THE IMPACT OF VEGETATION STRUCTURE ON MICROCLIMATIC CONDITIONS IN URBAN ENVIRONMENT OF NITRA CITY

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Trend of nowadays is decreasing of green areas related to increasing urbanization and spatial requirements of urban population. According to Wardoyo (2011) is urban environment specific to hard surface, typical urban geometry, vegetated areas and variability of surface materials. In urban environment is large concentration of surfaces which are strongly overheated and have large thermal capacity. As a result is the accumulation of heat in the city environment (Hudeková, 2012). One of the factors that influences the local climate conditions in relation to environmental risks are vegetated areas in urban environment. Vegetated areas in urban environment have the capability to eliminate extreme demostrations of local climate. The impact of transpiration causes increasing of the relative air humidity reduces the effect of solar radiation. As a result is the elimination of surface temperature in vegetation. The aim of this study was to evaluate the potentiality of impact of vegetation structure and type of surface on microclimatic conditions. The legwork ran in summer period June-August 2013 and 2014 in residential area Chrenova 1 in the city Nitra by using the method of thermal surface monitoring. Microclimatic conditions and climatic factors, air temperature [°C], relative air humidity [%], air flow [l.s^{-1}], surface temperature [°C], we observed in six localities – vegetated areas of Housing Estate Chrenova 1. Our measurments were realized during the standard atmospherical conditions (anticyclonal type of weather).

Keywords: vegetation, microclimate, urban environment

INTRODUCTION

Vegetation plays the significant role in the forming of microclimate and thermal comfort in urban environment.Surface temperature of vegetation influence the thermal balance through the blazing change (Scudo et. al., 2002). Different type of surface in urban environment have the different impact on vegetation. The outflow and sedimentation is changing depending on the type of material (Godefroid, Koedam, 2004). Tree vegetation uses 2 % of solar energy on photosynthesis, 60-80 % absorbs by leafs and 5-15 % reflects back to space. The rest of solar energy goes trough leaves. The certain amount of radiation is being used for warming up the particular parts of the tree. Trees with thin crowns can receive 60-80 % of solar radiation. Through the trees with compact crowns penetrates 2-3% of solar radiation (Reháčková, Pauditšová, 2006). Different thermal characteristic of active surfaces lead to raising of heat absorption in period of positive energy balance. Due to this modification the built-up areas can be warmer than surrounding land. According to Oke (1997) the specific thermal conditions are related to albedo and to the air pollution. Vegetation areas dont accumulate heat. After the opening of stomata and during the assimilation the temperature of stomata matches with the air temperature or drops down under this temperature (Slováková, Mistrík, 2007).

MATERIALS AND METHODS

In research areas of Housing estate Chrenova 1 we realized the inventory of species in spring session 2013 and 2014. We evaluated structure of vegetated area, foliation and species diversity, percentage, high of trees and canopy of crowns by using the method of Machovec (1987).

Structure of vegetated areas

Locality A1: Vegetation in the locality A1 is bilayer with 50 trees. Monitoring point is located in dense and relative closed canopy of 26 trees with continuity on the open lawn. The highest part has the type *Acer pseudoplatanus* – 16 % .

Locality A2: Vegetation in the locality A2 is three-layer with 33 trees, it is structured into 5 formations with central lawn. Vegetated area is opened to the inside of residential area. Monitoring point is located in sparse vegetation with 7 trees. The highest percentage has *Pinus sylvestris* – 38 %

Locality B1: Vegetation in the locality B1 is three - layer with 46 trees. Trees are organized into 3 small clusters on the left side. In the middle of the vegetated area is the lawn with solitaire tree.Monitoring point is located in vegetation with dense canopy of crowns with 9 trees. The highest percentage has *Tilia cordata* – 34,9 % .

Locality B2: The vegetation in the vegetated area B2 is three - layer, it is organized into 2 cluster with dense canopy of crowns. Number of trees in vegetated area is 11. Monitoring point is located in central lawn near the children's playground. The highest percentage has *Pseudotsuga menziesi* – 35,8 %.

Locality C1: Vegetation in the locality C1 is three-layer with 68 trees. Tree vegetation is organized into 5 clusters. The lawn is open near the river Nitra. Monitoring point is located in the cluster of 3 trees with sparse canopy of crowns. The highest percentage has *Juglas regia* – 42,8 %.

Locality C2: The vegetated area in locality C2 is typical bounded area by inside of residential area. In vegetation area are 22 trees organized into 5 clusters with sparse canopy of crowns. Monitoring point is located in central lawn. The highest percentage has *Taxus baccata, Pseudotsuga menziesii, Tilia cordata* – 25 %.

Measurments in research areas

The legwork ran in summer sessions June-August 2013 and 2014 in residential area Chrenova 1 in the city Nitra by using the method of thermal surface monitoring with instrument Anemometer TSI Veloci Calc. Microclimatic conditions and climatic factors, air temperature [°C], relative air humidity [%], air flow [l.s^{-1}], surface temperature [°C], we observed in six localities – vegetated areas of Housing Estate Chrenova 1. Our measurments were realized during the standard atmospherical conditions (selected days with anticyclonal type of weather) at 6:00 a.m. and 12:30 p.m.. Microclimatic factors were statisticaly evaluated in software Statistica 7 by using the Kruskal –Wallis analyse.

RESULTS

We compared differences in microclimatic factors between selected vegetated areas depending on vegetation structure in times 6:00 a.m. (one hour after sunrise in summer sessions 2013-2014), 12:30 p.m. (at noon in summer sessions 2013-2014) and overheating of surface in time of positive energy balance (in interval 6:00 a.m. – 12:30 p.m. in summer sessions 2013-2014).

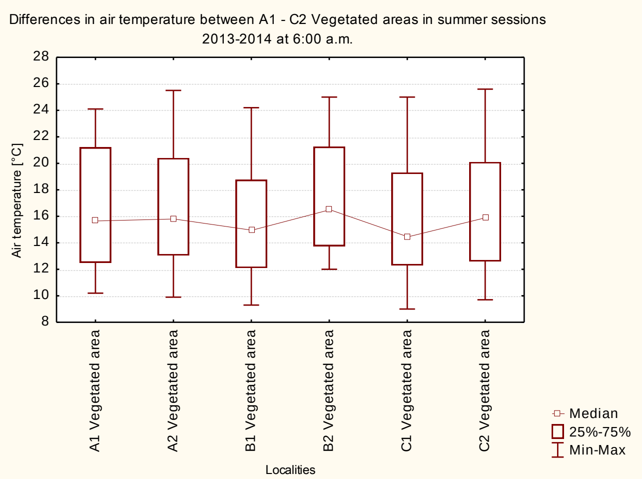

Fig. 1: Microclimatic factor air temperature in vegetated areas A1 – C2 in summer sessions 2013-2014

In the Fig. 1 we compared microclimatic factor air temperature at 6:00 a.m. (one hour after sunrise in summer sessions 2013-2014) between all selected vegetated areas with different vegetation structure. The lowest value of air temperture at 6:00 a.m. we noticed in Vegetated areas (B1, C1 – 15,9 [°C]). In these localites dominated leaf trees, in B1 Vegetated area - the highest percentage has *Tilia cordata* – 34,9 %, in C1 Vegetated area - The highest percentage has *Juglas regia* – 42,8 %. The highest value of air temperature at 6:00 a.m. was noticed in B2 Vegetated area (17,5 [°C]). In Vegetated area B2 is three –layer vegetation with 11 trees, it is minimum number of trees between all selected vegetated areas.

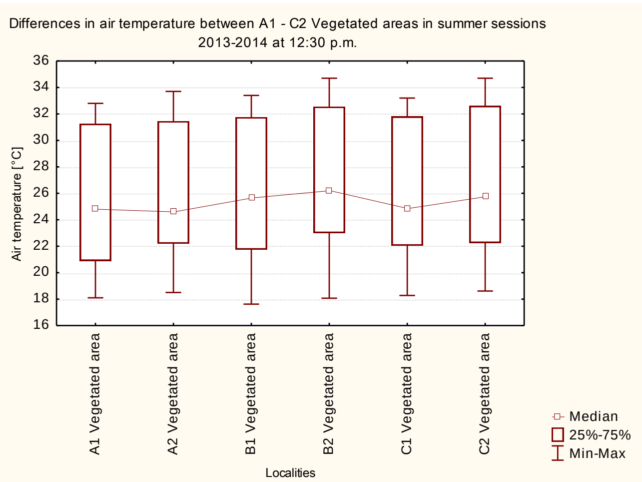

Fig. 2 : Microclimatic factor air temperature in vegetated areas A1-C2 in summer sessions 2013-2014

In the Fig.2 we compared microclimatic factor air temperature at 12:30 p.m (at noon in summer sessions 2013-2014) between all selected vegetated areas with different vegetation structure. Median values of air temperature were appropriately balanced in range 25,7 – 27,3 [°C]) for all research areas. Statistically significant diferences were not recorded.

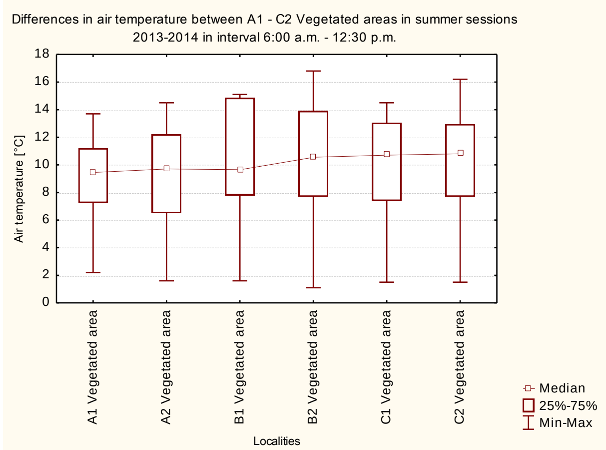

Fig. 3: Differences in air temperature between vegetated areas A1-C2 in interval 6:00-12:30 in summer sessions 2013-2014

In the Fig. 3 we evaluated microclimatic factor air temperature in interval 6:00 a.m. – 12:30 p.m. in time of positive energy balance for selected vegetated areas of housing estate Chrenova 1. In the research area A1 value of air temperature increased up to 9,2 [°C]). Vegetation in the locality A1 is bilayer with 50 trees. Monitoring point is located in dense and relative closed canopy of 26 trees with continuity on the open lawn. Trees vegetation in dense canopy has the function of thermal stabilizer, as a result is the lowest increase of air temperature in vegetation between selected vegetated areas.

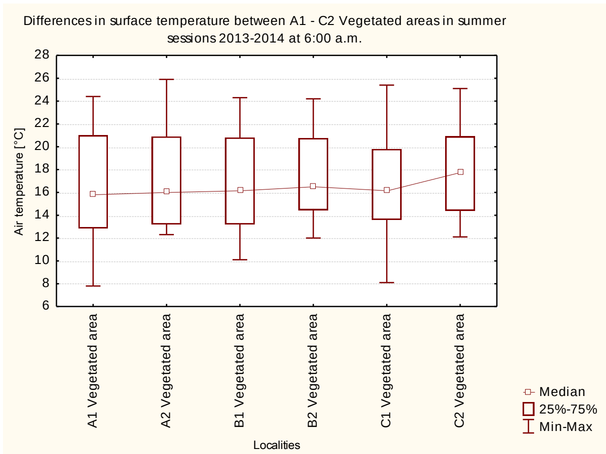

Fig. 4*:* Microclimatic factor surface temperature in vegetated areas A1-C2 in summer sessions 2013-2014

In the Fig. 4 we compared microclimatic factor surface temperature at 6:00 a.m. (one hour after sunrise) for selected vegetated areas depending on vegetation structure. The highest median values of surface temperature was noticed in vegetated area C2 with central lawn. This locality is typical bounded area by inside of residential area.

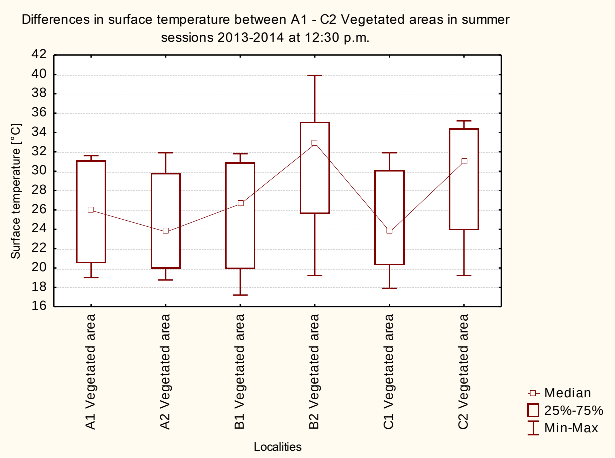

Fig. 5: Microclimatic factor surface temperature in vegetated areas A1-C2 in summer sessions 2013-2014

In the Fig. 5 we evaluated microclimatic factor surface temperature at 12:30 p.m. (at the noon) in time of positive energy balance, when the overheating of different type of surfaces is significant. The highest median value of surface temperature was in vegetated area B2 – 30.9 [°C], with dominance of open lawn, number of trees is 11. The highest percentage has *Pseudotsuga menziesi* – 35,8 %. The lowest median value of surface temperature was observed in vegetated area C1-24,8 [°C].

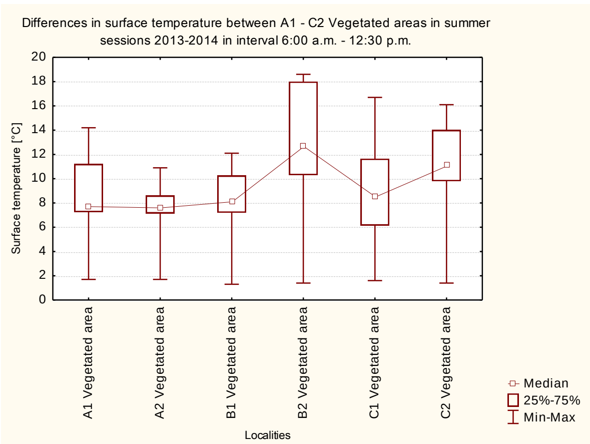

Fig. 6*:* Differences in surface temperature between vegetated areas A1-C2 in interval 6:00-12:30 in summer sessions 2013-2014

In the Fig. 6 we evaluated increasing of surface temperature depending on vegetation structure between selected vegetated areas A1-C2 in summer sessions 2013-2014. Statistically significant differences were recorded between vegetated areas A2-B2 (7,6-12,7 [°C], in p-level, p=0,01, p<0,05). Between localities B1-B2 was recorded statistically significant difference in p level (p=0,03, p<0,05). Number of trees in vegetated area B2 is 11. Monitoring point is located in central lawn near the children's playground. The capability to absorb solar radiation in time of positive energy balance is depending on the vegetation structure, the canopy of trees and quantity (Čaboun, 2008).Very important factor which influences overheating of surface is managment of vegetated areas in urban environment. Vegetated areas with the dominant lawn and uncovered clusters of soil can by overheat in time of positive energy balance equally as hard surfaces.

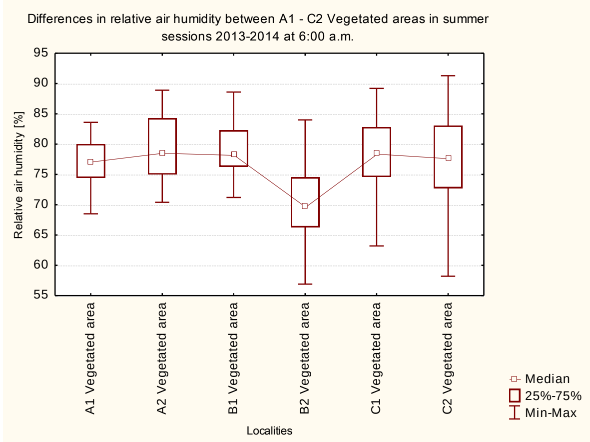

Fig. 7: Microclimatic factor relative air humidity at 6:00 a.m. in vegetated areas A1-C2 in summer sessions 2013-2014

In the Fig. 7 we compared microclimatic factor relative air humidity at 6:00 a.m. between selected vegetated areas A1-C2. The changes of relative air humidity are related to the air temperature. According to (Tužinský, 2002) is higher relative air humidity in the part of trunk – the morning type of humidity. Statisticaly significant differences in factor relative air humidity were recorded between vegetated areas A2-B2 (79,4 % - 69,9 %, p=0,009, p<0,01), B1-B2 (78,9 – 69,9 %, p=0,01), B2-C1 (69,9 – 78,2 %, p=0,02, p<0,05), B2-C2 (69,9 – 77,8 %, p=0,04, p<0,05). On process of transpiration has significant impact air temperature, characters of growth and temperature in growth, LAI index, radiation balance and air humidity. Characters of growth are represented with number of trees, species diversity (coniferous or foliose trees), age of growth and canopy (Škvarenina et.al, 2013). The lowest median values of relative air humidity at 6:00 a.m. was recorded in vegetated area B2 with dominance of *Pseudotsuga menziesi* – 35,8 %.

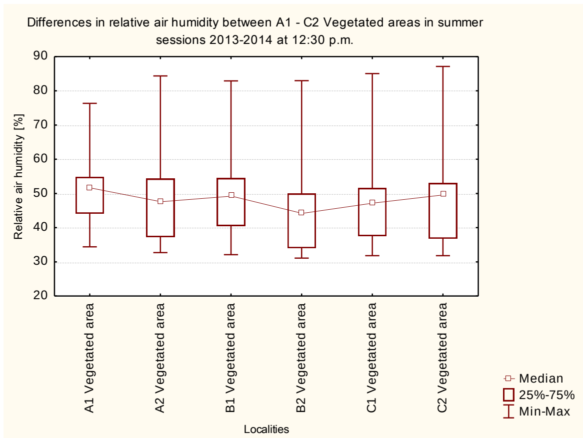

Fig. 8: Microclimatic factor relative air humidty in vegetated areas A1-C2 in summer sessions 2013-2014

On microclimatic factor of relative air humidity in vegetated areas has the significant impact canopy of crown, number of trees and species diversity. Thermal balance is influenced by the level of transparency of vegetation - density of crown, size of leaves and their orientation (Reháčková, Pauditšová, 2006). In the Fig. 8 we compared median values of relative air humidity at 12:30 p.m. in summer sessions 2013-2014. The highest value of relative air humidity was in vegetated area A1 with 50 trees in dense canopy, the lowest value of relative air humidity was in vegetated area B2 with dominance of open lawn with minimum of trees vegetation between selected research area.

CONCLUSION

The aim of this study was to evaluate impact of vegetation structure on microclimatic conditions in urban environment of Nitra. Research areas were selected in Housing estate Chrenova 1. In vegetated areas A1-A2-B1-B2-C1-C2 we realized measurments by using method of thermal surface monitoring with instrument Anemometer TSI Veloci Calc. We observed microclimatic factors air temperature, surface temperature and relative air humidity in time of positive energy balance (at 6:00 a.m. – one hour after sunrise, at 12:30 p.m. – at the noon). For evaluating of microclimatic factors was used software Statistica 7 – Kruskal-Wallis analyse. We compared microclimatic condition depending on vegetation structure between selected vegetated areas. Statistically significant differences were recorded in microclimatic factor surface temperature in interval 6:00 a.m. -12:30 p.m. between vegetated areas A2-B2 (7,6-12,7 [°C] in p-level, $p=0,01$, $p<0,05$) and between localities B1-B2 in p level ($p=0,03$, $p<0,05$). These results indicate, that vegetated areas with the dominant lawn and uncovered clusters of soil can by overheat in time of positive energy balance equally as hard surfaces. According to Wardoyo (2011) is urban environment specific to hard surface, typical urban geometry, vegetated areas and variability of surface materials. For every active surface is typical that there is a transformation of the energy of the shortwave radiation to the thermal energy. Accumulation of solar radiation and reflected radiation are forming microclimate. In urban environment is large concentration of surfaces which are strongly overheated and have large thermal capacity. Vegetation areas in urban environment have the capability to eliminate extreme demostrations of local climate. In time of marked climate changes, that influence quality of live in urban environment, is important dedicated to effectively management of vegetated areas. Functional planting and proposals are the tool for eliminate of negative impact of increasing temperature and extremes of weather in urban environment. Significant capability of vegetation for thermal comfort of residents is to keep relative air humidity by transpiration. Relation between air temperature, relative air humidity and velocity of air have the impact on wind chill factor. On process of transpiration has significant impact air temperature, characters of growth and temperature in growth, LAI index, radiation balance and air humidity). In certain conditions plants are on direct sun overheating too, but this is just short-term overheating. In selection of woody species with positive adaptation on climate change is applicable to planting of foliose trees, invasive species are unsuitable, because higher air temperature has the impact on their spreading (Záborská a kol., 2014 in Hegei, Šteiner, 2014).

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