5.3 The case of Toruń, Poland

Introduction

The urban soil cover pattern is unique for every city and it largely depends on a few factors, i.e. the length of a settlement, population density, types of technogenic activities (like industry or transportation), natural and human-induced disasters (e.g. war destruction). Toruń is located in Northern Poland (Fig. 5.3-1). Because of the medium size (area of 116 km^2 and the population of nearly 192,000; source: Toruń City Council Census 2016) and a long history (founded in 1233), the city of Toruń seems to be a good study area. Both, long-term or short-term anthropogenic and technogenic transformations of soils on this scale can make it usually easier to identify and analyze developments of soil characteristics than in larger urban centers. Moreover, Toruń was saved from typical Northern Poland massive destruction of World War II. It can therefore be concluded that it is possible to observe and study the "natural" process of urban soil development and evolution.

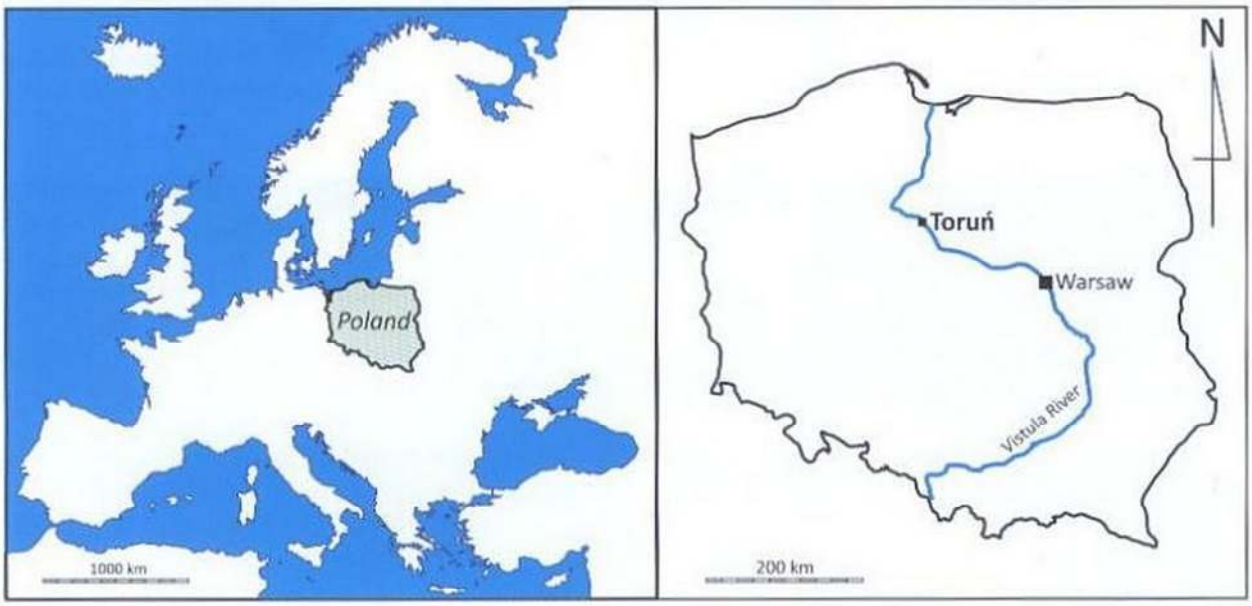

Fig. 5.3-1. Location of Toruń.

The history of research on the Toruń soil cover

The first studies of the Toruń SUITMAs (Soils of Urban, Industrial, Traffic, Mining and Military Areas) began in the early 2000s. The starting point was a conceptual (deductive) soil map (1:15 000) plotted in accordance with the land use (Bednarek et al. 2003). Next, the individual soil contours were verified, based on both fieldwork and laboratory analysis (Fig. 5.3-2). In total, more than 90 soil profiles were described and sampled. The scientific approach used in those investigations, directly follows traditions of Nicolaus Copernicus University, the Soil Science Department, where research has been mainly focused on the genesis, classification and geography of soils (e.g. Bednarek and Prusinkiewicz 1999 with four editions). However, there are studies that also apply to other scientific aspects, such as microbiological characteristics and biochemical properties of soils (Charzyński et al. 2013c, Piotrowska-Długosz and Charzyński

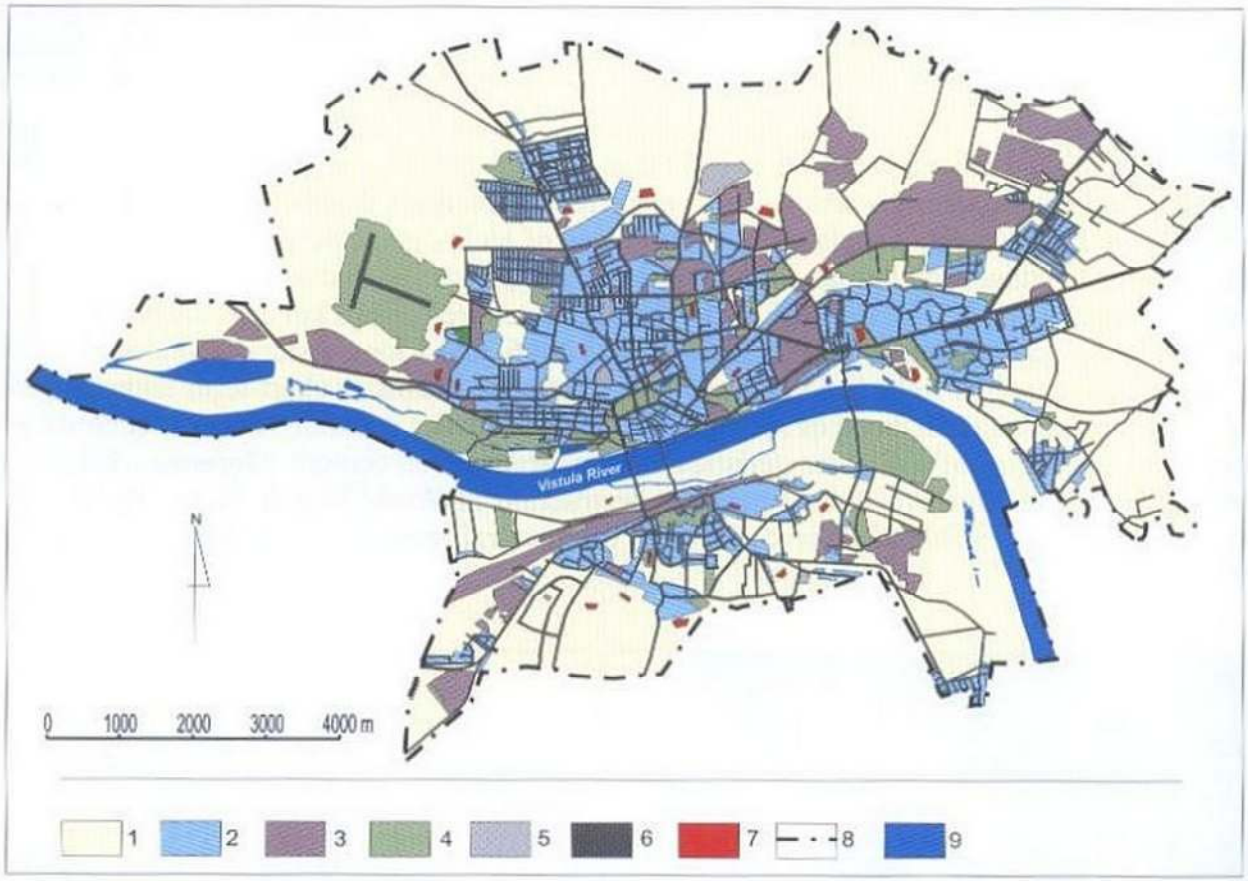

Fig. 5.3-2. The soil map of Toruń (Bednarek et al. 2003, Bednarek, Jankowski 2006, Charzyński et al. 2013, modified). Explanations: 1 – Brunic Arenols and Fluvic Gleysols (undisturbed and weakly transformed soils), 2 – Urbic Technosols, Eutric Arenosols (Technic), 3 – Spolic Technosols, Dystric Arenosols (Technic), 4 – Fluvic Hortic Pheozems (Siltic or Loamic), Haplic Pheozems (Arenic or Siltic), 5 – Ekranic Technosols, Relocatic Pheozems, 6 – Ekranic Technosols, 7 – Isolatic Technosols, 8 – city boundaries, 9 – surface waters.

2015) as well as the assessment of their contamination with heavy metals and Polycyclic aromatic hydrocarbons (PAHs) (Mendyk and Charzyński 2016).

SUITMAs of Toruń

The comprehensive overview of urban soil cover in Toruń was presented by Charzyński et al. (2013b) and Hulisz et al. (2016), and further supplemented by a chapter (Charzyński et al. 2013a) in the atlas of urban soils (Charzyński et al. 2013f). The short summary of specific studies is presented below. According to the above-mentioned authors, the SUITMAs cover over 50% of the total city area. Due to the location of the city in the Vistula River valley (53°01′20″ N, 18°36′40″; Figs 5.3-1 and 5.3-2), the materials used for man-made formation of these soils may be both alluvial sediments and sands of higher river terraces and dunes.

The increase in the cargo freight and passenger traffic resulted in the expansion of transport zones both within and outside the urban areas, and the growth of areas covered by the transport infrastructure. **Ekranic Technosols** is the World Reference Base for Soil Resources (WRB) classification used to describe these soils (Figs 5.3-2 and 5.3-3). Sealing of soils is one of the main causes of the soil degradation in the European Union. Therefore, the direction and extent of changes in soil properties after sealing are a primary soil research focus in Toruń (Charzyński et al. 2011a, 2013c, 2016, 2017, Charzyński and Świtoniak 2014, Piotrowska-Długosz and Charzyński 2015, Mendyk and Charzyński 2016).

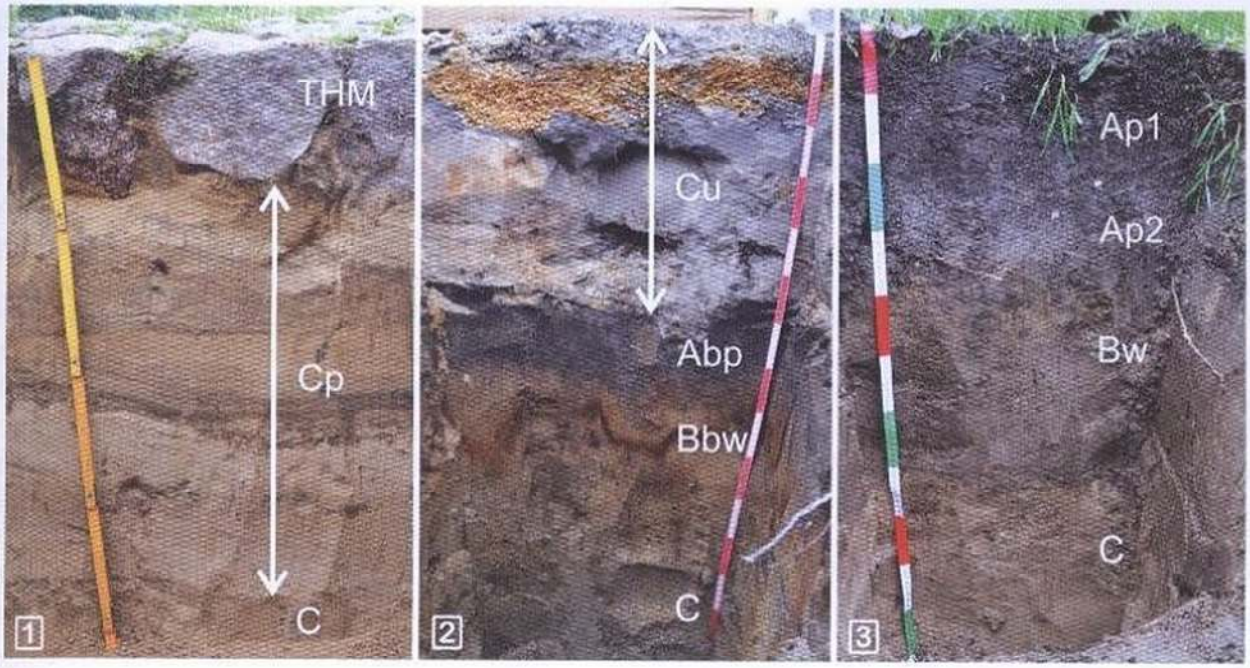

Fig. 5.3-3. Examples of strongly transformed urban soils in Toruń: 1 – Eutric Arenosol (Relocatic, Technic); 2 – Spolic Technosols (Hyperdystric, Arenic, Thionic, Toxic); 3 – Fluvic Hortic Pheozem (Episiltic, Endoarenic).

Fig. 5.3-4. Examples of soils forming on buildings: 1 – Isolatic Technosol (Arenic, Humic); 2 – Isolatic Technosol (Loamic, Humic); 3 – Isolatic Technosol (Folic); 4 – Isolatic Technosol (Arenic).

The WRB unit of **Isolatic Technosols** (Fig. 5.3-4) groups two very different variants of constructed soils on rooftops—one the so-called 'green roofs' and the other, soils formed on abandoned and poorly maintained buildings that were developed without intentional human activity. The second group was already the subject of several studies (Charzyński et al. 2011c, 2013a, 2015). Their name Edifisols, which comes from the Latin word *edificium* (which means building), was proposed by the author of this paper (Charzyński et al. 2011c). The need to name the object of research demonstrates the pioneering nature of the undertaken studies. These soils are interesting counterparts of the natural initial soils, but instead they develop on the technogenic

substrate. Analysis of the properties of the researched Edifisols enabled us to estimate the rate and direction of the secondary succession of plants in places from which they were removed as a result of construction works. Humus properties of Edifisols are currently being studied.

The soil heterogeneity is an effect of zonal, spot and linear human intervention in the soil cover. These include the levelling of land as a preparation stage for construction; the deposition of transported materials; the mixing *in situ*; the admixture of various artifacts (usually associated with the disposal of waste materials); and the construction or modernization of underground transmission networks. Such activities result in the diversity of soil properties even within a small area. Consequently, a mosaic pattern of soil units develop, often clearly different from each other. Furthermore, in contrast to natural soils, boundaries between units are sharp and transitional stages generally do not occur. A perfect example of the above statement may be soils of cemeteries, commonly named Necrosols (Burghardt 1994, Stroganova et al. 1998), with a mosaic of soil units composed of **Ekranic Technosols** (under tombstones, sidewalks), Urbic Technosols (Fig. 5.3-2), soils with properties similar to **Hortic Anthrosols** and **Isolatic Technosols** (Charzyński et al. 2011b). Such soils have very specific characteristics and they are associated with places of strong negative perception. This is the reason why so far only a few researchers have addressed this issue, hence the works from Toruń are among the very few studies on this topic in the world.

Individual papers were devoted to the issues of disturbances caused by military activities (Jankowski and Sewerniak 2013), constructed soils – **Linic Technosols** (Jankowski et al. 2013) and **Urbic Technosols** (Charzyński et al. 2013d). Soils of postindustrial areas of Toruń (Figs 5.3-1 and 5.3-2) and garden soils (Figs 5.3-1 and 5.3-3) are currently researched. The allotment gardens in Toruń cover ca. 3% of the total area of the city. The oldest (established in 1928) still existing allotment garden is located just outside the Old Town area. The main objective of the current study is to evaluate the criteria for the identification of the hortic horizon according to WRB (IUSS Working Group WRB 2015).

Technogenic soils are extremely heterogeneous. Despite the fact that the list of qualifiers for Technosols was one of the longest of all Reference Soil Groups(RSGs) defined in the 2006 edition of WRB (IUSS Working Group WRB 2007), the research conducted (mainly in Toruń municipal area) convinced the authors that it was still insufficient and does not allow for precise classification of pedons, which underwent transformations related to the construction, industry, transportation, mining and military activities.

In response, several papers were prepared and published between 2007 and 2013 with numerous suggestions of additions and modifications to the WRB system (Charzyński et al. 2011c, Uzarowicz and Skiba 2011, Charzyński and Hulisz 2013, Greinert and Drab 2013, Jankowski and Sewerniak 2013). In the article by Charzyński et al. (2013f), proposals of new qualifiers were collated. Some suggestions for extending the applicability of the existing ones were also presented. The paper was published in early 2014. Some ideas presented in the above-mentioned paper have been positively accepted and included in the new version of WRB (IUSS Working Group WRB 2014).

Summary

The investigations of SUITMAs in Toruń are based on a long-lasting history of urban disturbance in situ, allowing the urban soil research to focus on the genesis and classification of soils. The results of studies performed in Toruń advance knowledge about the diversity, soil genesis and specificity of the SUITMAs and provided suggestions for improvement of the WRB concerning qualifier levels. The collected data has also supported decision-making in spatial planning of urban and traffic areas.

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