Bio-thermal conditions of some housing estates in Warsaw

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Abstract. The majority of Polish population lives in urbanized areas. Polish cities are under great pressure of planning new residential districts. Developers, architects and landscape architects propose not only new technical solutions but also a new philosophy of organization of space. The modern cities should be friendlier and less stressed for citizens. Residential areas should also create optimal conditions for daily outdoor recreation for elderly people and children. The aim of the present paper is to discuss how some architectural solutions used in selected housing estates in Warsaw modify bio-thermal conditions in micro scale.

Introduction

Warsaw is a city with an area of about 500 km^2 and with significant differentiation of land use. About 243 km^2 is a built-up area (28% no-dense and 22% dense settlements). Forests cover about 13% of city and 85 km^2 is used as meadows and fields. Relatively great area (about 60 km^2, i.e. 12%) is covered by transport system (roads and railways). When analysing thermal LANDSAT image we have found coefficients reducing air temperature (*TR*) for various types of land use in Warsaw. They changed from 0.85 for water bodies up to 1.2 in dense settlements and industrial areas (Blazejczyk and Blazejczyk 1999). Spatial distribution of relative values of air temperature, derived from LANDSAT image, is presented on figure 1.

Polish cities are under great pressure of planning new residential districts. Developers, architects and landscape architects propose not only new technical solutions but also a new philosophy of organization of space. The general idea is to make cities friendlier and less stressed. Residential areas should also create optimal microclimatic and bio-thermal conditions for daily outdoor recreation for elderly people and children. Very important is rational use of existing components of environment (e.g. relief, natural vegetation, hydrology, city surroundings). In micro scale the attention should be paid for building size and orientation, the structure of trees and green carpets as well as small forms of architecture (Błażejczyk and Kunert 2006).

The previous research of Błażejczyk (2011) shows general spatial overview of Universal Thermal Climate Index (*UTCI*) in Warsaw. At air temperature of about 20ºC moderate heat stress (*UTCI* of 26-32ºC) can be found only inside industrial and very dense settled areas. However, during sunny, hot, humid and calm weather several hot spells with extreme heat stress are found, especially in the city centre. In housing estates located at peripheral parts of the city bio-thermal conditions are relatively mild.

The aim of the present paper is to discuss how some architectural solutions used in selected housing estates in Warsaw modify bio-thermal conditions in micro scale. For the present paper two housing estates: Kamińskiego and Włodarzewska are chosen (Fig. 1).

Methods and materials

The materials used in the studies consist of two data sets: micro meteorological and environmental. Micro meteorological measurements have two time perspectives. The first one was long-term meteorological observations. In this purpose in each studied estates the HOBO Pro data loggers were installed in site representated spatial organization of estate (so called base data). Air temperature and humidity were collected every 10-minutes 1.5 m above grass surface.

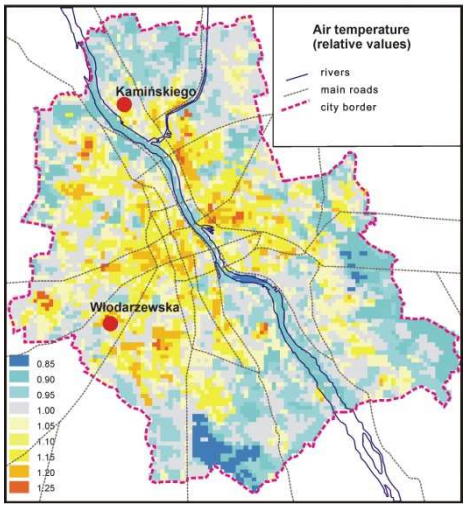

Fig. 1. Distribution of relative values of air temperature in Warsaw; studied housing estates indicated by red circles Source: Kozłowska-Szczęsna et al., 1996

To recognize spatial distribution of bio-thermal conditions special route measurements inside the quarters were made on chosen days in summer 2009. Measurements were carried with HOBO loggers in 6-12 posts over different surfaces and in different urban structures in each estate. The observers measured also wind speed and they noted their thermal sensation and cloud cover.

As environmental indicators we have used detailed inventory data regarded vegetation (type, height), buildings heights and orientation as well as surface cover. Created data base has been used for statistical calculations and spatial analyses relevant for ratio of biologically vital areas (RBVA) and green plot ratio (GPR) for each housing estate. RBVA is the index comprises the area of lawns, flowerbeds, hedgerows, tops of the trees as well as ground surfaces. However, GPR is based on leaf area index (LAI), which is defined as the single-side leaf area per unit ground area.

Results and discussion

Kamińskiego estate is located on NE suburbs of Warsaw next to the open, green area. The C-shaped, mostly 4-floors blocks which form some kind of courtyards of different seizes (Fig. 2). The RBVA is 44.5% and GPR is very high (2.25). In general, thermal and bio-thermal conditions are relatively mild in comparison to the city center. *UTCI* is considerably higher than on forested and open areas in the close surroundings (Fig. 3). The housing estate' structure, the mosaic of different kind of surfaces evenly distributed cause that location of the warmest or the coldest places depend mainly on insolation. The north part of the estate is under the influence of both: the outside open green and high leafy trees which are grouped here. It chills down easily in the evening and stays cool in the morning and warm up fast in the afternoon (Fig. 3, measure posts 8-11). In the south part of the estate little warmer than others is the lawn of south exposure (post 6). Despite of low RBVA the estate is characterized by high participation of leafy species and quite favorable sensible climate.

Fig. 2. Schematic map of Kamińskiego housing estate in Warsaw

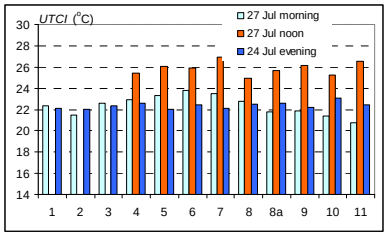

Fig. 3. Values of Universal Thermal Climate Index (UTCI) at measuring posts at Kamińskiego estate in Warsaw, July 2009

Włodarzewska estate is located SW from the city centre. It is surrounded by many open spaces and park. It is characterized by compact development, many small flowerbeds and lawns, partly settled on the top of the underground parking. RBVA is 40.7% and GPR is 1.28 only (Fig. 4). In spite of location of Włodarzewska estate at western peripheries of Warsaw the distance from the city center is relatively small. It cause that *UTCI* are higher than at Kamińskiego estate.

In dense built area there is no evidence for the cooling effect of small green areas, especially during midday hours. Even more, the air above the small flowerbed adjacent to the building could be hotter (measure post 6) then above the concrete square (posts 5, 6a). There is also no evidence for the cooling effect of neighboring park. The south-east part of estate is under the influence of the fertile lawn and residuals of meadow, which is exposed to the sun and getting warm quickly during the day and getting cold rapidly in the evening. This produce stressful bio-thermal conditions because of great heat load in the day and cold stress in the evenings (Fig. 5).

Fig. 4. Schematic map of Włodarzewska housing estate in Warsaw

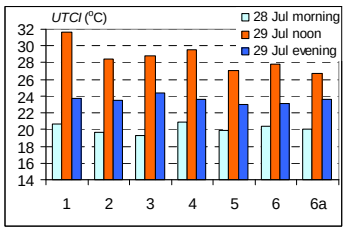

Fig. 5. Values of Universal Thermal Climate Index (UTCI) at measuring posts at Włodarzewska estate in Warsaw, July 2009

Conclusions

When comparing two studied estates we can conclude that: - the array of buildings enabled the advection of air from outside and in effect improve sensible climate; - important is the proper maintenance of green areas: abandoned, dried lawns or only recumbent coniferous plants do not positively meliorate climate and bioclimate; - small flowerbeds adjacent to the buildings do not play any positive role for bio-thermal conditions; - when fencing the estates people should prefer rather openwork, metallic fencing than high brick walls which unable infiltration of air from outside.

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