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QUALITY INDICATORS OF STATUS AND MAINTENANCE OF URBAN GREENERY

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The study deals with the evaluation of quality indicators of vegetation elements forming urban greenery areas. There were detailed evaluation indicators of quality defined for individual vegetation elements and also the indicators of their maintenance care quality. Detailed field survey was done in selected areas of greenery of residential complexes in Ostrava (Czech Republic). There were 2005 pieces of vegetation elements assessed on a total area of 17.71 hectares. The results of the study highlighted the differences in quality of individual elements as well as in the quality of achieved maintenance care. The worst average values of qualitative indicators were determined at the groups of trees. 60.59 % of the evaluated groups of trees were in poor qualitative condition and 50.48 % of the groups of trees showed poor quality of the maintenance care. The results also demonstrated the influence of the quality of maintenance care on the qualitative status of the individual elements. The proposed indicators and results of this study have direct applicability on the management of urban green spaces.

Keywords: urban greenery, vegetation elements, qualitative indicators, maintenance care, residential areas

Introduction

Evaluation indicators are current tool in the area of a residential greenery management, sustainable development and other horticultural and environmental fields. The most important use is found in the monitoring of changes in individual indicators over time and also in the possibility of comparison of the objects, settlements, etc. In the global context, there are in addition to indicators evaluating the spatial structure of residential green spaces (e.g. Zhou and Wang, 2011) also relevant indicators of the state of urban populations of trees (e.g. Cumming et al., 2008). Set of 25 indicators for evaluating the urban population of trees defined Kenney et al. (2011). Indicators included for example the tree health condition, the portion of trees with tree inventory and tree risk assesment. Based on the results of the assessment of individual trees growing in the City of New York (USA) was compiled qualitative indicator condition of trees (collectively revealing the health state and vitality of trees) by Peper et al. (2007). Chen and Jim (2008) assessed quality population of trees in Nanjing (China) by using the indicator condition of trees. Results of both studies showed a high variability of this indicator in different types of urban green areas Other compositional elements of green space, except the trees, were given only marginal or no attention.

The assessments made in the Czech Republic (CZ) focused on selected green residential areas of Prague and the Central Bohemian Region were implemented by Sojková and Knotková (2008) and Sojková and Hrubá (2006). The obtained results highlighted inappropriate sortimental composition of the trees and a high proportion of trees in unsatisfactory quality status. The evaluation of the level of maintenance care in different cities of the Czech Republic was carried out by Šimek (2010). The results of his study indicated different levels of maintenance at different types of vegetation elements and even at different functional types of green areas. The Slovak authors describing possible approaches to the general evaluation of urban greenery were Supuka and Feriancová (2008).

The aim of the study is to apply evaluation indicators to know actual state of selected area of urban greenery.

Material and methods

The model area

The field evaluation was done on public green areas of selected residential elements of Ostrava (Czech Republic). Greenery of residential complexes was defined by Šimek (2001) as areas of vegetation within a concentrated residential areas, immediately following built-up areas and intended for the use of residents of housing estates. There were assessed 2005 pieces of vegetation elements (VE) in total, which represented an area of 17.71 hectares. The total length was 4 916 m in the case of linear VE. This field evaluation ran for a period from June till September 2013.

Classification of composite elements

Individual VE forming the evaluated objects of green areas were passportized and subsequently categorized into

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Table 1 Qualitative assessment of VE status – rating scale

Status of VE		Description of the state – vegetation elements (VE)
1	Very good	– Plants forming the VE are fully vital, healthy, having typical or desired habitus, without symptoms of damage – VE is fully functional in terms of meeting the required functions, perspective and stable
2	Good	– Plants forming VE have minor flaws in comparison to the previous category, but do not significantly reduce the performance of their required functions, perspective and stability
3	Average	– Plants forming VE have moderately reduced vitality, signs of damage and impaired health status – Meeting the required functions, perspective and stability are only partially reduced
4	Poor	– Plants forming VE have due to their age, damage, disease or pests substantially reduced vigor, and/or health status – Implementation of the required functions, perspective, stability is significantly reduced
5	Very poor	– Plants forming VE have due to their age, damage, diseases or pests, totally reduced vigor, and/or very bad health status. There is no assumption of even a short existence. Elements do not fulfill their function at all, they are completely unstable

Vitality and health status was assessed according to the methodology Pejchal (2008). Detailed description of the evaluated attributes and individual levels see Pejchal (2008)

Table 2 Qualitative evaluation of maintenance care – rating scale

Quality of Care		Description of maintenance care quality
1	Very high	– No signs of deficiencies in maintenance care
2	High	– VE show signs of partial, minor deficiencies in maintenance care
3	Average	– VE show signs of partial, serious deficiencies in the maintenance care
4	Poor	– VE show signs of significant deficiencies in the maintenance care
5	Very poor	– VE show signs of very significant deficiencies in the maintenance care or its complete absence.

Evaluation criteria quality of maintenance care were evaluated according to the methodology Šimek (2010) and were related to the five-point rating scale

areal VE (groups of trees, groups of shrubs, flower beds, lawn areas), linear VE (alleys, shaped hedges) and point VE (solitary tree, solitary shrub). The solitary tree category was divided into sub-categories: solitary tree – an adult tree (further mentioned as a solitary tree) and solitary tree – new plantings (further mentioned as new plantings). The structure and representation of the VE shows Tab. 3.

Table 3 The structure and amount of tested categories of VE

Vegetation element type	Pieces	Area in m²	Length in m
Solitary tree	422		
New plantings	52		
Solitary shrub	284		
Group of trees	105	11 606	
Group of shrubs	138	6295	
Flower-bed	26	612	
Lawn area	730	158 166	
Alley	32		1 414
Shaped hedge	216	426	3 502
Overall	2005	177 105	4 916

Qualitative status of elements

There was a 5-point scale used for evaluation of the qualitative status of each element (Tab. 1). The areal and linear VE were also evaluated from the perspective of their integrity (failures, blanks). There was also the vertical and horizontal canopy taken into account in the case of shaped hedges.

The qualitative state of maintenance care

For each VE, the quality of maintenance care was assessed (see Tab. 2). The principals for the evaluation were inspired by the work of Šimek (2010), but it was slightly modified and extended. For each type of VE there were developed detailed evaluation criteria, which reflected the typical characteristics of quality care maintenance. E.g. at the VE consisting of trees, there was evaluated an absence of tree maintenance care (presence of dead branches, presence of hazardous trees, absence of thinning). The shaped hedges were assessed as complying with the optimum growing shape. According to above mentioned scale, the flower-beds and lawn areas were evaluated in terms of the degree of weed infestation, maintenance of edges and watering.

Statistical evaluation of the impact of quality of maintenance care on quality of VE

Pearson's chi-square test of independence, at a significance level of 0.05 was used for test of the

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Table 4 Representation of quality for each vegetation element type

Vegetation element type	1		2		3		4		5	
	Quality of element	Quality of care	Quality of element	Quality of care	Quality of element	Quality of care	Quality of element	Quality of care	Quality of element	Quality of care
Solitary tree	0.47	1.90	13.74	35.55	39.34	**34.83**	**43.60**	24.88	2.84	2.84
New plantings	**32.69**	30.77	28.85	**32.69**	26.92	15.38	11.54	21.15	0.00	0.00
Solitary shrub	0.35	7.75	34.86	**35.21**	25.00	32.04	**39.44**	25.00	0.35	0.00
Group of trees	0.00	0.95	5.71	15.24	33.33	33.33	**60.95**	**50.48**	0.00	0.00
Group of shrubs	0.72	1.45	22.46	28.26	35.51	**38.41**	**41.30**	31.88	0.00	0.00
Flower-bed	0.00	3.85	**73.08**	**65.38**	23.08	30.77	3.85	0.00	0.00	0.00
Lawn area	0.00	0.00	13.97	26.16	**70.68**	**65.47**	14.38	8.36	0.96	0.00
Alley	0.00	6.25	15.63	12.50	**68.75**	**59.38**	15.63	21.88	0.00	0.00
Shaped hedge	0.00	0.93	12.96	8.80	24.54	28.70	**62.50**	**54.63**	0.00	6.94
Average in %	3.80	5.98	24.58	28.87	**38.57**	**37.59**	32.58	26.47	0.46	1.09

dependence between the variables. The conditions for using the Chi-square test were not met, the test was repeated using Monte Carlo analysis. To determine the strength of the relationship between the two attributes was used Cramer contingency coefficient V and contingency coefficient. Data were analyzed using the program R, version 3.0.1 (R Core Team, 2013) with the optional package "vcd" (Meyer et al., 2012). For writing R scripts was used Tinn-R script editor (Faria, 2012).

Results and discussion

Qualitative indicators of vegetation elements

Table 4 shows representation of quality for each vegetation element type. Predominant representation of the quality of VE and the quality of care is highlighted black for each VE. In the overall average, the most represented were the values of category 3, which shows the average quality (38.57 % for the quality of VE and 37.59 % for the quality of care). A high proportion of values represented category 4, indicating poor quality of VE (32.58 %) and poor quality of care (26.47 %) and then the values of category 2, indicating good quality of VE (24.58 %) and a high quality of care (28.87 %). Categories 1 and 5 occured in only a few cases of evaluated sample. Among the best rated VE in terms of quality belonged flower-beds and new plantingss. The quality of lawn areas and alleys was mostly average. The solitary shrubs showed balanced distribution of quality in categories 2 and 4 of qualitative scale. Solitary trees, groups of trees, groups of shrubs and shaped hedges were predominantly evaluated within the qualitative category 4. In terms of quality of care, the top rated VE were flower-beds and new plantings. It should be noted that at the same time, 21.15 % of new plantings belonged to category 4, which refers to the poor quality of care. Relatively uniform distribution of the percentage in categories 2, 3 and 4 was shown in the case of solitary shrubs and solitary strees and groups of shrubs. Groups of trees and shaped hedges predominantly represented the category number 4.

Lower quality of trees groups and shrubs groups is due to the absence of thinning. Lower quality is also caused by the low number of maintenance care interventions in groups of trees to trees that have strong competitive growth defects in habitus (V-forked branch, asymmetric unstable crown, etc.). Competitive growth and negative manifestations are not typical for solitary trees so demands on the amount of maintenance care may be lower.

These results can be partially compared with the results of other authors. Qualitative status of trees growing in New York (USA) was evaluated by Paper et al. (2007) using the indicator condition of trees. Excellent condition (hereinafter referred to as the quality): 23.9%, good: 66.4%, poor 8.3%, dead 1.4%. Results of the condition indicator of trees quality in study Chen and Jim (2008) assessing in Nanjing (China) is as follows: excellent 15%, good: 50%, fair: 29%, poor: 5%, dying: 1%. In this work (Ostrava) was much higher portion of poor quality trees than in two cited studies. A higher portion of better quality of trees (Chen and Jim, 2008; Paper et al., 2007) may be caused by high quality of maintenance care in selected locations of their occurrence (habitate type). This follows from the conclusions of the cited works. Localization of trees in a recently constructed parts of the city may also have effect in case of study Chen and Jim (2008).

In the study by Šimek (2010), the quality of care for VE in the green areas of residential complexes interfaced the average and below average (poor) quality. In this work, the most abundant were VE showing average quality of care (37.59 %) with a balanced overlap to the

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above-average quality (high quality) and also to below-average quality (poor quality). In the case of groups of trees and shaped hedges outweighed poor quality of care. It can be concluded that the results of these two works are similar.

The above mentioned statement is also proved by the work of Sojková and Knotková (2008) carried out in a greenery of residential complexes. According to the cited results, 72 % of trees showed average quality and 24 % of trees showed poor quality, 67.5 % of VE consisting of shrubs showed unsatisfactory quality level. Unsatisfactory growing conditions were observed at 47 % of assessed trees and shrubs. When compared with the results of this work, it is evident that in both cases VE consisting of trees and shrubs achieved average and substandard values of the qualitative status and also the quality of care. This identical finding should be an impulse for the management of residential green spaces and the introduction of systematic steps to improve the situation.

Relationship between quality of element and quality of care

The final match between the degree of quality of element and the same level of quality of care is shown in Tab. 5. Combinations marked with the symbol "–" were not present on the evaluated area. The strongest consensus between both assessed attributes was found at the qualitative category no. 1. 95.24% of all VE in the 1st qualitative category had concurrently the care of qualitative category 1. Other categories showed lower, but still high conformity. The biggest differences between the quality level of element and the same quality level of care were found at solitary trees (in categories 2 and 4), new plantings (category 3), lawns (category 2), groups of trees and groups of shrubs (category 4).

Table 5 Correspondence between quality of element and quality of maintenance care in %

Quality of element	Quality of maintenance care				
	1	2	3	4	5
1	**95.24**	4.76	–	–	–
2	8.26	**63.36**	25.90	2.48	–
3	0.43	27.25	**63.73**	8.58	–
4	–	9.96	30.76	**56.61**	2.67
5	–	6.25	31.25	6.25	**56.25**

Effect of quality of maintenance care to the quality status of VP. Based on the results of the Pearson chi-square test of independence is possible to conclude that there is the statistically significant relationship between the quality of VP and quality of maintenance care: χ^2 (16, N = 2005) = 2002.12; p <0.001. The result is statistically significant even when using the Monte Carlo method (with 2000 replications) χ^2 (NA, N = 2005) = 2002,12; p <0.001. The correlation between two attributes is strong (Cramer contingency coefficient V: 0.50 and contingency coefficient: 0.71).

The reason for the lower percentage of compliance between qualitative categories 2 and 3, and especially between 4 and 5, is the effect of other factors that may affect the qualitative status of VE. Lawn areas were often damaged by trampling, excavations, etc. VE consisting of trees and shrubs were often influenced by inappropriate choice of taxon due to unfavorable habitat conditions. New plantings and groups of shrubs were in several cases damaged by vandalism. Specific VE could thus show significant decrease in their qualitative status, in spite of even high or average quality of care. This situation shows that quality of care is important, but not the only factor that affects the quality of VE.

Conclusions

The study presented evaluation indicators for assessing the quality of VE and related maintenance services. Obtained results demonstrated differences in the quality of maintenance care among individual VE and the quality of each VE. The quality of VE and the quality of maintenance care is different for each VE. The most elements achieved average quality of both indicators. The worst average values of both qualitative indicators were determined for groups of trees. The best quality of both indicators were determined for flower beds and new plantings. The results showed a correlation between quality of maintenance care and quality of VE. Results and principles of this work are fully utilized primarily by the management of urban greenery and they will find application when comparing greenery, and design of an appropriate method of care management.

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