.14	63	2	
		Yh			10-41	0.15	0.26	63	3	
Typic Calciorthid	Calcic Yermosol	Yk	bush	alluvium	0- 5	0.19	0.33	36	1	0.37
		Yk			5-10	0.23	0.40	36	2	
		Yk			10-23	0.23	0.40	36	3	
		Yk			23-36	0.2	0.34	36	4	
Typic Calciorthid	Calcic Yermosol	Yk	bush	aeolian	0-15	0.02	0.03	61	1	0.07
		Yk			15-41	0.06	0.10	61	2	
Typic Paleorthid	Calcic Yermosol	Yk	bush	alluvium	0- 3	0.12	0.21	64	1	0.18
		Yk			3-10	0.09	0.16	64	2	
		Yk			10-23	0.1	0.17	64	3	
		Yk			23-36	0.12	0.21	64	4	
Petrocalcic Paleargid	Luvic Yermosols	Yl	bush	alluvium	0- 1	0.44	0.76	40	1	0.87
		Yl			1- 5	0.29	0.50	40	2	
		Yl			5-15	0.37	0.64	40	3	
		Yl			15-28	0.74	1.28	40	4	
		Yl			28-30	0.15	0.26	40	5	
Typic Durargid	Luvic Yermosols	Yl	grass	alluvium	0- 5	0.35	0.60	56	1	0.49
		Yl			5-15	0.29	0.50	56	2	
		Yl			15-23	0.26	0.45	56	3	
		Yl			23-30	0.26	0.45	56	4	
Typic Haplargid	Luvic Yermosols	Yl	bush	colluvium	0- 3	0.98	1.69	57	1	0.57
		Yl			3-12	0.26	0.45	57	2	
		Yl			12-23	?		57	3	
Typic Paleargid	Luvic Yermosols	Yl	grass	alluvium	0- 5	0.25	0.43	59	1	0.62
		Yl			5-15	0.33	0.57	59	2	
		Yl			15-28	0.43	0.74	59	3	
		Yl			28-53	0.34	0.59	59	4	

Soil Taxonomy	FAO/UNESCO	code	Landuse	parentmat	depth	OC	OM	Pedon	layer	OM-cont 0-30 cm
Petrocalcic Paleargid	Luvic Yermosols	Yl	bush	fluvial	0- 5	0.25	0.43	60	1	0.28
		Yl			5-18	0.13	0.22	60	2	
		Yl			18-25	0.17	0.29	60	3	
		Yl			25-36	0.14	0.24	60	4	
Typic Gypsiorthid	Gypsic Yermosol	Yy	bush	alluvium	0-0.5	1.27	2.19	39	1	1.33
		Yy			0.5-5	0.96	1.66	39	2	
		Yy			5-13	0.93	1.60	39	3	
		Yy			13-33	0.63	1.09	39	4	
Typic Salorthid	Orthic Solonchak	Zo	grass	alluvium	0- 5	0.1	0.17	41	1	0.29
		Zo			5-15	0.17	0.29	41	2	
		Zo			15-25	0.2	0.34	41	3	
		Zo			25-58	0.16	0.28	41	4	
Typic Salorthid	Orthic Solonchak	Zo	bush	alluvium	0-11	0.69	1.19	65	1	0.95
		Zo			11-15	0.38	0.66	65	2	
		Zo			15-20	0.6	1.03	65	3	
		Zo			20-36	0.44	0.76	65	4	

Soil Organic Matter Map of Europe



% organic matter in topsoil

- very low (1%)
- low (2%)
- low/moderate (3%)
- moderate (4%)
- moderate/high (5%)
- high (8%)
- high/very high (10%)
- very high (14%)
- organic soils (30%)

Source: UNESCO/FAO, RIVM

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