reviewed paper

A Thematic Soil Plan for the City of Munich – Scopes and Limits of Soil Evaluation in Urban Planning Procedures

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1 SOIL AS COMPONENT OF THE URBAN ECOSYSTEM

Soil as the top layer of the earth's crust, formed by mineral particles, organic matter, water, air and living organisms performs a variety of ecological, social and economic functions vital for human life. Nevertheless the ecological value and significance of intact soils is often grossly underrated compared to the economic value of land. Especially in densely populated areas soils and their manifold functions are impaired and endangered by sealing, compaction, contamination or outright removal. In Germany the conservation of soil is therefore regulated by the German Federal Soil Protection Act (BBodSchG 1998). However, until recently soil played but a minor role in urban planning procedures mainly due to a lack of interpreted, planning-oriented information concerning urban soils and their natural functions. Information about "soil" is usually limited to the economic value, i.e. real estate value or land price, to known or assumed contaminations, to the degree of surface sealing and to the mechanical and geohydrological suitability as building ground. Comparatively little is known about the potential of local soils to develop biotopes for animals and plants, about soil performances in carbon, nutrient and water cycles – e.g. the capacity to infiltrate rain water – or soils' capacity to filter, buffer and transform potentially harmful substances. In this paper the evaluation of natural soil functions listed in BBodSchG, art. 2, in the City of Munich and the implementation of evaluation results in a Thematic Soil Plan as a basis for future planning decisions are presented.

2 SOIL PROTECTION IN THE CITY OF MUNICH

The integration of soil aspects in urban planning procedures is an important step regarding the "mission statement" of soil conservation in the City of Munich with its major objective of "sustainable handling of soil resources to secure or restore their ecological capabilities" (Landeshauptstadt München 2000, p. 4).

This overall concept is substantiated by several guidelines, strategies and measures. The first and most important point is the reduction of soil consumption by restricting the conversion of previously undeveloped areas into building land and limiting the level of sealing. This aim can be achieved by "conventional" planning instruments like the Zoning Plan (Flächennutzungsplan) or Local Development Plans (Bebauungspläne). Because merely quantitative soil protection might not be sufficient for sustainable development of urban centres of growth (Häberli et al. 2002) soil quality has to be introduced as an additional indicator in the planning process. "Quality" in this context must not be reduced to the concentration of contaminants in the soil, which has to be taken into consideration in planning procedures according to detailed regulations (e.g. German Federal Soil Protection Ordinance, BBodSchV 1999), but rather be defined more comprehensively by evaluating natural soil functions (see chapter 4).

Consequently soil conservation policies in the City of Munich include, among others, the preservation or restoration of natural soil functions (Landeshauptstadt München 2002, cp. BayStMUGV 2004). This objective should be achieved by means of both quantitative measures like

- preserving unsealed areas and detecting areas where de-sealing measures are feasible,
- demanding compact building forms in Local Development Plans,
- recycling and vitalisation of abandoned industrial, military or railway grounds,
- inner-city development instead of conversion of agricultural land at the periphery,
- and additional measures taking soil quality into account like
- protecting especially valuable or especially vulnerable soils; in general soil with a high potential to fulfil one or more functions is considered to be "valuable" and worth of proction while "vulnerable" soils are such with a low capability for certain functions (BayGLA 2003) or in need of protection due to high susceptibility to contamination, erosion or compaction (Mosimann 1999),
- preserving natural and near-natural soils especially such with a high potential as biotope for rare species and

- sustainable soil use in agriculture, e.g. minimised application of fertilisers and pesticides, restricted use of heavy machinery on "soft" ground, etc.

Areas with soils particularly worthy or in need of protection as well as areas where action for the preservation of soil functions needs to be taken shall be highlighted in the Landscape Plan (Landschaftsplan). The Thematic Soil Plan (Fachplan Boden) provides previously missing basic information about the characteristics and quality of soil in the City of Munich and is a valuable amendment to the Landscape Plan.

3 THEMATIC SOIL PLAN

The Landscape Plan of the City of Munich shows spatially relevant requirements and measures concerning environmental protection. It is an important instrument for directing future building development towards ecologically less sensitive locations. Goals and objectives of landscaping for the City of Munich are listed in the brochure "Green Planning in Munich" (Landeshauptstadt München 2005). According to these guidelines landscape planning is focussed on achieving four aims of effective and enduring conservation of the natural urban environment:

- "Recreation": allocation and preservation of sufficient green spaces for citizens,
- "Natural scenery": preservation or creation of an appealing environment,
- "Natural balance": e.g. preservation of green corridors for cooling, ground water protection, de-sealing of soils,
- "Protection of biotopes and species": preservation or creation of habitats (biotopes) for rare or endangered plants and animals.

To ensure a consideration of environmental aspects on a par with urban development interests early in the planning process, the Landscape Plan is designed not as an additional planning instrument but as a legally binding integral part of the Zoning Plan (cp. BayNatSchG, art 3, and BauGB, art 1 para 6 and 7g). Thus the Zoning Plan includes stipulations concerning environmental interests on various levels of information (Landeshauptstadt München, 2005). On the first level green spaces for recreation and important biotopes are explicitly included as seperate zoning categories ("public green areas" – Allgemeine Grünflächen and "ecologically sensitive areas" – Ökologische Vorrangflächen). The second level covers special objectives such as (built or partly sealed) areas that are in need for measures to improve urban green, areas with restricted use to conserve and improve especially valuable natural inventory or areas suitable for compensation measures (cp. German Federal Nature Protection Act, BNatSchG, art. 18). Finally, regional or local green corridors – both existing and intended – and areas protected according to other legal regulations e.g. nature reserves, water protection areas or valuable components of the landscape (Bavarian Nature Protection Act, BayNatSchG) are added on the third level (Landeshauptstadt München 2005).

As a synopsis of several thematic plans and concepts the Landscape Plan integrates data about various subjects of protection like water, air/climate and vegetation. These thematic plans help to make contents and specifications of the Landscape Plan more transparent and comprehensible for decision makers and the public. With the Thematic Soil Plan a previously missing component is added to the Landscape Plan.

The Thematic Soil Plan consists of a basic soil map, several evaluation maps (cp. graph 1) showing the capability of soils to fulfil soil functions and sub-functions listed in article 2 of the Federal Soil Protection Act (BBodSchG 1998), synoptic maps with aggregated information of several functions (cp. graph 2) and a textbook with explanations of these maps and the underlying methodology. It provides detailed information about soils for almost the entire municipal territory. Only building blocks in the city center with less than 20 % unsealed surface area are excluded because no technically justifiable evaluation is possible for such strongly altered areas. Moreover, remaining soil on such building blocks should be conserved as habitat for plants and animals, for human recreation and for water retention anyway (cp. BayStMUGV 2004).

4 SOIL EVALUATION

4.1 Data sources and evaluation systems

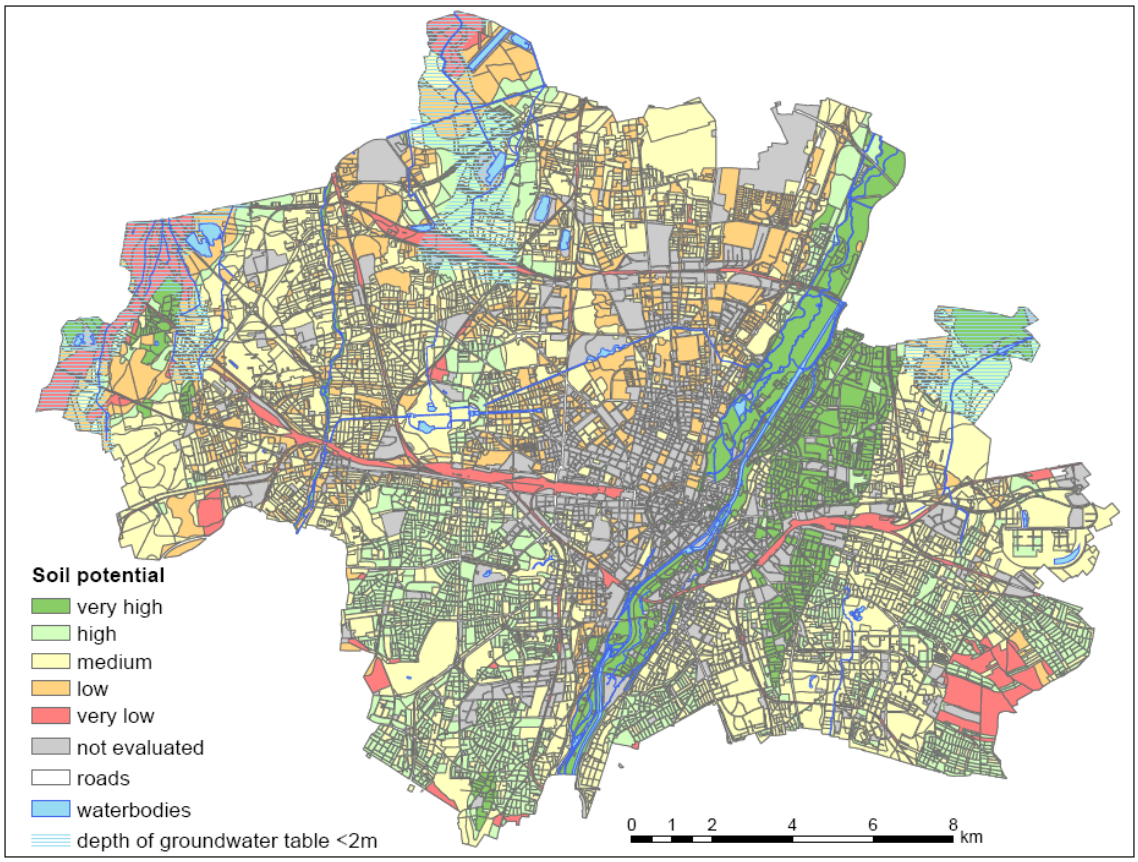
To reflect the heterogeneity and peculiarities of soils in urban areas and thus to provide input of highest quality for evaluation algorithms, area-wide soil mapping would be necessary (AKS 1997, Hochfeld et al.

2003, Faensen-Thiebes et al. 2006). As costs for a high resolution mapping campaign of the entire municipal territory (310 km²) would amount to several million Euro this approach is only feasible for limited areas in the course of specific development projects.

In view of the target scale of 1:25,000 soil parameters were rather derived from existing data sources such as the Soil Map of Bavaria (BayGLA 1986), a Conceptual Map of the potential natural distribution of soils in the city center (Linder 1998), the Land Taxation Overview Map (BayGLA 1985), information about the average depth of the ground water table (Landeshauptstadt München 1993) and a land use map of the City of Munich (Landeshauptstadt München 1996). These basic data were used to evaluate soil (sub-)functions or – more precisely – the potentials of soil to fulfil these natural functions (cp. definition by Hepperle and Stoll 2006). The algorithms applied to derive these information by combining basic soil parameters and additional data are based on existing systems developed and tested in the City of Hamburg (Hochfeld et al. 2003), the Free State of Bavaria (BayGLA 2003), the State of Baden-Württemberg (Umweltministerium Baden-Württemberg 1995) and in various urban regions in the course of the just recently finished INTERREG-IIIB Alpine Space Project TUSEC-IP (Lehmann et al. 2007) to which the authors of this paper were also contributing (cp. Landeshauptstadt München 2006).

In the City of Munich soil plays a role in all the subjects of landscape planning mentioned in the bullet-points above, but especially in the context of ground water protection and as habitat for rare species. Therefore these two aspects shall be explained in detail to exemplify the procedure and results of soil evaluation.

4.2 Soil as filter and buffer of heavy metals



Graph 1: Evaluation results for "soil as filter, buffer and transformer of substances: potential for filtering and buffering heavy metals"
Applied evaluation method: HENNINGS (2000)
Legal basis: BBodSchG art. 2 para. 2 subpara. 1 lit. c

Clay minerals and organic components of the soil have the capability to adsorb, decompose and transform air-borne or water-borne pollutants. Thus soil minimises their potentially toxic effects on plants, animals and subsequently also on humans. Unlike organic compounds heavy metals can not be transformed or decomposed but only (temporarily) be withdrawn from natural cycles by filtering and buffering processes. The potential to filter and buffer heavy metals therefore is of utmost significance in connection with ground water protection (Blume 2004).

The applied evaluation method (Hennings 2000) is also used in the evaluation systems of Bavaria (BayGLA 2003) and Hamburg (Hochfeld et al. 2003). The capacity of soil to adsorb the especially mobile and toxic substance cadmium is assessed as "worst case"-example for other heavy metals such als nickel, cobalt, zinc, chromium, lead or mercury.

In a first evaluation step a certain "relative adsorbation capacity" is assigned to each soil horizon based on the pH-value because filter and buffer capabilites are best under neutral to slightly alcaline conditions (pH-value >6.5). This factor is increased for soil horizons in which the content of organic matter exceeds 2 % and / or the content of clay minerals exceeds 12 %. Finally the "adsorbation factor" is reduced by the content of coarse material – depending on natural conditions and anthropogenic modifications (cp. chapter 4.4) – to relate this factor to the actual amount of fine soil which is relevant for filtering and buffering.

Due to the carbonatic substrate and the modifications in the course of building development – in which artificial carbonatic material such as bricks or building residues are likely to be added to the soil – the pH-value of the topsoil exceeds 6.5 in almost the entire City of Munich. Therefore a rather high relative adsorbation capacity could be assumed. But because the Regosols and Luvisols of the Munich Gravel Plain (Münchener Schotterebene) have extraordinarilly high contents of coarse material only a comparatively small amount of fine soil is actually available. Thus extensive parts of the city, especially the northern part with shallow soils, are only rated as "low" to "medium" while the highest potential is reached in the clayey Luvisols of loess and in Fluvisols along the rivers Isar and Würm.

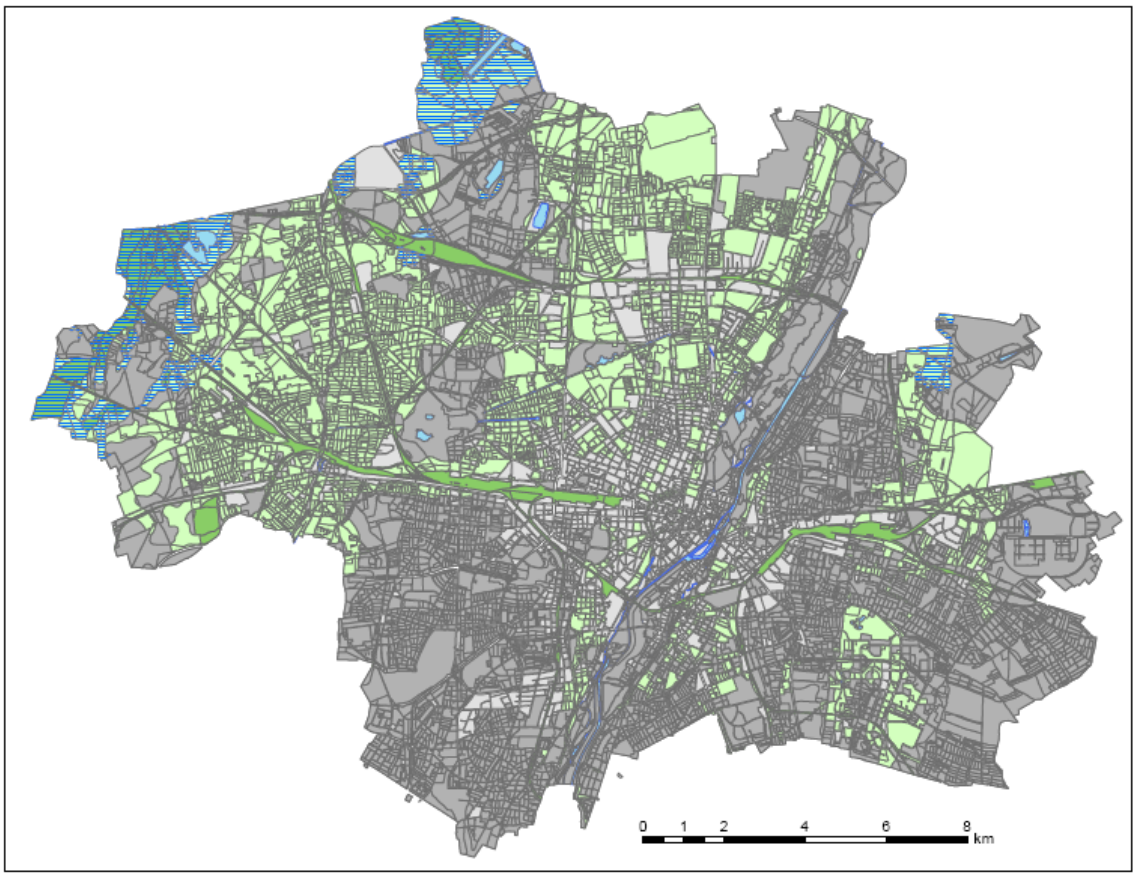
For planning decisions it must be kept in mind that a high potential as filter and buffer for harmful substances must not necessarily imply a high suitability for emitting forms of land use for several reasons:

- The evaluation allows no statement whatsoever about the pre-loading with contaminants. Soil might already be highly enriched with heavy metals so any further immissions would not be adsorbed.
- The change of land use often leads to a change of conditions as e.g. topsoil might be removed causing a decrease of the content of organic matter, pH-values might be altered, etc. A change of land use could therefore cause a desorption of heavy metals stored in the soil matrix.
- Extensive parts of the City of Munich are covered with highly permeable soils. Even though the filter and buffer capacity might be high only insufficient protection of the ground water is granted as water will infiltrate too fast for adsorption processes to take effect (cp. Lehmann et al. 2007). This factor is taken into account in a separate map not presented in this paper.
- Especially in the alluvial plain where high evaluation results are achieved, a high contamination risk must be assumed because the ground water table is close to the surface.
- In addition a fundamental conceptual shortcoming of this soil function has to be discussed: A high potential to filter and buffer heavy metals might be important for ground water protection – but conversely it means an enrichment of contaminants in the soil which actually contradicts the aim of soil conservation.

In a similar manner potentials for nine other soil (sub-)functions were evaluated and presented as maps with comprehensive textual explanations. In addition, some results were combined at the request of planners to aggregate more information within one map.

4.3 Soil as location for potential biotopes

Graph 2 shows such a synoptic map in which the potential of soil to provide good living conditions for specialised flora and fauna is highlighted. The best evaluation results are achieved for soils which offer either very dry or very wet conditions. Conserving soils with extreme conditions is a necessary measure to ensure high biodiversity in the city.



Graph 2: Evaluation results for "soil as a basis for life and habitat for plants and animals: potential as location for biotopes"
Applied evaluation methods: BayGLA (2003), TUSEC (Lehmann et al. 2007); modified
Legal basis: BBodSchG, art. 2 para. 2 subpara. 1 lit. a

"Very dry" conditions – i.e. areas with "very high potential as habitat for xerophilous species" in graph 2 – are assumed for soils with a naturally very low available field capacity (soil water available for plants) of less than 30 l/m² or for areas where such an environment is created by the current form of land use (railway grounds, gravel pits). Soils with an available field capacity of 30-60 l/m² are rated as having "high potential" as biotope for xerophilous species. This condition is fulfilled in extensive parts of the northern and northwestern municipal territory with shallow soils that emerged from the calcareous sediments of the Munich Gravel Plain.

"Wet" conditions are closely connected to the (former) influence of ground water. Soils classified as moors, fens or bogs – located mainly in the northern and western districts of Aubing and Feldmoching – are rated as having "very high potential" as habitat for hygrophilous species whereas "high potential" is assumed for semi-terrestrial soils (e.g. Gleysols) and terrestrial soils with an available field capacity of more than 220 l/m² (BayGLA 2003). The map shows locations at which biotopes for hygrophilous species would naturally develop if artificial measures – e.g. drainage for agricultural use – were given up. Renaturation measures on such locations can be recommended for the compensation of impairments due to building development at other sites as required in BNatSchG, art. 18 and 19, and BayNatSchG, art. 6 ("Eingriffs-Ausgleichsregelung").

Discussions with landscape planners in Munich led to the elaboration of an additional map in which this information is combined with data about the degree of anthropogenic influence (hemeroby). Abandoned railway grounds or gravel pits might be very good locations for xerophilous species and therefore have a high potential as biotopes. But from the point of view of soil conservation locations with naturally "dry" soils should be considered more worthy of protection than locations where these conditions are created

artificially by removing soil at the first place. The fact that only very few of these once extensively spread "poor grassland" areas (Magerwiesen) remained in the City of Munich gives them additional significance as natural heritage.

4.4 Limitations

Due to missing data and / or inadequate evaluation methods certain aspects could not be evaluated including the potential of soil as transformer of organic pollutants (cp. Hochfeld et al. 2002) and the capability of soil in the nutrient cycle.

Especially in urban areas human influence on soils and soil forming processes as well as the heterogenity of soils is high (Pietsch and Kamieth 1991, AKS 1997, Blume 2004). However, for an evaluation of soil functions on an overview planning level based on existing data these anthropogenic alterations can be taken into account only in a very generalised form. For the Thematic Soil Plan the influence of different forms of land use on the most important soil characteristics (pH-value, bulk density, content of coarse material, content of humic substances) is assessed and integrated in the evaluation procedures (cp. Stahr et al. 2003). Historic land use left its imprints on urban soils, too. These influences are even harder to assess as data is only available – if at all – in form of historic maps and texts. The localisation of specific land uses is therefore not always easy especially because historic maps usually do not have the necessary depth of detail concerning land use (Megele 1951).

Further research about the interrelations of soil and human activities is needed in order to be able to take anthropogenic alterations of natural soils into account adequately and thereby significantly increase the quality of urban soil evaluation. With regard to the assessment of the impacts planned land use changes might have on soils this is also an important contribution to providing a better and more comprehensive technical basis for Strategic Environmental Assessments.

5 IMPLICATIONS FOR URBAN PLANNING

5.1 Landscape Plan

The Thematic Soil Plan was elaborated in close cooperation with the municipal Department of Health and Environment (Referat für Gesundheit und Umwelt) and the Department for Urban Planning and Building Regulation (Referat für Stadtplanung und Bauordnung) which is also responsible for landscape and green space planning. Thus objectives of Munich landscape planners were taken into consideration throughout the evaluation procedure. Special attention was payed to some of their specific fields of interest, e.g. the potential of natural or semi-natural soils to provide good living conditions for xerophilous plants and animals and therefore to be worthy of protection as (potential) "poor grassland location" (cp. chapter 4.3).

Results of the soil evaluation procedure are shown as maps in the Thematic Soil Plan and can directly be used to detect areas which need special attention in the course of planning procedures either because of their ecological value (very high rating) or their vulnerability (very low rating for certain functions). It is not yet clarified if the contents of the Thematic Soil Plan will be added to the Landscape Plan as a new separate category (e.g. "priority area for soil conservation") or if they will be included in existing categories (e.g. "areas with restricted use to conserve and improve especially valuable natural inventory").

The aggregation of all evaluation results to a single figure is helpful for the implementation of these results in urban planning and the explanation and justification of planning decisions. Several different approaches for this complex step exist (Feldwisch and Balla 2006). Treating all evaluated soil functions and sub-functions equally (cp. Umweltministerium Baden-Württemberg 1995) is problematical because natural peculiarities and planning objectives can not be taken into account adequately. But prioritising specific functions and finding the appropriate weighting of the relative significance of each soil function constitute a major difficulty as well (Hochfeld et al. 2003). From a scientific point of view pros and cons can be found to legitimate or refuse high weighting for almost any soil function. Choosing the right methodology for an overall evaluation and subsequently for assessing the compatibility of soil conservation objectives with other planning targets seems rather a political than a technical decision. Therefore an overall evaluation map was elaborated as proposal but the actual integration of the Thematic Soil Plan in the Landscape Plan will be left to the responsible Department for Urban Planning and Building Regulation.

5.2 Zoning

Referring to chapter 3 contents of the Thematic Soil Plan can be integrated in zoning and preparatory land use planning on three levels:

- Areas with soils highly suitable as potential biotopes (cp. graph 2) but not yet protected can be excluded from future development by identifying them as "ecologically sensitive areas".
- The Landscape Plan as integral part of the Zoning Plan holds, amongst other things, information about areas with especially valuable natural inventory. Areas with valuable and / or vulnerable soils including soils worthy of protection as archives of natural or cultural history could be integrated in this category (see above).
- Soils with a high potential as biotopes or with special significance in the water cycle could be connected to regional or local green corridors or integrated in existing protected areas.

Another idea discussed with planners was the creation of "pedotopes" which could be protected according to the Nature Protection Act (BayNatSchG), art 9, in the same way as it is already common for "geotopes" (valuable geological archives of natural heritage) and "biotopes" (valuable habitats for rare species – cp. BayNatSchG, chapters IIIa and IV). A "pedotope" in this context could be defined as small area where soils are especially worthy of protection due to their rareness, their significance as natural archive or their ecological importance in a local or regional context.

5.3 Local Development Planning

It has to be kept in mind, that the evaluation of strongly altered sections in the city centre is merely based on repeatedly generalised, interpolated and complemented data from a conceptual soil map. So the presented evaluation results have to be seen as mere "indications" valid only at the targe scale of 1:25,000. For planning measures on a detailed level, e.g. for the elaboration of Local Development Plans, it might be necessary to provide more accurate input parameters by mapping soils in the field to ensure evaluation results of best quality (cp. Hochfeld et al. 2002, Faensen-Thiebes et al. 2006). In future, the survey of soil characteristics – and subsequent consideration of soil evaluation results – should be established as obligatory step for the elaboration of Local Development Plans. To minimise costs and effort such surveys could be combined with the already established collection of data about vegetation (Biotopkartierung), mechanical stability of the building ground (Baugrundeignung und Gründungsgutachten) and the present level of contamination (Altlastenuntersuchung).

In addition, binding regulations should be established for soil protection measures on construction sites and for the treatment and re-application of topsoil removed in the course of building development to ensure a preservation or even improvement of soil functions (cp. BUWAL 2001, BayStMUGV 2004) on parcel level.

5.4 Strategic Environmental Assessment (SEA)

The Thematic Soil Plan provides information for various steps of Strategic Environmental Assessments which have to be "carried out of certain plans and programmes that are likely to have significant effects on the environment" (SEA-Directive, 2001/42/EC, art 1). According to the Statutory Code on Construction and Building (BauGB, art 2 para 4) a Strategic Environmental Assessment has to be carried out for all urban land-use planning instruments (i.e. Preparatory Land Use Plan or Zoning Plan incl. Landscape Plan, Local Development Plans) – exceptions are defined in BauGB, art 13. So the "screening" if such plans are likely to have significant effects on the environment at all can usually be skipped (Busse et al. 2005, BayStMI 2004).

In a subsequent step the scope of the assessment of a certain plan must be defined in terms of time, extent, applied methods and required level of detail. The Thematic Soil Plan can help to decide which soil functions are of relevance in a proposed planning area and if the level of detail of the Thematic Soil Plan is sufficient at the required scale (e.g. for Local Development Plans, see above).

In the Environmental Report (SEA-Directive, art 5) both the current state and "likely significant effects" of certain plans and programmes are described for all relevant subjects of protection. It should summarise and evaluate the contents of the Landscape Plan as required by the SEA-Directive (Pröbstl 2006). The current quality of soils is shown in the maps of the Thematic Soil Plan, the impacts of planned land use changes (removal, sealing or compaction of soils; change of certain soil characteristics and subsequently of soil potentials) can be estimated following the descriptions in the accompanying textbook. Predefined standard

text elements for direct use in the Environmental Report are provided for all soil units and shall ease the argumentation for planning decisions (SEA-Directive, art 8).

The subsequent monitoring of the supposed significant effects (SEA-Directive, art 10) is also facilitated by the methods described in the Thematic Soil Plan.

6 CONCLUSIONS AND OUTLOOK

Relevant soil data including the evaluation maps of the Thematic Soil Plan will be kept easily accessible for all concerned departments in a currently developed, web-based soil information system. The next intended work step is the combination of quantitative and qualitative aspects of land and soil conservation for an ex-post-analysis of the ecological quality of soil which was lost to building development in the last years. For future planning decisions a monitoring system shall be established as another instrument to conserve the most valuable soils and thus contribute to finding compliant and sustainable solutions for future development of the City of Munich.

The Strategic Environmental Assessment seems to be an appropriate and important instrument for the implementation of soil conservation measures on all levels of planning. Even though the applicability is limited by the level of detail of the available basic data, the Thematic Soil Plan constitutes a good source of information and helps to take the qualitative aspects of soil – the "hidden" natural resource – into consideration in planning procedures for the first time in the City of Munich. The present Thematic Soil Plan can be improved by:

- Improvement and standardisation of evaluation methods (cp. Hochfeld et al. 2002, Ad-hoc AG Boden 2003) and especially of methods to correlate land use and soil characteristics (Stahr et al. 2003).
- Results of evaluations based on high-quality data from soil mapping campaigns (cp. chapter 5.4). Soil mapping in the field is especially recommended for planned land use changes in inner-city areas where evaluations are based on data from the conceptual map (Linder 1998) and therefore are likely to diverge from the actual situation on a specific plot of land. In addition blocks with especially "valuable" or "vulnerable" soils should also be given a closer look to verify the overview evaluation. Algorithms for the evaluation of urban soils on this level were developed and tested in the course of TUSEC-IP (Lehmann et al. 2007; cp. Landeshauptstadt München 2006). For easier application these methods were implemented in the web-based tool ILSE (Information on Land and Soil Information – http://ilse.grid-it.at/).
- Additional information on historic forms of land use for selective areas. While developed land is virtually never re-converted into agricultural land the establishment of residential areas, allotment gardens, public green areas or parks on strongly modified soils or artificially shaped terrain is quite common.
- More detailed data on the present hydrological situation especially in areas with semi-terrestrial soils that were formed under the influence of ground water. This would allow a better assessment of the capabilities of such soils in the water cycle and as potential biotopes for hygrophilous species.

The integration of soil into urban planning by means of a Thematic Soil Plan can only be one of several equally important steps to achieve comprehensive soil protection which comprises both quantitative and qualitative aspects, both preventive and remediating measures. Further need is for soil conservation by an extensification of agricultural use ("eco-farming") and garden use, minimisation of airborne contaminants from industry and traffic and soil-friendly synergies with of other nature protection measures (cp. BayStMUGV 2004; Blume 1992; Hepperle and Stoll 2006). If such regulations are to be widely accepted soil conservation on all levels needs accompanying information activities to raise public awareness about the significance of soil and its multitude of functions in the urban ecosystem.

7 ACKNOWLEDGEMENTS

The authors want to thank the members of the Department of Health and Environment, City of Munich, especially Mr. Werner Gruban and Ms. Annette Eickeler for their support in the elaboration of the Thematic

Soil Plan. Their efforts to provide all necessary data and maintain the contact to Munich landscape planners were essential for the successful completion of this work.

8 REFERENCES

AD-HOC AG BODEN – ARBEITSGRUPPE BODENKUNDE DER GEOLOGISCHEN LANDESÄMTER UND DER BUNDESANSTALT FÜR GEOWISSENSCHAFTEN UND ROHSTOFFE IN DER BRD: Methodenkatalog zur Bewertung natürlicher Bodenfunktionen, der Archivfunktion des Bodens, der Gefahr der Entstehung schädlicher Bodenveränderungen sowie der Nutzungsfunktion „Rohstofflagerstätte“ nach BBodSchG. Hannover, 2003.

AKS – ARBEITSKREIS STADTBÖDEN DER DEUTSCHEN BODENKUNDLICHEN GESELLSCHAFT: Empfehlungen des Arbeitskreises Stadtböden der Deutschen Bodenkundlichen Gesellschaft für die bodenkundliche Kartierung urban, gewerblich, industriell und montan überformter Flächen (Stadtböden) (2nd edition). Kiel, 1997.

BAUGB – BGBl. 1960, 341: Baugesetzbuch. Berlin, 2004.

BAYGLA – BAYERISCHES GEOLOGISCHES LANDESAMT [ed.]: Bodenschätzungs-Übersichtskarte von Bayern 1:25.000. Blätter 7834 und 7835. München, 1985.

BAYGLA – BAYERISCHES GEOLOGISCHES LANDESAMT [ed.]: Standortkundliche Bodenkarte von Bayern 1:50.000, München-Augsburg und Umgebung incl. Beiheft Bodenchemische und bodenphysikalische Analysenergebnisse. München, 1986.

BAYGLA – BAYERISCHES GEOLOGISCHES LANDESAMT [ed.]: Das Schutzgut Boden in der Planung. Bewertung natürlicher Bodenfunktionen und Umsetzung in Planungs- und Genehmigungsverfahren. München, 2003.

BAYNATSCHG – GVBl. 2006, 2: Gesetz über den Schutz der Natur, die Pflege der Landschaft und die Erholung in freier Natur (Bayerisches Naturschutzgesetz). München, 2006.

BAYSTMI – OBERSTE BAUBEHÖRDE IM BAYERISCHEN STAATSMINISTERIUM DES INNERN [ed.]: Der Umweltbericht in der Praxis. Leitfaden zur Umweltprüfung in der Bauleitplanung. Ergänzte Fassung. München, 2007.

BAYSTMUGV – BAYERISCHES STAATSMINISTERIUM FÜR UMWELT, GESUNDHEIT UND VERBRAUCHERSCHUTZ [ed.]: Arten- und Biotopschutzprogramm Bayern (ABSP). Stadt München. München, 2004.

BBODSCHG – BGBl. I 1998, 502: Gesetz zum Schutz vor schädlichen Bodenveränderungen und zur Sanierung von Altlasten (Bundesbodenschutzgesetz). Berlin, 1998.

BBODSCHV – BGBl. I 1999, 1554: Bundes-Bodenschutz- und Altlastenverordnung. Berlin, 1999.

BLUME, H.-P. [ed.]: Handbuch des Bodenschutzes. Bodenökologie und -belastung. Vorbeugende und abwehrende Schutzmaßnahmen. 3rd edition. Landsberg/Lech, 2004.

BNATSCHG – BGBl. I 2002, 1193: Gesetz über Naturschutz und Landschaftspflege (Bundesnaturschutzgesetz). Berlin, 2002.

BUSSE, J., F. DIRNBERGER, U. PRÖBSTL and W. SCHMIDT: Die neue Umweltprüfung in der Bauleitplanung. München, 2005.

BUWAL – BUNDESAMT FÜR UMWELT, WALD UND LANDSCHAFT: Bodenschutz beim Bauen. Leitfaden Umwelt Nummer 10. Bern, 2001.

FAENSEN-THIEBES, A., J. GERSTENBERG, M. GOEDECKE and U. SMETTAN: Karten zur funktionalen Leistungsfähigkeit von Böden in Berlin. In: Bodenschutz, 3/2006. Berlin, 2006

FELDWISCH, N. and S. BALLA: LABO-Projekt 3.05. Orientierungsrahmen zur zusammenfassenden Bewertung von Bodenfunktionen. Bergisch-Gladbach, Herne, 2006.

HÄBERLI, R., R. GESSLER and W. GROSSENBACHER-MANSUY: Vision Lebensqualität. Nachhaltige Entwicklung: ökologisch notwendig, wirtschaftlich klug, gesellschaftlich möglich. Zürich, 2002.

HENNINGS, V. [ed.]: Methodendokumentation Bodenkunde. Auswertungsmethoden zur Beurteilung der Empfindlichkeit und Belastbarkeit von Böden. Geologisches Jahrbuch, Sonderhefte, Reihe G, 1. Hannover, 2000.

HEPPERLE, E. and T. STOLL: Ressourcenplan Boden. Ein Konzept zum planerisch-nachhaltigen Umgang mit Bodenqualität. Umweltwissen 0633. Bundesamt für Umwelt. Bern, 2006.

HOCHFELD, B., A. GRÖNGRÖFT and G. MIEHLICH: Klassifikationssystem zur Bewertung der Leistungsfähigkeit und Schutzwürdigkeit der Böden als Entscheidungshilfe für die Raumplanung unter Berücksichtigung des Bodenschutzes. Hamburg, 2002.

HOCHFELD, B., A. GRÖNGRÖFT and G. MIEHLICH: Großmaßstäbige Bodenfunktionsbewertung für Hamburger Böden. Verfahrensbeschreibung und Begründung. Hamburg, 2003.

LANDESHAUPTSTADT MÜNCHEN [ed.]: Grundwassersituation im oberen Grundwasserstockwerk - Grundwasserflurabstand. München, 1993.

LANDESHAUPTSTADT MÜNCHEN [ed.]: Realnutzungskartierung – Karte der ökonomischen Grundstruktur 1:40.000. München, 1996.

LANDESHAUPTSTADT MÜNCHEN [ed.]: Erstellung eines Bodenschutzkonzeptes für die Landeshauptstadt München. Beschluss des Umweltschutzausschusses München vom 30.11.2000. München, 2000.

LANDESHAUPTSTADT MÜNCHEN [ed.]: Perspektive München – Leitlinie Ökologie. München, 2002.

LANDESHAUPTSTADT MÜNCHEN [ed.]: Flächennutzungsplan mit integrierter Landschaftsplanung. Erläuterungsbericht zum digitalen Flächennutzungsplan der Landeshauptstadt München. München, 2005.

LANDESHAUPTSTADT MÜNCHEN [ed.]: Soil Evaluation in Spatial Planning. A contribution to sustainable spatial development. Results of the EU-Interreg IIIB Alpine Space Project TUSEC-IP. München, Bozen, 2006.

LEHMANN, A., S. DAVID and K. STAHR: Handbuch zur TUSEC-Bodenbewertung (Technique of Urban Soil Evaluation in City Regions). Hohenheimer Bodenkundliche Hefte. Hohenheim, 2007 (in press).

LINDER, S.: Die Erstellung einer digitalen Konzeptbodenkarte für das Stadtgebiet München als Grundlage für die Entwicklung eines Bodeninformationssystems. München, 1998.

MEGELE, M.: Baugeschichtlicher Atlas der Landeshauptstadt München. – Neue Schriftenreihe des Stadtarchivs München, 3. München, 1951.

MOSIMANN, T.: Integration des Bodenschutzes in die Raumplanung. Ziele, Konzept und Methodik zur Bestimmung besonders schutzwürdiger Bodenflächen am Beispiel des Kantons Basel-Landschaft. Liestal, 1999.

PIETSCH, J. and H. KAMIETH: Stadtböden. Entwicklungen, Belastungen, Bewertung und Planung. Taunusstein, 1991.

PRÖBSTL, U.: The Environmental Report for the Preparatory Land Use Plan with Integrated Landscape Plan in Bavaria. This Approach will not be an easy one. In: UVP-Report, 20(4). Wien, 191-195, 2006.

SEA-DIRECTIVE: Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment. Official Journal L 197/30 of the European Communities, 2001.

STAHR, K., D. STASCH and O. BECK: Entwicklung von Bewertungssystemen für Bodenressourcen in Ballungsräumen. Hohenheim, 2003.

UMWELTMINISTERIUM BADEN-WÜRTTEMBERG: Bewertung von Böden nach ihrer Leistungsfähigkeit – Leitfaden für Planungen und Gestattungsverfahren. UM, 20/95. Stuttgart, 1995.