
The potential of cemeteries to improve urban green infrastructure - a case study in Nitra, Slovakia

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Introduction

Cemeteries comprise a significant area of green space in many cities, are located in prominent locations and are an important element of green infrastructure. Cemeteries offer additional value in the context of their historical and spiritual dimensions. The article is focused on the assessment of the current status of the greenery in five selected cemeteries in the town of Nitra. According to the analyses, we will point at the importance of the cemetery's greenery in a city. Authors emphasize hidden potential of the greenery represented by recreational use and connections to the green infrastructure of the city and take into account fact that there exist some limits which determine the functionality of the green areas.

Literature Review

The concept of cemeteries, as we know them nowadays, i.e. the green areas designed for burials, has appeared during the age of Enlightenment. At that time the burials near the churches were cancelled (due to hygienic reasons) and cemeteries were moved outside the city limits, i.e. Paris in 1765. In Paris, the cemeteries were designed as Elyse fields, for example Père Lachaise cemetery in 1804 or the monumental cemetery Montparnasse in 1801. Melancholic garden was transformed into park, where man could walk and recover, experiencing the nature. Under the influence of English landscape gardens there have been created new garden cemeteries. There were established hoop of burial grounds in London which became known as "The Magnificent Seven". These are: Kensal Green (1833), Norwood (1838), Highgate (1839), Abney Park (1840), Brompton (1840), Nunhead (1840) and Tower Hamlets (1840). From the 1830s onwards in Britain, the creation of new cemeteries became a major part of urban development and city-making (Worpole, K., 2003). Abney Park Cemetery for example has been expressly designed as an arboretum (Worpole, K., 2003). In North America the first of the great rural or garden cemeteries was established at Mount Auburn in Cambridge, Massachusetts, and consecrated in 1831. Mount Auburn was sometimes referred to as "the Père Lachaise of America". In 1838 was founded another garden cemetery Green-Wood Cemetery in Brooklyn, New York. Cemetery was created as part of overall city plan for Brooklyn and it was not seen only

as a burial place but also as a visitor attraction. By 1850 approximately 60,000 people annually took the organized Tour of Green-Wood, studied the plant and went boating on the lakes. An interest of visitors noted the need to build public parks in the United States (Worpole, K., 2003). The Ohlsdorf Hamburg Cemetery as a landscape park with total area of 400 ha was established during the years of 1897 to 1913 in Germany (Jöckle, 2000). The cemetery was designed by J. W. Cordes (1840 - 1917) and on the World Expo 1900 in Paris was cemetery awarded for garden design.

The recent modern cemeteries are already founded as a part of city plan and create green infrastructure of the seats. In contacts with landscape are designed as country or forest cemeteries linked to the surrounding countryside. Overall, we observe an increase of natural cemeteries without marking the graves, more burials in forests and other specific features.

The development of cemeteries may be seen in territory of Slovakia after restriction of burials in churches and building the cemeteries around church in the Austro-Hungarian Empire by decree of Emperor Joseph II in 1784. The new cemeteries were already founded outside the Slovak settlements. Burial fields were regularly structured by system of roads. The arrangement of greenery in this type of cemetery is influenced by architecture of the cemetery; the roads were lined by avenues of trees (Halajová, Kubišta, 2014). This architectonic type of cemeteries represents often significant areas of historical greenery in the Slovak seats.

Goals and objectives

The main goal of the work was to analyze the recent dendrological status of greenery and to propose the principles for restoration and maintenance management of greenery in five cemeteries in Nitra. The second goal was point to the possibilities and limits of the use of the cemetery greenery as green areas in cities and their role in green infrastructure.

Materials and methods

Our research is based on analyses of recent dendrological status of the greenery in cemeteries in Nitra. The town Nitra has 82,661 inhabitants and belongs among the five largest cities in Slovakia. Territory is spread in warm climate zone with an mean annual air temperature from 9 to 10 ° C and mean rainfall totals between 500 and 600 mm. Natural vegetation in the city area consists of forests with predominant tree species *Quercus robur* L., sometimes *Quercus cerris* L., with supplement of *Carpinus betulus* L., *Fraxinus excelsior* L., *Tilia platyphyllos* Scop., *Tilia cordata* Mill. In the city Nitra there are 12 cemeteries and analysis were carried out on five of them.

The Main Municipal Cemetery in the Nitra town is the oldest, largest and historically most valuable burial place of the city Nitra. *The Cemetery in Nitra – Chrenova* is a graveyard of city district Chrenova, that is typical panel housing estate from the 60s and 70s. *The Cemetery in Nitra – Kynek* was originally a typical small rural graveyard with dominant of church. At present it is intended for expansion in connection with the expansion of the suburban Kynek district. Two cemeteries in district Dolné Krškany represent typical small cemeteries. *The Old Cemetery in Dolné Krškany* was originally rural cemetery with church from the 18th century. *The New Cemetery in Dolné Krškany* (near railway) is newer cemetery, less than half of the area is without trees and graves. All cemeteries are an architectural type of burial place with a regular geometric segmentation, negative marked by high density of graves. Dominant type of graves is family grave side – by – side with concrete or stone plate on all area of grave (Table 1).

Table 1. Characteristics of cemeteries

	The Main Municipal Cemetery	The Chrenova Cemetery	The Kynek Cemetery	The Old Cemetery in Dolné Krškany	The New Cemetery in Dolné Krškany
Area (hectares)	3.64	1.5	0.5	0.25	0.53*
Number of graves	5800	1600	350	318	370
Density of graves (graves/hectares)	1594	1066	700	1272	1233
Dominant type of graves	Side-by-side	Side-by-side	Side-by-side	Side-by-side	Side-by-side
Dominant surface of grave	Concrete or stone plate	Concrete or stone plate	Concrete or stone plate	Concrete or stone plate	Concrete or stone plate

* 0.23hectares are new area without graves

The inventory was done in 2012 (The Main Municipal Cemetery, The Chrenova Cemetery) and 2015 (Kynek and Dolné Krškany cemeteries). The inventory of woody plants consists of data identification connected to woody plants, dendrometric value assessment, health condition of woody plants and proposals for the tree treatments or eventual felling. The collected data consist of dendrometric values (height of trees, crown width, trunk perimeter, age of trees) determined according to the methodology of Machovec (1987). The evaluation of health condition of woody plants consists of 5-point classification system created by Juhásová (2003), in which 5 points are allocated to the most damaged tree species, intended for felling.

As a result of processed analyses various measures were determined for greenery maintenance. We propose such measures as felling and treatment of woody plants, special maintenance of trees, elaboration of expertise and planting of new trees. *Special maintenance* of the woody plants was proposed as a set of measures that should result in improving or preservation of their health and landscape value as well as to ensure their stability and security of visitors and should be carried out by specialist – arborists.

Results

The results of woody plant abundance in five cemeteries show, that number of woody plants is dependent on area of cemetery. There are totally 366 individuals and 37 species of trees and shrubs in the Main Municipal Cemetery and 14 individuals of trees and 7 species in the Old Cemetery in Dolné Krškany (Table 2). The species composition is poor, the three most abundant species on cemeteries represent together from 59 to 85 % of all individuals. The most abundant species are conifers *Thuja occidentalis* L. and *Thuja orientalis* L., deciduous trees are mainly represented by alley's trees such as *Tilia cordata* Mill., *Tilia platyphyllos* Scop. and *Aesculus hippocastanum* L. (Table 3).

Table 2. Woody plant abundance

	The Main Municipal Cemetery	The Chrenova Cemetery	The Kynek Cemetery	The Old Cemetery in Dolné Krškany	The New Cemetery in Dolné Krškany
Number of trees	367	267	43	14	15
Number of species of trees	37	32	8	7	8

Table 3. Representation of three most abundant woody plants

The Main Municipal Cemetery	The Chrenova Cemetery	The Kynek Cemetery	The Old Cemetery in Dolné Krškany	The New Cemetery in Dolné Krškany
<i>Thuja occidentalis</i> 23 %	<i>Thuja orientalis</i> 27 %	<i>Tilia platyphyllos</i> 44 %	<i>Aesculus hippocastanum</i> 50 %	<i>Thuja orientalis</i> 26 %
<i>Thuja orientalis</i> 22 %	<i>Thuja occidentalis</i> 21 %	<i>Thuja orientalis</i> 18 %	<i>Thuja occidentalis</i> 35 %	<i>Betula pendula</i> 20 %
<i>Tilia cordata</i> 18 %	<i>Tilia cordata</i> 17%	<i>Tilia cordata</i> 16 %	-----	<i>Aesculus hippocastanum</i> 13 %
Σ 63 %	Σ 65 %	Σ 78 %	Σ 85 %	Σ 59 %

On base of woody plants health condition assessment has been found that almost half of the woody plants at burial ground are healthy, with no signs of diseases (Table 4). There are a few trees (4.6 %) with the highest degree of damage (5 points), as a consequence of intensive and regular tree felling in last decades in the cemeteries. The most common type of damage of alley's trees is characterized by unprofessional cutting of woody plants, tree trunk cavities, damage of tree roots during burials and construction works and dry branches. From plant health point of view follows that worst health conditions are connected to old individuals in alleys represented by species: *Tilia cordata* Mill., *Tilia platyphyllos* and *Aesculus hippocastanum* L.

Table 4. Health status of woody plants

Health status (point classification)	The Main Municipal Cemetery *	The Chrenova Cemetery *	The Kynek Cemetery *	The Old Cemetery in Dolné Krškany*	The New Cemetery in Dolné Krškany *
5	-----	-----	4.6 %	-----	-----
4	2.2 %	-----	-----	-----	-----
3	9.2 %	0.6 %	16.3 %	28.6 %	-----
2	21.2 %	5.7 %	30.2 %	28.6 %	6.7 %
1	20.1 %	17.3 %	14.0 %	14.2 %	20.0 %
<i>healthy</i>	47.4 %	76.5 %	34.9 %	28.6 %	73.3 %

* percentage of woody plants

The cultivation measures and treatment of woody plants have been most commonly proposed for alley's trees (Table 5). Felling of woody plants was frequently proposed too because of grave damage risk, poor health condition or serious threat to the safety of visitors. The plants with low vitality and those which do not pose threat to visitors have been proposed for survival. In the treatment of woody plants have been proposed different kinds of cuts of trees, removing of seeding trees, the cavities treatment and treatment of trees by chemical spraying. The most of the measures have been proposed for alley's trees. The special maintenance and the elaboration of the expertise have mostly been proposed for species located in the tree alley too. In the Main Municipal Cemetery and the Chrenova Cemetery were proposed reconstruction of alleys by planting of new trees of genus *Tilia* and *Aesculus*.

Table 5 Proposal for cultivation measures and treatment of woody plants

Proposal for cultivation measures and treatment	The Main Municipal Cemetery in Nitra*	The Chrenova Cemetery*	The Kynek Cemetery*	The Old Cemetery in Dolné Krškany*	The New Cemetery in Dolné Krškany*
Felling of woody plants	5.5 %	6.4 %	13.9 %	-----	13.3 %
Woody plants proposed for survival	6.8 %	1.1 %	13.9 %	-----	-----
Woody plants proposed for the treatment	10.0 %	5.6 %	23.2 %	14.2 %	53.3 %
Woody plants proposed for the special maintenance	23.5 %	15.3 %	9.3 %	57.1 %	-----

* percentage of woody plants

Discussion and conclusion

Due to relatively large area of cemeteries greenery in the settlements there is requirement for their full integration into system of greenery in settlements. The cemeteries in system of green infrastructure of city have the eco-stabilizing function, as well as recreational and educational ones. New cemeteries in Munich (Neubiberg built in 2000 and Riem built in 2001) are a prime example links green paths, bike trail, parks and recreation zones of the city without disturbance of quiet atmosphere of remembrance.

On base of our results we found several limiting factors for inclusion cemeteries to the green infrastructure. The *significant quantity decline of the greenery* in the evaluated cemeteries, as well as poor health condition of the greenery and lack of its maintenance are the most important limiting factors for further recreational use as a functional green area. There is a significant decrease of the alleys of deciduous trees, which represent long-life trees and as such create the bone-structure of the greenery composition of the site. The comparison of the inventory in Main Municipal Cemetery results with the last survey of trees condition in the cemetery carried out by Juhásová (2003) in 2002 showed that the number of woody plants decreased from 565 to 366 individuals during one decade. We assume that such intensity of trees removal will result in elimination of all trees in alley. Problematic is also a reconstruction of alleys for lacking of free space for new plantings.

Another negative factor is *damage of original landscape composition of cemeteries* caused not only by decreasing of alley deciduous trees, but also by the individual planting (owners of graves) of conifers inside the grave fields, especially introduced plants of the genus *Thuja*. These woody plants represent problems connected to maintenance of the cemetery, but also with the orientation and safety of visitors.

Very important negative factor is a *large density of graves*, which is related to the lack of places for burying in towns. Especially on attractive cemeteries located in urban centers is frequent expansion of burial spaces built at the expense of green areas. It is also known from the past, when popular parks Père Lachaise Cemetery in Paris under the pressure of burying turned into a stone city.

The limiting factor is also the *lack of greenery in the visual field* of the visitor. Surface of graves usually represents stone or concrete plate. This situation is the result of lack of services of cemetery garden centers, that would ensure the planting on graves.

And not to mention a *human factor* in particular in relation to the perception of cemetery as a place of pious, quiet, or also unpleasant and dangerous. This can significantly reduce the use of cemetery greenery by residents.



Figure 1. Kynek Cemetery - originally a typical small rural graveyard with dominant of church; at present in suburban of Nitra, with massive solitary trees near church (2 individuals of *Tilia platyphyllos* with perimeter 257 cm and 367 cm)

It follows that in the architectural cemeteries there are many limiting factors for the use of cemeteries as a green areas. In our case the Kynek Cemetery is best suited for linking the greenery system (Figure 1). There is also the largest green area, historic church and massive solitary tree as well as an area for expansion. It is also possible to link cemetery by alley with near historic park. The most important task is to solve the quality of greenery on the largest historic the Main Municipal Cemetery in Nitra, which is located in the city center with lack of greenery.

For using greenery of old cemeteries is need to improve the quality of the of greenery by restoring original landscape compositions in cemeteries, implementation of the substitute planting of alley's trees, protection of root trees damage by abolition of graves and regular maintenance carried out by arborists. All these measures should lead to the conservation of greenery in the cemetery, but new possibilities of historic cemeteries exploitation as the valuable greenery areas are also significantly opened after the stopping of burials.

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