01.06 Soil-Scientific Characteristic Values (2013 Edition)

Overview and Statistical Base

In addition to a survey of the distribution and heterogeneity of the particular soil associations in the municipal area (cf. Map 01.01), data on their **ecological properties** are of great importance for statements regarding the qualities, sensitivity and pollution of the soil. This involves primarily characteristic values regarding the chemistry, the physical state and the water balance of the soil. The quality of these characteristic quanta is determined primarily by the soil associations, but it is substantially influenced by current land use.

The soil-scientific characteristic quanta described here have been derived from the soil associations, taking land use into account (cf. Maps 06.01 and 06.02). The assumption was that the quality of the characteristic soil values for certain soil associations with a certain land use would be identical for all lots of such a combination, in the context of the required precision of statements.

The characteristic quanta for every **combination of land use and soil associations** were determined as representative values from existing documents. The data were primarily taken from the assistance manual for the maps of soil associations (Dissertation, Grenzius 1987), in which landscape segments and sample profiles on particular soil associations are documented, based largely on measurements by the Institute for Soil Science at the Berlin University of Technology. In addition, various other soil-scientific maps were evaluated. Moreover, it was possible to access the results of the extensive soil analyses of the heavy-metal investigation programme for humus content and pH values.

If no measurements were available for certain combinations, the values were assessed by expert evaluations, using data on comparable uses or comparable soil associations. Due to the often very different number of measurements available per combination and the great variety of analogical evaluations, **the precision of the values given varies greatly**.

For most characteristic quanta, the data refer to the topsoil (0 - 10 cm) and the subsoil (90 - 100 cm) separately.

Due to the map scale, the units given in the legend of the soil map refer to soil associations which are in many cases have very heterogeneous soil-ecological qualities. The **complexity** of the ecological conditions, with the assigned typical values which refer to a single characteristic soil type of the respective soil associations, is **represented in greatly simplified terms**. Therefore, the soil-scientific database contains, in addition to the representative value (e.g. typical pH value), the maximum and minimum values available from the respective evaluations.

For these reasons, the maps are therefore designed **only as general maps** in a scale of 1:50,000, and cannot replace site-specific investigations in particular cases.

01.06.1 Soil Textures

Description

The type of a particular soil, or “soil **texture”** is determined by the grain size composition of its mineral components. **Coarse soil** (grain diameter >2 mm) and **fine soil** (grain diameter <2 mm) types are distinguished. In addition, in very wet locations, **peat** is formed by the accumulation of incompletely decomposed plant material, which overlays the mineral soils.

Fine Soil Textures

Fine soil textures are formed from certain proportions of the grain fractions clay, silt and sand. The main soil types are subdivided into **clay, silt, loam and sand**, with loam representing a grain mixture of sand, silt and clay. Soil texture is an important identification value for the derivation of such ecological qualities as nutrient and pollutant retention capacity, hydrologic budget and retention capacity, and filtration and buffering capacity for pollutants.

Coarse Soil Textures

All mineral components of the soil >2 mm in diameter are described as **coarse soil textures**, or the soil skeleton. The proportion of coarse soil has an effect on water permeability, air and nutrient balance, and the capacity to bind nutrients and pollutants. The higher the share of coarse soil, the more permeable a soil is, due to the large pores, while the capacity to bind and the nutrient level depend on the type of fine soil.

Peat Textures

Peat is formed in a water-saturated environment from the accumulation of incompletely decomposed plant material. It is characterized by a high water-retention capacity and a very high cation exchange capacity (CEC). Various peat textures can be distinguished, according to the type of plant remains and their formation conditions. Bog peat is rich in alkalines and nutrients, and in many cases, even in carbonates. Transition-mire peats include plant remains from both low and high-nutrient locations.

Methodology

The fine, coarse and peat soil textures, each differentiated between topsoil and subsoil, were determined for each soil association. The data were essentially taken from the profile sections by Grenzius (1987). Some values have been supplemented by expert evaluations.

The mapped **fine soil textures** are summarized in Table 1. Since the soil textures are in many cases different in the topsoil and the subsoil, respectively, due to the material of which the soil was originally formed, to the soil development and to its use, they have been examined separately. In addition, soil textures which occur frequently within a soil association are identified as the main soil texture, and distinguished from the more rarely occurring soil textures, known as subsidiary soil textures.

Soil texture	**Designation**	**Mapped** in Berlin	**Soil texture**	**Designation**	**Mapped** in Berlin
fS	fine sand	x	Su2	weakly silty sand	x
gS	coarse sand		Su3	medium silty sand	x
Ls2	weakly sandy loam		Su4	strongly silty sand	
Ls3	medium sandy loam	x	Tl	loamy clay	
Ls4	strongly sandy loam	x	Ts2	weakly sandy clay	
Lt2	weakly clayey loam		Ts3	medium sandy clay	
Lt3	medium clayey loam		Ts4	strongly sandy clay	
Lts	sandy clayey loam		Tt	pure clay	
Lu	silty loam	x	Tu2	weakly silty clay	
mS	medium sand	x	Tu3	medium silty clay	
Sl2	weakly loamy sand		Tu4	strongly silty clay	
Sl3	medium loamy sand	x	Uls	sandy loamy silt	
Sl4	strongly loamy sand	x	Us	sandy silt	x
Slu	silty loamy sand		Ut2	weakly clayey silt	
Ss	pure sand		Ut3	medium clayey silt	x
St2	weakly clayey sand		Ut4	strongly clayey silt	
St3	medium clayey sand		Uu	pure silt	

Table 1: Soil Textures and their Occurrence in Berlin (i.a.: Soil-Scientific Mapping Directive 1994)

Those soil associations which have largely the same fine soil textures for the topsoil and for the subsoil were combined to a **soil texture group**. The assignment of soil texture groups has thus been done merely for the sake of a readable map with an easily comprehensible number of legend units. For details or further calculations, more precisely differentiated data are available. Soil associations occur which consist of the same soil textures, both in the topsoil and in the subsoil. However, the majority of soil associations have different soil textures between the topsoil and the subsoil.

The combination of the soil textures of the topsoil with those of the subsoil resulted in 14 soil texture groups of fine soil (<2 mm), which are shown by the legend units of the map.

However, the soil associations of a soil texture group may differ within this group with regard to the peat or stone fragment content (soil skeleton, coarse soil >2 mm) of the topsoil and subsoil, so that these have been shown by additional designations.

The **coarse soil textures** in the Berlin soils are compiled in Table 2. Their occurrence in the topsoil and the subsoil, respectively, is distinguished.

Coarse Soil Textures	Designation
o2	Low proportion of rounded stones
x2	Low proportion of angular stones
x3	Medium proportion of angular stones
fG1	Very low proportion of fine gravel

Table 2: Designations of Coarse Soil Textures Occurring in Berlin Soils (Soil-Scientific Mapping Directive 1994)

The **peat textures** occurring in Berlin are compiled in Table 3. For the representation of their ecological qualities and the ascertainment of their characteristic values, a distinction is made between peat occurring in the topsoil and the subsoil, respectively. If several peat textures occur in a soil or a soil association, only the characteristic type of peat is taken into account (characteristic peat type).

Peat Textures	Designation
Hn	Bog peat
fHn	Fossile bog peat
Hu	Transition-mire peat

Table 3: Name of Peat Textures Occurring in Berlin Soils (Soil-Scientific Mapping Directive 1994)

01.06.2 Utilizable Capillary Capacity of Flat-Root Plants

Description

The Utilizable Capillary Capacity is the quantity (nFK) of water in l/m^2 or mm which the soil can contain, and which is usable for plants.This water fraction is held in the pores of soil against the force of gravity, and is available for the plants. The nFK depends on the soil texture, the organic content, the compaction of the soil, and the fragmented stone content. Fine soil can store significantly more water than coarse soil, so that in the case of the latter, precipitation water seeps away more quickly, and can no longer be used ba the plants. High organic contents and peat shares increase water storage.

Methodology

The nFK values of soil asssociations and soil textures were taken from profile section drawings by Grenius (1987). There are two types of zones: the flat-root zone (0-3 dm), and the deep-root zone (0-15 dm). The minimum and maximum nFK values for the flat-root zone are defined by the soil texture of that soil association with the highest or lowest nFK values, respectively. In addition, the typical nFK value for the respective root zones is determined. In this map, only the typical values of flat-root zones is given.

Supplementary research on the soil associations in East Berlin was carried out by AEY (1993) based on the geology. In 2005, low nFK-values were corrected further and differentiated more precisely, with reference to data from Grenzius (1987).

The results were compiled in six levels (Tab.1) based on Grenzius (1987), since there was no gradation given in the Soil-Scientific Mapping Directive (1994).

nFK [mm]		nFK Level	
Flat-root zone (0-3dm)	**Deep-root zone (0-15dm)**		
< 20	< 60	1	very low
20 - < 40	60 - < 120	2	low
40 - < 60	120 - < 180	3	medium
60 - < 80	180 - < 240	4	medium-high
80 - < 110	240 - < 320	5	high
>= 110	>= 320	6	very high

Table 1: Utilizable Capillary Capacity for the Flat and Deep-Root Zones in (mm) and their Evaluation according to GRENZIUS (1987)

01.06.4 Utilizable Capillary Capacity of the Effective Root Zone

Description

An assessment of the hydrologic budget via the utilizable capillary capacity in the effective root zone (nFK_{We}) yields a differentiated analysis of the availability of water to plants for a specific location. The different rooting depths and root zones are taken into account, in accordance with soil type and use. Thus, forests and groves have a considerably greater root zone than, e.g. garden uses. In sandy soils, the effective root zone is lower than in loamy soils. In loamy soils, precipitation water is retained longer than in sandy soils, so that it is advantageous for plant roots, in terms of the water and nutrient balance, to develop a larger root zone than in sandy substrata. In boggy soils, the effective root zone only extends down to the zones affected by groundwater, so that only the top 20-30 cm usually serve as a root zone. The reason for the shallow root zone is the lack of air in the permanently water-saturated zones. Therefore, with the exception of some specialist plants, roots are confined to the upper zones, which contain both sufficient air and water.

The additional water supply to the plants from the capillary rise of the groundwater during the vegetation period, which decisively influences the nFK_{We} at low land-parcel intervals, was not taken into account in the present investigation.

Methodology

The ascertainment of the nFK_{We} for soil associations in dependence on actual land use was carried out by the Department of Soil Science at the Berlin University of Technology, in the context of an expert report (Plath-Dreetz/ Wessolek/ Renger 1989).

First, the effective root zones for Berlin locations appropriate to the respective uses were taken from Table 1. Based on the depth of the effective root zones, the usable capillary capacities ascertained for each zone for the sample profiles documented by Grenzius (1987) were added up to form the nFK_{We}. Appropriate correction factors for organic substances were taken into account. Since different soil textures appear within a soil associations, a range is derived for each soil association, described by the minimum and maximum nFK_{We} values. In addition, the typical nFK_{We} value for the respective soil associations, shown on the map, is determined depending on use.

	Farmland Gardens Cemeteries	**Grass-land**	**Forest**	**Parks**	**Allotment Gardens**
Sands	6	5-6	10	7	6
Loams	7	6-7	12	8	7
Boggy soils (groundwater influenced)	-	2-3	4	4	4

Table 1: Depths of the Effective Root Zone (in dm), by Soil Texture and Use (Plath-Dreetz et al. 1988)

The results were compiled in five stages (Tab. 2):

nFK_{We} [mm]	Stage	Designation
< 60	1	very low
60 - < 140	2	low
140 - < 220	3	medium
220 - < 300	4	high
>= 300	5	very high

Table 2: Gradation of the Utilizable Capillary Capacity of the Effective Root Zone (Soil-Scientific Mapping Directive 1994)

01.06.5 Organic-Matter Shares

Description

The organic fraction of soils consists of the transformed remains of dead plants and animals. The **humus** is formed by mulch and humin materials. The high sorption capacity of the humin materials, the high share of nutrients available to plants, and favourable qualities for the hydrologic budget characterize many soil functions. The humus content of mineral soils is determined by soil genesis and use. Such uses as horticulture with introduction of compost, or intensive pasturing favour humus enrichment, while other uses show a considerably lower organic-substance content (cf. Tab. 1).

Wet vegetation locations, e.g. flood-plain soils and mires, have high biomass production but low humus reduction. The enriched organic substance is present in the form of **peats** of varying degrees of decomposition. Bogs and semi-bogs have organic substance contents of 15 - 80 %, depending on their use and the degree of decomposition of the peat. The prerequisite for a high organic substance content is permanent wetness in the topsoil and near-natural utilization, such as extensive pasturing.

The **organic-matter shares** represent the quantity of organic substance present at a location for a defined soil lot, depending on soil type and land use. The amount of humus is primarily an indicator of the nitrogen stock and the easily mobilizable nitrogen proportion. But other important nutrients such as potassium, calcium, magnesium and phosphorus are also released and made available to plants by means of the decomposition and humification of organic substances. In addition to the availability of nutrients, the organic fraction functions as a nutrient and water reservoir, and is able to bind pollutants to a high degree. The organic content of a soil depends on the humus content and the thickness of the humus zone. This differs according to soil type and use. Thus, for example, damp boggy locations with high biomass production and low decomposition have a high humus quantity, and sandy dry soils with low vegetation coverage have a low humus quantity.

Methodology

The average organic content of mineral soils depending on soil type and use was taken from investigations by Grenzius (1987) and soil analyses performed under the Heavy-Metal Investigation Programme (1986, 1987). These data were initially evaluated by Fahrenhorst et al. (1990) and the average humus content ascertained for the characteristic soil type of the various soil associations at different uses An expansion of the database using various specific mappings was carried out in 1993 (Aey 1993). A rough orientation, purely by use, is shown in Table 1.

Use	Organic Content [% by mass]
Residential areas	5
Mixed areas	3
Core areas	3
Commercial and industrial areas	3
Special uses, utilities	3
Weekend home areas	6
Forest	4
Grassland	12
Farmland	3
Parks, green spaces, city squares	3
Cemeteries	4
Allotment Gardens	6
Fallow areas, meadow-like vegetation	3
Fallow areas, bushes, trees	4
Camping and sports facilities	4
Tree nurseries	4

Table 1: Average Organic Contents by Use, compiled from Fahrenhorst et al. (1990)

The humus contents of peats formed at wet locations are not taken into account for mineral soils; their contents and thicknesses are listed separately in the investigation of humus quantity.

Humus quantity was ascertained from humus content of the humus layer, taking into account peat quantity [mass %] and the effective retention density and thickness of the organic zones.

Humus quantity ascertained for the various locations was broken down into five stages, according to Table 2.

Organic Content [kg/m^2]	Stage	Designation
0 - < 5	1	very low
5 - < 10	2	low
10 - < 20	3	medium
20 - < 100	4	high
100 - < 2000	5	very high

Table 2: Gradation of Organic Content, according to Results from Berlin Soils (Gerstenberg 2013)

01.06.6 Organic Carbon Stocks

Description

Soil organic matter consists of approximately 50 % carbon and is of elementary importance to the hydrological and nutritional balance of soils. As a result of the concentration and mineralization of organic matter, and therefore carbon, soils play a major role in the global carbon cycle.

Soils constitute the largest form of terrestrial carbon storage and besides oceans the largest form of carbon storage of the world (IPCC 2000). A major influence on the carbon dynamic in soils is land use. Soils in urban environments are subjected to very high land use pressure, and suffer significant anthropogenic impact. On the one hand, this results in higher carbon stocks than in natural systems, for instance due to horticultural activities. On the other, the destruction of natural soil functions leads to higher levels of mineralization of organic matter and therefore the release of carbon dioxide (CO_2) into the atmosphere. This is an important fact, as the concentration of organic matter in soils, and therefore their function as carbon storage, takes place over a very long period of time.

A particular role in the global carbon cycle is played by carbon sinks. Carbon sinks are also present in urban environments. Hydromorphic soils such as peat are notable in this context. Peat soils can potentially store up to ten times more carbon than other ecosystems (Batjes 1996). Due to changes in the hydrological balance of agricultural soils, most peat soils emit CO_2 and MH_4 (methane). For this

reason, the protection and conservation of peat soils is of particular importance to local, regional and global climate protection. With a total area of 7 %, but almost 50 % of the carbon storage in the soils of Berlin, it becomes clear that peat soils have an important role to play as a carbon sink. Horticultural and other sites with long-term pedogenesis such as graveyards, old forest sites and historical parks are also valuable carbon sinks due to their long-term storage of carbon.

As a result of their function as carbon sinks, soils play a very important role in climate protection, which should attract attention in terms of planning and authorization processes (Dahlmann et al. 2012). According to Dahlmann et al. (2012) it is reasonable for soils containing a high amount of carbon stocks to be protected from land use with negative impacts, such as sealing of non-sealed soils. It is also advantageous to re-cultivate existing structures, especially peat soils. For this reason, the soil buffer for the carbon budget is also considered in the assessment of the filter and buffer function of soils (e.g. map 01.12.3).

The calculation based on this map shows that a total of 5.28 million tonnes of carbon are stored in Berlins soils. This is equal to 19,3 million tonnes of CO_2.

Berlins total CO_2 emissions amounted to approximately 18 million tonnes in 2009 (Statistic BBB 2012). This means that Berlins soils store more CO_2 than was emitted by Berlin in 2009 as a result of primary energy consumption.

Methodology

Calculation of the carbon stocks in Berlin's soils is based on the organic matter amounts [kg/m²] provided by the Berlin Soil Database (Gerstenberg 2013). The organic matter amounts were derived from the organic matter content of the topsoil layer, taking into account the peat content [mass-%], the effective bulk density and the thickness of the organic topsoil layers (see also Map 01.06.05 Organic Matter Content). For the calculation of peat layers, a bulk density of 0.9 [g/cm³] was postulated. The organic matter content was divided by a factor of 1.72, according to the "Bodenkundliche Kartieranleitung" (2005). To calculate the organic carbon stocks for all of Berlin, the organic carbon contents were multiplied by the area of the Berlin block structure.

The carbon stocks of Berlin's soils determined in this manner correspond only to a first assessment and are in part methodologically uncertain. This is because the organic matter contents displayed in the Berlin block structure are based on a soil map which is only conceptual in nature. In addition, the organic matter content, the thickness of the mineralic top soil layers and peat layers, and bulk density are in part merely estimates. The "carbon stocks" thematic soil map 01.06.6 is therefore only an approximate representation of reality. Within the scope of the research project "Berliner Moorböden im Klimawandel" (free translation: Berlin peat soils and climate change) in progress at the Humboldt University in Berlin, more detailed data on the organic carbon stocks of Berlin's soils is currently being collected, and will serve to enhance knowledge about carbon stocks in Berlin's soils in the future.

01.06.7 pH Values of Topsoil

Description

The pH value (soil reaction) influences the chemical, physical and biological qualities of the soil. It affects the availability of nutrients and pollutants, and provides information about the ability of the soil to neutralize acids or bases. It is important for the filtration and buffering capacities of soils. Thus, at low pH values, no acids can be neutralized in the soil, the heavy-metal connections increasingly dissolve, and the available nutrients are largely washed out.

Methodology

The pH values were derived from existing documents for the soil associations, taking land use into account. The data were essentially taken from the profile sections in Grenzius (1987). Some values have been supplemented by expert assessments, in most cases using a great variety of different soil-scientific reports. If no measurements were available, the values were assessed using data of comparable uses or comparable soil associations. In addition to the representative values (typical pH values) for the topsoil and subsoil, the respective maximum and minimum values were also determined.

On the map, only the pH-values of the topsoil are shown, since they are more important for determining soil functions than the pH values of subsoil, and shows greater operational differences.

The gradation of pH values was carried out according to the Soil-Scientific Mapping Directive (Bodenkundliche Kartieranleitung 1994), according to a scale from 1 through 12, which permits the soil reaction to be differentiated according to its alkalinity or acidity, from extremely alkaline to extremely acidic (cf. Tab. 1).

pH value	pH level	Designation
>=11	1	extremely alkaline
10 - < 11	2	very strongly alkaline
9 - < 10	3	strongly alkaline
8 - < 9	4	medium alkaline
7.5 - < 8	5	weakly alkaline
7 - < 7.5	6	very weakly alkaline
6.5 - < 7	7	very weakly acidic
6 - < 6.5	8	weakly acidic
5 - < 6	9	medium acidic
4 - < 5	10	strongly acidic
3 - < 4	11	very strongly acidic
< 3	12	extremely acidic

Table 1: pH Levels (Soil-Scientific Mapping Directive, 1994, modified)

01.06.8 Sum of Exchangeable Alkaline Cations in the Topsoil (S-Value)

Description

The exchangable cations in the soil are usually distinguished as acidic and alkaline cations, respectively. The former include primarily hydrogen ions (H-ions), and also those, especally Al ions, which trigger hydrolysis when released into the soil solution, and thus release H-ions; their sum is known as the *H-value*. The alkaline cations are primarily Ca^{2+}, K^{+} Mg^{2+} and Na^{+}, and, in agricultural soil (after fertilizing), also NH_4^{+}, with Ca^{2+} usually dominant, with more than 80%. Their sum is known as the *S-value*. Its concentration can be given in $cmol_c$/kg, and its quantity in mol_c/m^2. The percentage share of the S-Value in exchangable cations is known as *alkaline saturation*.

The S-value thus describes the quantity of the cations provided by the soil which is relevant for plant nutrition, and is hence an important indicator of soil fertility.

Methodology

The quantity of exchangable alkaline ions (S-Value) for topsoil (here, 0-3 dm) can be calculated by multiplying the effective cation interchagable capacity (CEC_{eff}) by alkaline saturation, considering packing density and coarse fractioin.

The calculation of effective cation exchangable capacity is shown in Map 01.06.09. The alkaline saturation can thus be calculated from the pH value ($CaCl_2$).

Ascertainment is accomplished using the pH value typical of the location of the topsoil, (cf Map 01.06.07); the alkaline saturation is derived according to Table 1. Then, a linear interpolation between these pH stages of this table is carried out.

pH ($CaCl_2$)	BS [%]	pH ($CaCl_2$)	BS [%]	pH ($CaCl_2$)	BS [%]	pH ($CaCl_2$)	BS [%]	pH ($CaCl_2$)	BS [%]
3	2	4	18	5	47	6	77	7	97
3.1	3	4.1	20	5.1	50	6.1	80	7.1	98
3.2	4	4.2	23	5.2	53	6.2	82	7.2	98
3.3	5	4.3	25	5.3	56	6.3	85	7.3	98
3.4	6	4.4	28	5.4	60	6.4	87	7.4	99
3.5	7	4.5	31	5.5	63	6.5	89	7.5	99
3.6	9	4.6	34	5.6	66	6.6	91	7.6	99
3.7	11	4.7	38	5.7	69	6.7	93	7.7	100
3.8	13	4.8	41	5.8	72	6.8	95	7.8	100
3.9	15	4.9	44	5.9	75	6.9	96	7.9	100

Table 1: Relationship between Alkaline Saturation in % and the pH ($CaCl_2$) of Mineral Soil Zones in Berlin (Grenzius 1987)

Table 2 shows the S-values, classified into 1-10 categories (extremely low –very high).

Alkaline Saturation [mol_c/m^2.]	Level	Designation
<1	1	extremely low
1- < 2	2	very low
2-<3.5	3	moderate to very low
3.5-< 5	4	moderate low
5 -<10	5	low
10-<25	6	moderate
25-<50	7	medium
50-<100	8	moderate high
100-<200	9	high
>=200	10	very high

Table 2: Gradation of S-Value (Schlichting et al. 1995 Gerstenberg & Faensen-Thiebes 2005)

The categorization of low level values is carried out in very small stages, in order to show the precise gradation necessary for an evaluation of the function “habitats for near-natural and rare plant communities” in low-nutrient soil.

01.06.9 Mean Effective Cation Exchange Capacity

Description

The effective cation exchange capacity (CEC_{eff}) represents the quantity of cations bound to soil colloids, taking into consideration the strongly pH-value-dependent charge of the organic substances. The exchangeable cations are bound to clay minerals and humus colloids. In neutral to weakly acidic soils, calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na) dominate the sorption complex; in acidic soils, e.g. pine and heath locations, aluminum (Al), hydrogen (H) and iron (Fe) predominate. The binding capacity of organic substances is considerably higher than that of the clay minerals. The strength of the bond with the organic substances is pH-dependent, while the bond with clayey minerals is independent of the pH value. Thus, the binding capacity of the humus drops with the pH value. Clayey and humus-rich soils with neutral soil reaction can therefore bind considerably more nutrients and pollutants, and prevent a washout of these substances into the groundwater, than can sandy, humus-poor locations. Effective cation exchange capacity is therefore useful for describing the nutrient and pollutant binding potentials of soils.

Methodology

The CEC_{eff} of the soil associations is derived from the main soil type of the topsoils and subsoils, as in (Table. 1). Topsoil is assumed to have a depth of 0 - 1 dm; the subsoil 3 - 15 dm. The exchange capacity of the humus (Table 3), corrected by a pH-dependent factor (Table 2), is added to the averaged cation exchange capacity of the main and subsidiary soil types. Since both the humus contents and the thickness of the humus layer may differ, depending on soil genesis and use, and

since these are also incorporated into the calculation of the CEC, different use-specific values are ascertained for each soil associations.

Soil Texture	CEC_{eff} [cmol/kg]	Soil Texture	CEC_{eff} [cmol/kg]	Soil Texture	CEC_{eff} [cmol/kg]
fS	2	Sl3	6	Ts4	15
G	2	Sl4	9	Tt	39
gS	2	Slu	9	Tu2	29
Ls2	13	St2	6	Tu3	21
Ls3	12	St3	11	Tu4	18
Ls4	12	Su2	2	Uls	9
Lt2	17	Su3	4	Us	5
Lt3	22	Su4	4	Ut2	9
Lts	19	Tl	29	Ut3	11
Lu	15	Ts2	28	Ut4	14
mS	2	Ts3	20	Uu	6
Sl2	4				

Table 1: Average CEC Values of the Soil Textures (Soil-Scientific Mapping Directive, 1994)

pH Value ($CaCl_2$)	pH Factor
< 3.5	0.15
3.5 - < 4.5	0.25
4.5 - < 5.5	0.4
5.5 - < 6.5	0.6
6.5 - < 7.5	0.8
>= 7,5	1

Table 2: pH Factors for the Determination of the Effective CEC of the Humus Fraction (Soil-Scientific Mapping Directive 1994)

Organic Content [Mass %]	CEC_{pot} [$cmol_c$ / kg]
0 - < 1	0
1 - < 2	3
2 - < 4	7
4 - < 8	15
8 - < 15	25
15 - < 30	50
30 - 100	110

Table 3: Relationship between Organic Content and Potential CEC (Soil-Scientific Mapping Directive 1994), supplemented by Z3 peat

The values ascertained have been assigned to the categories 1 through 5, from “very low” to “very high”, according to the Soil-Scientific Mapping Directive (1994) (Table 4).

CEC_{eff} [cmolc / kg]	Category	Designation
0 < 4	1	very low
4- < 8	2	low
8-< 12	3	medium
12-< 20	4	high
< = 20	5	very high

Table 4: Effective Cation Capacity Categories (Soil-Scientific Mapping Directive 1994),

01.06.10 Water Permeability (kf)

Description

Water permeability (saturated water conductivity, kf value) indicates the permeability of soils. It depends on the soil type and the storage density of the soil. Loose soils with high sand contents therefore have a considerably higher permeability than do clay-rich soils consisting of till. Water permeability is important for the evaluation of the storage wetness, filtration qualities, erosion vulnerability and drainage effectiveness of soils. The speed of water permeability is given in m/s or in cm/d. The data on speed of water movement apply only to completely water-saturated soil, in which all pore spaces are filled with water. As a rule, terrestrial soils display non-saturated water conditions, with only a portion of the pores filled with water; at such non-saturated conditions, water movement is considerably slower. In addition, a large portion of the available water is taken up by the plants and is not available for flow. Since measurement of non-saturated water conductivity (ku) is very expensive and complicated, so that no accessible data are available in the Soil-Scientific Mapping Directive (1994), the attested values for saturated water conductivity are used in scientific practice as a rough measure.

The influence of the coarse soil was not taken into account.

Methodology

The kf value for the main soil textures of the topsoil and the subsoil was taken from Table 1. The kf value for the topsoil and subsoil is the mean value of the topsoil kf and the subsoil kf. The kf values listed in the Table depending on soil texture are based on the effective packing density of Ld3, which corresponds to the mean for Berlin soils.

Soil Texture	kf Value [cm/d]	Soil Texture	kf Value [cm/d]
fHn	30	Slu	11
fS	106	Ss	229
fSms	169	St2	79
gSfs	130	St3	17
Hn	30	Su2	88
Hu	30	Su3	32
Ls2	20	Su4	24
Ls3	7	Tl	3
Ls4	14	Tt	2
Lt2	9	Tu2	5
Lt3	10	Tu3	28
Lts	6	Tu4	28
Lu	18	Uls	14
mS	427	Us	10
mSfs	221	Ut2	7
mSgs	281	Ut3	8
Sl2	49	Ut4	9
Sl3	33	Uu	7
Sl4	21		

Table 1: Water Permeability in Water-saturated Soil (kf Value) by Soil Texture at the Mean Effective Retention Density of Ld3, supplemented by Medium-decomposed Peat (Z 3) at Medium Substance Volume (SV 3); from the Soil-Scientific Mapping Directive (1994).

For representation on the map, the water permeability results have been categorized in six stages, from very low to extremely high (1 -6), as shown in Table 2.

kf Value [cm/d]	Stage	Designation
0 - < 1	1	very low
1 - < 10	2	low
10 - < 40	3	medium
40 - < 100	4	high
100 - < 300	5	very high
>= 300	6	extremely high

Table 2: Classification of Water Permeability in Water-saturated Soil (Soil-Scientific Mapping Directive 1994)

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