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Microclimatic conditions of Housing estate Chrenova 1 in Nitra city

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Abstract

Observation of microclimate in urban environment is nowadays current topic which links up several fields of science. Measurements, analysis and proposals are the tools for effective solutions of negative impact of climate changes. The aim of this study was to evaluate the interaction between vegetation structure and microclimatic conditions of Housing estate Chrenová 1 in Nitra city. Housing complexes A, B, C are part of the first construction on Chrenová 1. There are housing complexes with meander structure and 4 floors. This layout allowed the allocation of block areas with vegetation area near the building (Jarabica, 2011). The legwork was accomplished during the spring season, in months (April, May). Vegetation areas in urban environment pursue several functions. Significant impact on the wind direction has vegetation with structure and type of canopy. Vegetation areas in urban environment work as a thermal stabilizer. Crowns of trees in dense canopy keep the air temperature in the spring period. Significant microclimatic function of vegetation is to provide partially obscuration.

Key words: vegetation area, hard surface, measurment, function

Introduction

According to Wardoyo (2011); (Wardoyo, 2011) is urban environment specific to hard surface, typical urban geometry, vegetation areas and variability of surface materials. These factors form and influence microclimate. For every active surface is typical, that there is a transformation of the energy of the short wave radiation to the thermal energy. The part of this energy goes to sub base of active surface and vice versa. The active surface is the main climatic factor (Středová, et. al., 2011). Vegetation plays the significant role in the forming of microclimate and thermal comfort. Surface temperature of vegetation influence the thermal balance through the blazing change (Scudo et. al., 2002). 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 (Pauditšová, Reháčková 2006). 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). According to Small and Miller (2010); (Small, Miller, 2010) vegetation influences the city conditions of the environment. Vegetation areas have the impact on energetic demand and on formation of thermal heats Island. In certain conditions plants are on direct sun overheating too, but this is just short-term overheating, Leaves close the stomata to prevent excessive evaporation which cause seven more overheating of leaves. It is important to mention that overheated dry soil, asphalt, concrete, walls of the buildings, tin roofs, or body shells of cars radiate the heat even though sun is not shining (Čaboun, 2008).Vegetation decreases UHI effect, the air temperature on areas with vegetation can be lower by 2,5°C (comparing to maximum temperature in the city) (Gomez, Gaja&Reig, 1998). Vegetation improves environmental variables such as solar radiation, surface temperature, air temperature, relative air humidity, velocity of air. These variables are important for thermal comfort (Akbari, Pomerantz&Taha, 2001). Mode of surface temperatures in urban and suburban land can be defined with surface thermal monitoring.

The aim of this study was to evaluate the interaction between vegetation structure and microclimatic conditions of Housing estate Chrenová 1 in Nitra city.

Materials and methods

In Housing estate Chrenová 1 have been selected research areas A1, A2, B1, B2, C1, C2 (Fig. 1), depending on vegetation structure.

We accomplished the analysis of characteristic of selected model of vegetation according to Rózová, Mikulová (2011), (Rózová, Mikulová, 2011).

Fig. 1: Research areas A1, A2, B1, B2, C1, C2 in Housing estate Chrenova 1

Foliation

Three-foliation – trees-shrubs-herbs

Bilayer-foliation – trees-shrubs, trees-herbs, shrubs-herbs

Single-foliation – trees, shrubs, herbs

***Species diversity* -** the number of species in the area

Involvement - overlapping of vegetation parts

We accomplished analysis of relations with surrounding (Rózová, Mikulová, 2011). It is relations on surrounding, connection of vegetation in site and in surrounding landscape.

Measurements on research areas were implemented during the spring season (in months April, May) in the noon (12:30). Using the method of surface thermal monitoring – with Anemometer TSI VelociCalc and Surface temperature Probe, following microclimatic factors were observed : air flow, air temperature, relative air humidity and surface temperature in two type of active surface – vegetation area and hard surface. In three second's interval for measurement points were accomplished 20 samples.

Places of measuring:

1. In vegetation area
2. On hard surface

Measurement points were chosen on the basis of assumed differences of measured values depending on type of surface.

Vegetation area- in summer time vegetation carries function of heat stabilizer. Vegetation areas also do not accumulate heat and during assimilation their temperature equalizes with air-temperature, or more precisely decreases under this temperature. As a result is reduction of maximum of day temperature in vegetation comparing to surrounding landscape.

Hard surface – (road communication separating vegetation area from the housing area). Overheating of asphalt area and radiate heat exchange plays significant role in summer times. During the day, hard surface absorbs much more of thermal energy as plants (for example asphalt absorbs 75-90% of solar radiation).

Statistically evaluation

Measurement of microclimatic factors we evaluated by using the softwer Statistica 7. For comparing of microclimatic factors depending on specific areas we used the Tukey HSD test. Microclimatic factor of surface temperature between two type of active surface we evaluated using by Mann- Whitney test.

Results

Analysis of vegetation structure on research 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. Vegetation 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 vegetation 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 vegetation area B2 is three-layer, it is organized into 2 cluster with dense canopy of crowns. Number of trees in vegetation 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 vegetation 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%.

Results of measurements in research areas

We compared all microclimatic factors (air flow [l/s], air temperature [°C], relative air humidity [%], surface temperature [°C]) of vegetation areas depending on vegetation structure by using the softwer Statistica 7.

In the (Fig. 2) we compared the microclimatic factor of air flow [l/s] for all vegetation areas of localities A1, A2, B1, B2, C1, C2. The lowest value of median of factor air flow we recorded in the vegetation area A2 (4.05l/s). Vegetation in this locality is structured into 5 formations with central lawn. This vegetation area is opened to the inside of residential area. Intensity of air flow influences urban geometry, density and type of buildings change the wind direction and in this case have an effect on barriers in urban environment. The highest value of median of air flow we recorded in the vegetation area B2 (5.56 l/s). Vegetation in this locality is organized into 2 cluster with dense canopy of crowns. This vegetation area has the heterogeneous organisation, number of trees is 11. Monitoring point is located in central lawn. In this vegetation area, we dont recorded an effect on barriers of build-up areas or trees vegetation, as a result is the big range between minimum and maximum of measurment values of air flow.

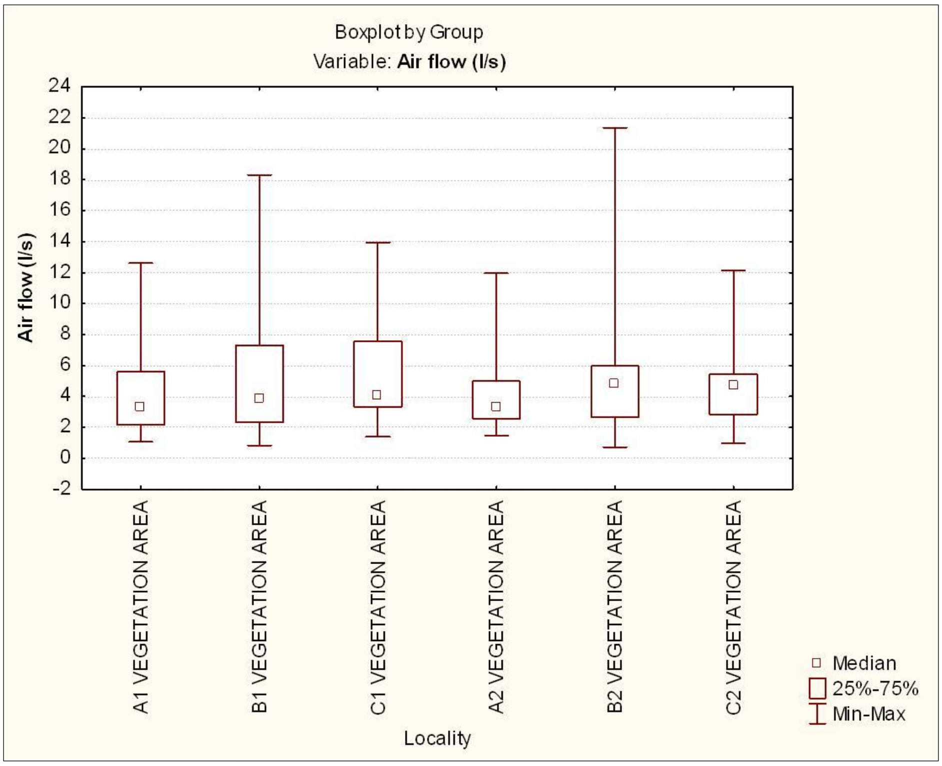

Fig. 2: Comparing of microclimatic factor of air flow depending on vegetation area

In the (Fig. 3) we compared the microclimatic factor of air temperature (°C) for all vegetation areas of localities A1, A2, B1, B2, C1, C2. The lowest value of median of air temperature we recorded in the vegetation area A2 (18.9°C). Monitoring point is located in the sparse canopy of 7 trees. In the vegetation area A1 we recorded the highest value of median of air temperature during the spring period (20.06°C). Monitoring point is located in dense and relative closed canopy of 26 trees with continuity on the open lawn. Closed canopy of vegetation in this area is the factor, which influences the values of air temperature. Crowns of trees in dense canopy keep the air temperature in the spring period.

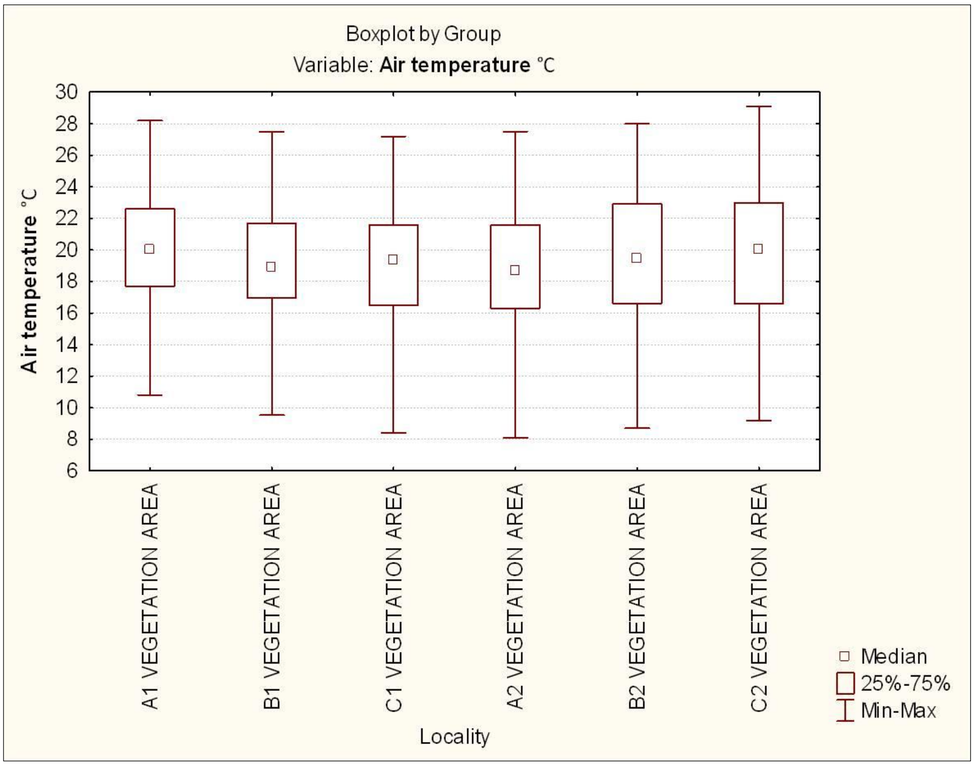

Fig.3: Comparing of factor of air temperature depending on vegetation area

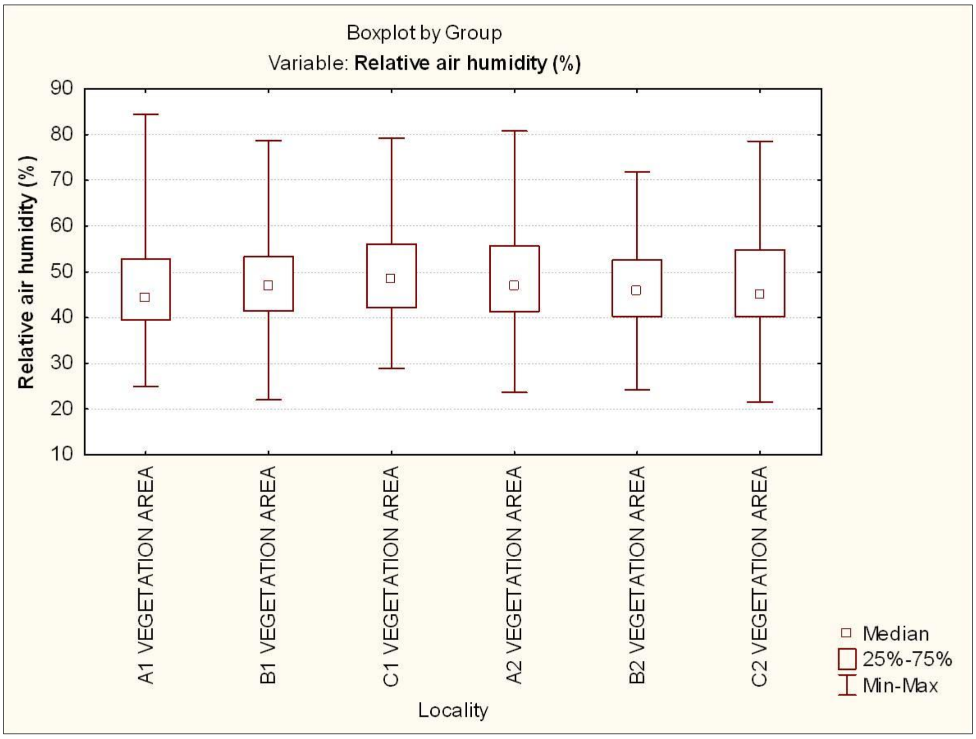

Fig. 4: Comparing of factor of relative air humidity depending on vegetation area

In the (Fig. 4) we recorded the highest value of median of relative air humidity in the vegetation area C1 (49.57 %). Vegetation in the locality C1 is three-layer with 68 trees. According to Čaboun, (2008), (Čaboun, 2008) vegetation increases the relative air humidity on average 18%. Monitoring point is located in the cluster of 3 trees with sparse canopy of crowns, which continue on open lawn. The significant role in factor of relative air humidity plays too vicinity of river Nitra. 50% of values of relative air humidity were in range – minimum-maximum (28-79%) during the spring season.

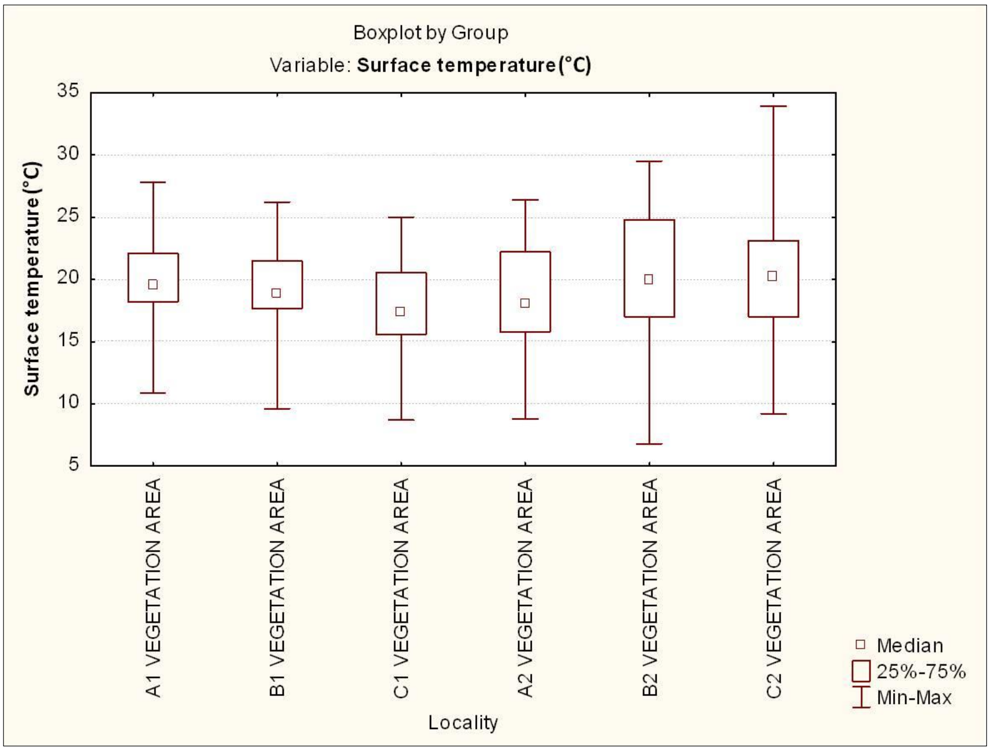

Fig. 5: Comparing of factor of surface temperature depending on vegetation area

In the (Fig. 5) we compared the values of median of surface temperature for all vegetation areas depending on vegetation structure. Geometry of active surfaces and its structure in urban environment influences intensity of falling on and reflecting solar radiation. The highest value of median of surface temperature we recorded in the vegetation area C2 (19.98°C). Here is monitoring point located in central lawn with sparse cover without trees. The lowest value of median of surface temperature we registered in vegetation area C1 (17.74 °C). In this vegetation area was the highest value of relative air humidity between localities. Between measuring microclimatic factors of relative air humidity and surface temperature we recorded the negative corelation (Fig. 6) during the spring season (R= -0.105772, in p level=0.042013).

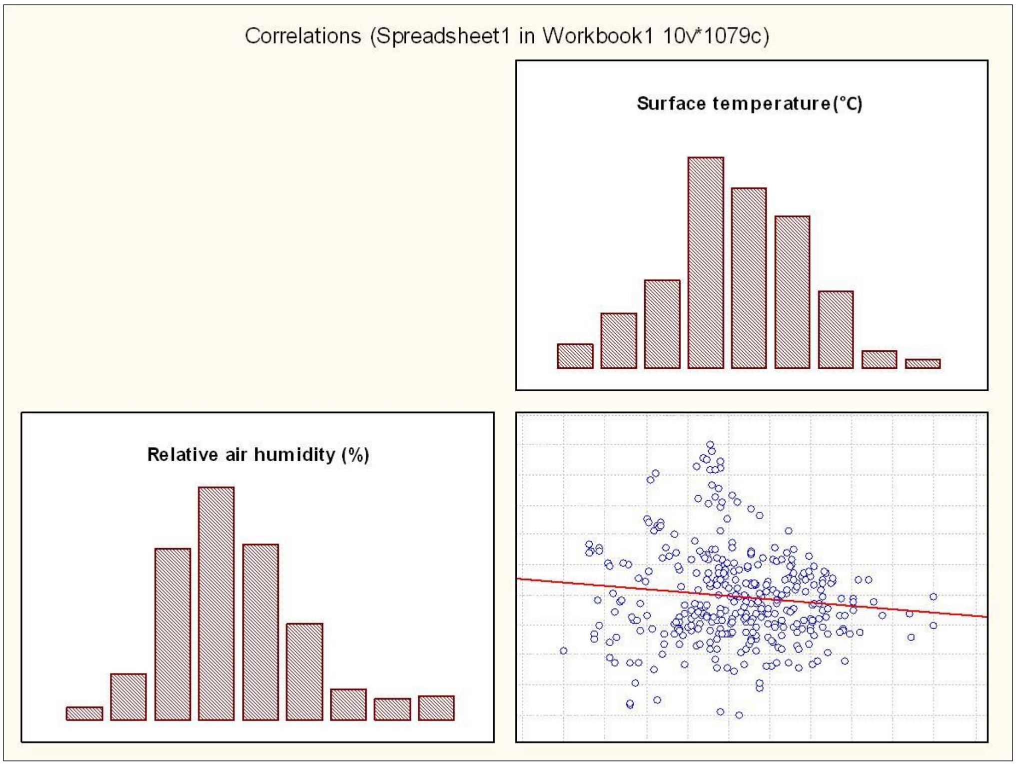

Fig. 6 : Negative correlations between microclimatic factors – surface temperature and relative air humidity in research areas during the spring period

Vegetation carries the function of thermal heat stabilizer. Active surfaces limit the area with direct light from source of radiation. This effect we recorded in the (Fig. 7) in microclimatic factor of surface temperature between measuring points vegetation area and hard surface in locality A1. Trees in dense canopy provide partial shading on hard surface in time of positive energy balance (12:30). As a result is minimal difference in factor of surface temperature between hard surface and vegetation area.

The highest statistically significant difference in microclimatic factor of surface temperature between active surfaces – hard surface and vegetation area we recorded in the locality B2 (Mann-Whitney test, p=0.000932, p<0,001) (Fig. 8). Value of median of surface temperature in measuring point hard surface during spring season was (24.82°C). In measuring point vegetation area was the median of value of surface temperature (19.91°C). In vegetation area B2 is monitoring point located in central lawn. Variance of surface temperature between two types of active surfaces – lawn and asphalt presented (4,91°C).

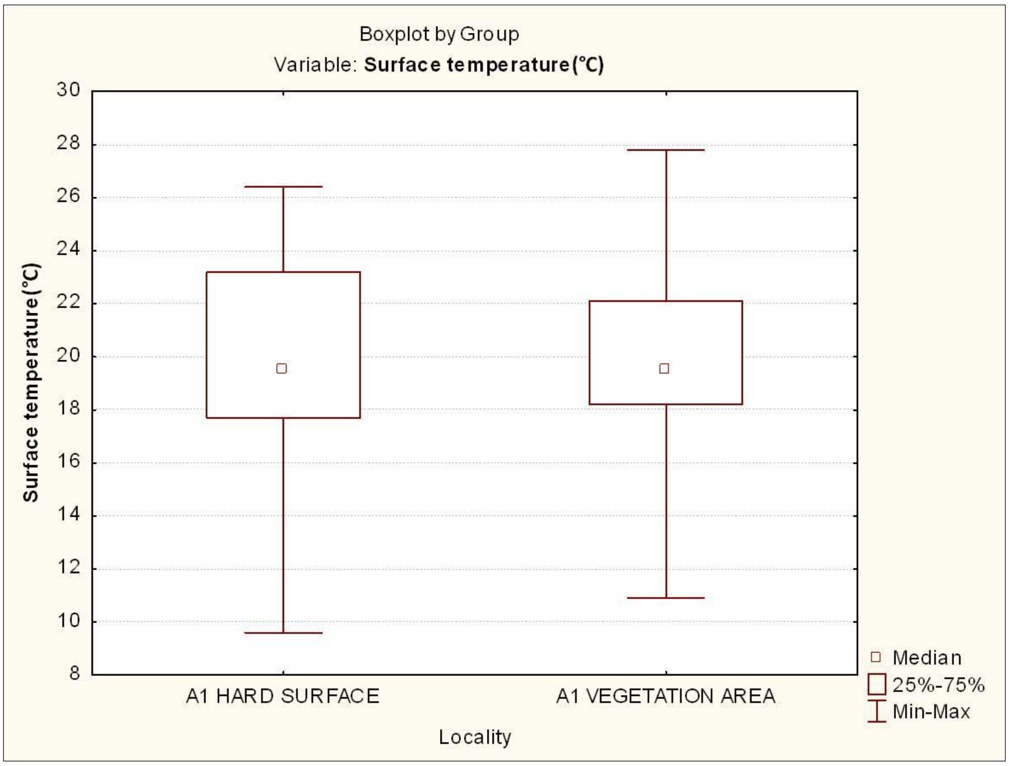

Fig. 7: Minimal difference in the surface temperature between two measuring points – hard surface and vegetation area in the locality A1

Discussion

In this study we dedicated evaluation of the interaction between vegetation structure and microclimatic conditions of Housing estate Chrenova 1 in Nitra. The legwork was accomplished during the spring season, in months (April, May) after the beginning of phenology phase. Measurements by method of surface thermal monitoring were accomplished in two types of active surfaces – vegetation area and hard surface. According to Voogt, Oke, (2003), (Voogt, Oke, 2013) during the day, hard surface absorbs much more of thermal energy as plants. On the other side vegetation areas do not accumulate heat and during assimilation their temperature equalizes with air-temperature. According to Wardoyo, (2011), (Wardoyo, 2011) intensity of air flow influences urban geometry; density and type of buildings change the wind direction and have an effect on barriers in urban environment (Fig. 2). Significant impact on the wind direction has vegetation with structure and type of canopy. The big range between minimum and maximum value in factor of air flow was recorded in locality B2. Vegetation in this area has heterogeneous structure, trees in sparse canopy have not the windbreak function. Vegetation areas in urban environment work as a thermal stabilizer. In the vegetation area A1 crowns of trees in dense canopy keep the air temperature in the spring period. This function influences the highest value of median of air temperature. According to Čaboun, (2008), (Čaboun, 2008) vegetation increases the relative air humidity on average 18%. The highest value of median of relative air humidity was recorded in the vegetation area C1. Structure of vegetation area and vicinity of river Nitra influence the microclimatic factor of relative air humidity. Significant microclimatic function of vegetation is to provide partially obscuration. This effect was recorded in the (Fig. 7), where the value of median of surface temperature between measuring points vegetation area and hard surface in locality A1 was the lowest. These points represent the different type of active surface in urban environment.

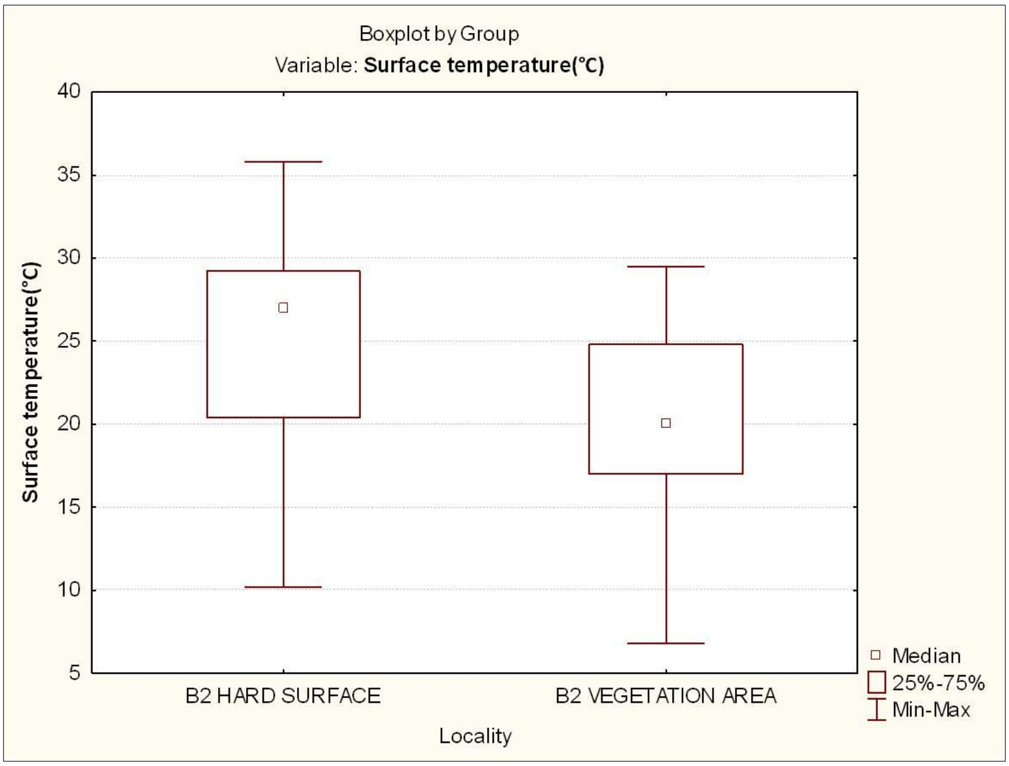

Fig. 8: The highest statisticaly difference in factor of surface temperature between two measuring points- hard surface and vegetation area in the locality B2

Conclusion

The increasing of variability of active surfaces in the cities is very typical nowadays. It leads to rising of air temperature and surface temperature in urban zones. The extreme conditions of weather are more often. Superheat of hard surfaces in time of positive energy balance lead to change of atmosphere and to change of temperature conditions. The tool for regulation of negative changes is the vegetation care and effective new planting. Up-to-date urban proposals and solutions should be based on functionality of vegetation areas and their positive impact on urban climate. Research in this field of science confirms that vegetation areas in urban environment are effective tool of how to eliminate negative impact of urban climate.

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Summary

Cílem naší studie bylo vyhodnotit vztah mezi strukturou vegetačních ploch a mikroklimatickými podmínkami na sídlišti Chrenová 1 v Nitře. Terenní průskum proběhl v jarní sezoně v letech 2013-2014 na vybraných lokalitách A1, A2, B1, B2, C1, C2 metodou pozemního termálního monitoringu. Sledovali jsme vybrané mikroklimatické faktory – proudění vzduchu [l/s], teplotu vzduchu [°C], relativní vlhkost vzduchu [%], teplotu povrchu [°C] ve dvou typech aktivního povrchu. Jednotlivé měření jsme vyhodnotili v softwaru Statistica 7, pro porovnání mikroklimatických faktorů v závislosti od lokality jsme použili Tukey HSD test. Zjistili jsme, že funkční vegetační plochy svojí strukturou pozitivně ovlivňují mikroklimatické

podmínky v urbanizovaném prostředí. Vegetační plochy působí jako tepelný stabilizátor. Kompaktní plochy vegetace zmírňují vzdušné proudění a plní funkci větrolamu na rozdíl od ploch s heterogenní strukturou. Vegetace v hustém uzavřeném zápoji udržuje teplotu vzduchu v porostu a zvyšuje relativní vlhkost vzduchu. Tyto plochy zajišťují stín a tím regulují teplotní rozdíly v různých typech aktivních povrchů (vegetační plocha – zpevněná plocha). V urbanizovaném prostředí je právě funkční vegetace jedním z nástrojů na eliminaci negativních dopadů změny klimatu. Už plochy relativně malých rozměrů v jednotlivých městských čtvrtích ovlivňují mikroklimatické podmínky a tím kvalitu života ve městech.

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