Pol. J. Environ. Stud. Vol. 21, No. 2 (2012), 235-239

Special Issue

Air Temperature Increase and Quality of Life in an Anthropogenically Transformed Environment: A Case Study

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Received: 14 June 2011
Accepted: 12 October 2011

Abstract

This paper to assesses the impact of air temperature increase connected with the degree of anthropogenic transformation of an area on the subjectively perceived quality of life. The area under study is the Metropolitan Association of Upper Silesia (Górnośląski Związek Metropolitalny – GZM).

We analyzed the average monthly temperatures in different seasons and the human impact ratio of the area. The ratio was determined based on population density, road network density, the amount of waste produced and the number and size of buildings in the analyzed area.

The result is a methodology that involves anthropogenic and non-anthropogenic factors to assess the impact of weather conditions on the quality of life in the analyzed area. The average temperatures in GZM have a similar spatial distribution pattern regardless of the season. The highest temperatures are recorded in the central part of GZM. The spatial fluctuations of the human impact factor are large in the area studied, with values varying from 2.5 to 10.1. These values points to the risk of exposure to harmful factors and a lower quality of life perception. As evidenced by the human impact factor calculated, these are the districts where human influence on the environment is the most noticeable. After analysis of temperature distribution the similarities in the distribution patterns of both factors are evident Therefore, temperature should also be taken into account when identifying sites particularly harmful to human health.

Keywords: air temperature, quality of life, anthropogenization index, human impact

Introduction

Location and Area of Study

The Metropolitan Association of Upper Silesia (GZM) is located in the central part of Śląskie Voivodship. The 14 cities, functioning at the same time as districts that form the association, cover an area of 1,218 km^2 (Fig. 1). These districts are economically and socially connected and are linked by the transport infrastructure.

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While analyzing this area, the diversity of spatial organization, which is an important factor affecting the quality of life, should be taken into account. The current GZM landscape is the result of settlement, transport, and industrial processes that have occurred for centuries. Several urban forms can be identified in the area studied: suburban residential areas, highly urbanized areas, industrial areas, and wastelands. The suburbs, with detached housing in partly agricultural areas and attraction in terms of living conditions, are generally perceived positively. The city centers, which have a high population density, serve as residential and service areas, but they are often also industrial centers.

The landscapes that affect the environment the most, due to the high concentration of industrial facilities, are industrial sites and post-industrial wastelands. Despite many successful attempts and despite the visible systematic transformation of the urban space of the GZM cities, it is impossible to remedy a number of factors, such as industry, population and building density, even in the long term. These affect the urban heat island due to the various interactions between human and environmental factors, and caused by the distortion in the energy balance in the constructed areas resulting from the thermal behavior of the materials used in the buildings [1]. The urban heat island can determine the climatic comfort of the urban populations, affecting their health, their labor, and their leisure activities; there are also economic effects, for example the additional cost of climate control within the buildings, and environmental effects [2].

All these factors will continue to negatively affect the quality of life of the area residents.

Human Impact in the Study Area

The specificity of this area's development consists of the accumulation of natural resources, which are mainly zinc and lead ores and coal. For at least 200 years, the mining of these resources has entailed intensive industrial development which, in turn, has enhanced the urbanization process. For many years, the area was highly exploited, densely populated and chaotically developed. At the same time, it was neglected in terms of quality of life as perceived by its residents.

Mineral resources are an important factor in the location of iron and coke industries, energy production and other energy-intensive industries. For most of its existence, the GZM area has been used for production purposes, with the dominance of heavy industry. Heavy industry is located in all GZM cities. The percentage of the population employed in these industries – from 36% in Katowice to 57% in Dąbrowa Górnicza, Jaworzno, Mysłowice, Piekary Śląskie, Ruda Śląska, and Zabrze – shows its importance for the residents of the area. These numbers not only reveal an enormous demand for labor, they also demonstrate the monofunctionality of cities and their impact on the environment. After system transformation in the early 1990s, the structure of employment changed significantly. The number of people working in the industries decreased: in 1988, it was 63.2% of total workforce, and in 2006 it was only 41.1%. These reductions changed the function and character of the cities. The process of improving the quality of life is on-going, but its pace differs between cities.

Another important factor affecting the quality of life in the GZM area is the density of the road network. GZM is located at the crossroads of major communication and

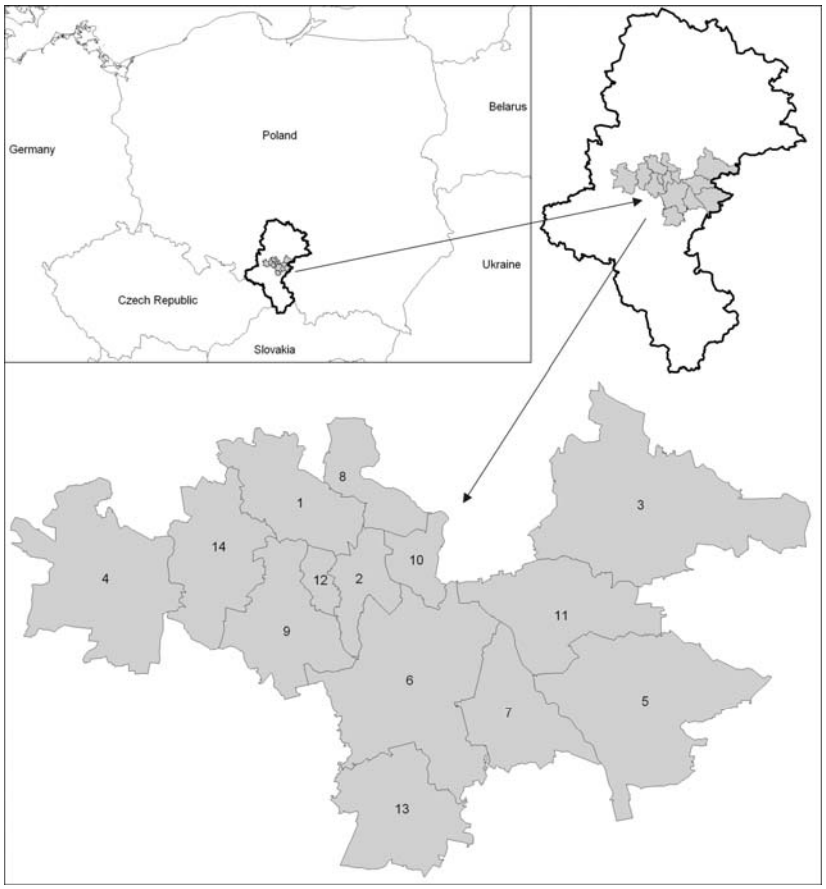

Fig. 1. The Metropolitan Association of Upper Silesia: 1 – Bytom, 2 – Chorzów, 3 – Dąbrowa Górnicza, 4 – Gliwice, 5 – Jaworzno, 6 – Katowice, 7 – Mysłowice, 8 – Piekary Śląskie, 9 – Ruda Śląska, 10 – Siemianowice Śląskie, 11 – Sosnowiec, 12 – Świętochłowice, 13 – Tychy, and 14 – Zabrze.

Table 1. Population density, the amount of waste generated and transportation network density in GZM cities with district rights compared with respective data for Śląskie Voivodship.

District ID	District	Population density persons per km^{-2}	The amount of waste generated Mg·km^{-2}	Transportation network density km 100 km^{-2}
1	Bytom	2678	5,923.2	290
2	Chorzów	3445	13,469.7	402
3	Dąbrowa Górnicza	681	12,077.8	194
4	Gliwice	1473	10,273.1	277
5	Jaworzno	624	12,647.7	175
6	Katowice	1892	22,014.5	328
7	Mysłowice	1135	5,563.6	230
8	Piekary Śląskie	1477	11,267.5	334
9	Ruda Śląska	1854	28,189.7	317
10	Siemianowice Śląskie	2865	456.0	366
11	Sosnowiec	2446	1,344.0	360
12	Świętochłowice	4194	1,015.4	578
13	Tychy	1583	3,215.9	327
14	Zabrze	2363	10,216.3	357
15	Śląskie Voivodship	370	2,862.0	164

transport routes, which are also a consequence of industry developing in this area over many years [13]. According to the Polish Central Statistical Office, the city of Świętochłowice has the most developed transportation network: nearly 600 km·100 km^{-2} (Table 1). For comparison, the density of the road network in Poland is 79 km·100 km^{-2}, and in the Śląskie Voivodship it is 164 km·100 km^{-2}.

High industrial concentration, dense transportation networks, and high population density directly affect the quality of life.

Thermal Conditions Affecting the Quality of Life

The climate and weather conditions of the area under consideration are important because, although they are rarely associated with anthropogenic changes, their spatial analysis may reveal a number of interesting correlations. Climate as a component of the geographical environment has a significant impact on life conditions and on the way humans shape the environment. GZM is located in a temperate climate zone with variable weather conditions.

The average annual temperature in GZM is 8.1ºC. The differences in the spatial distribution of temperature in GZM are related to the different levels of urbanization and industrialization. Accordingly, these temperatures may vary from 1.2 to 1.5ºC, with higher temperatures recorded in industrial areas [3]. The warmest season in this area is summer, and the coldest season is winter. The spatial temperature variation is not significant, reaching a value of 1.0ºC.

Materials and Methodology

The research was based on each season's average temperature. The temperature values were interpolated using the inverse distance weighting method to create a thematic map. Based on data indicating population density, road network density, the amount of waste generated, and the percentage of built-up land in GZM districts, a map showing the spatial distribution of the human impact factor was created. The factor was calculated using the formula below:

$$IA = [a_1/b_1 + a_2/b_2 + a_3/b_3 \ldots]/\sum[c_1 + c_2 + c_3] \quad (1)$$

...where a_1, a_2, and a_3 determine the value of the factor affecting the degree of anthropogenization (in this case population density persons per km^{-2}, the amount of waste generated in Mg·km^{-2} transportation network density km 100 km^{-2} Table 1); b_1, b_2, and b_3 are the average factor values for the whole voivodship; and c_1, c_2, and c_3 are each factor's weight (in this case each factor equals 1).

Data concerning the thermal conditions calculated for each calendar season were averaged and then correlated with the value of human impact factor of the area under consideration.

Research Results

The average temperatures in GZM have a similar spatial distribution pattern regardless of the season. The highest temperatures are recorded in Bytom, Piekary Śląskie,

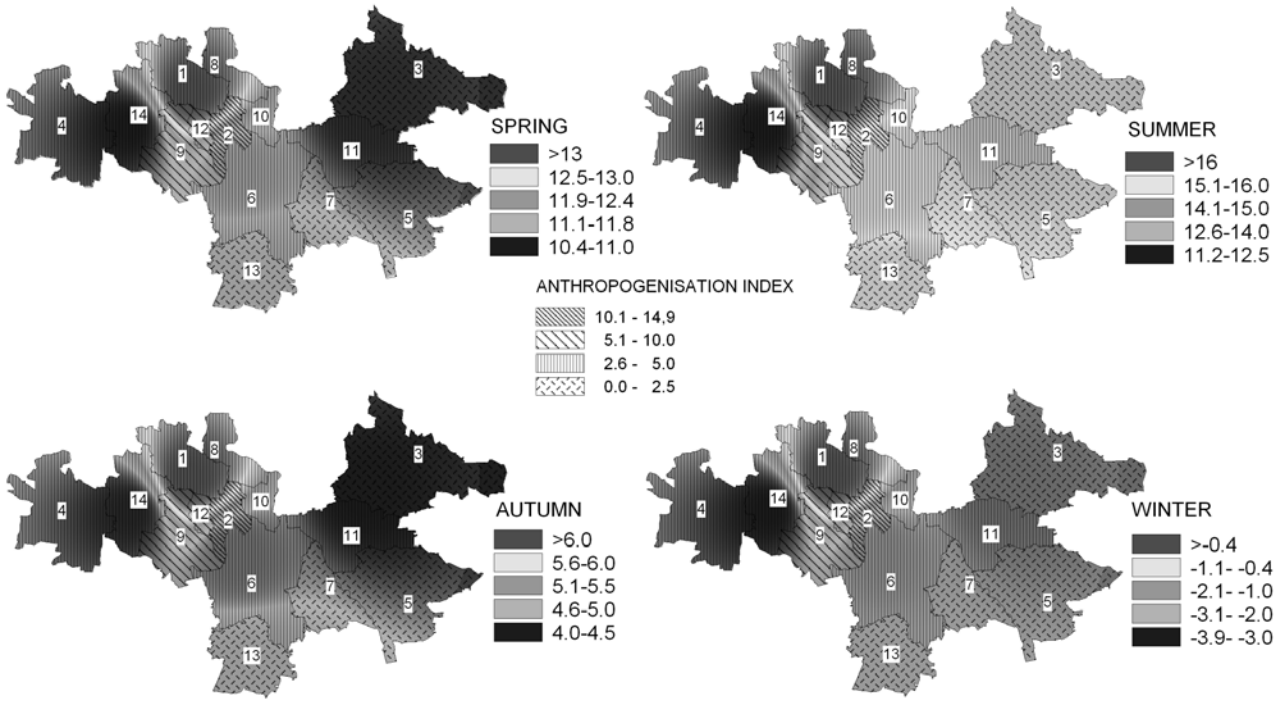

Fig. 2. Average temperature variation in different seasons of the year and their correlation with the anthropogenisation index. Districts marked as in Fig. 1.

Świętochłowice, and Chorzów. The lowest temperatures are recorded in Gliwice, Dąbrowa Górnicza, Sosnowiec, and Jaworzno. Thus, the highest average temperatures occur in the central part of GZM (Fig. 2).

The spatial fluctuations of the human impact factor are large in the area studied, with values varying from 2.5 to 10.1. These values are high when compared with those recorded in other parts of Śląskie Voivodship – the lowest value of the human impact factor in GZM is 2.5 times higher than the average for Śląskie Voivodship, which points to the risk of exposure to harmful factors and a lower quality of life perception.

In the GZM area, higher temperatures are recorded in the following districts: Bytom, Piekary Śląskie, Świętochłowice, and Chorzów. As evidenced by the human impact factor calculated, these are the districts where human influence on the environment is the most noticeable.

After the analysis of the temperature distribution in successive seasons and the human impact factor distribution, the similarities in the distribution patterns of both factors are evident (Fig. 2). Therefore, the temperature should also be taken into account when identifying sites particularly harmful to human health. Temperatures higher than in the surrounding area result, to some extent, from urbanization (the so-called urban heat island effect). The factors mentioned above also affect the well-being of the residents and their quality of life.

Results and Discussion

Air pollution, intensive urbanization, and other factors associated with human impact are often assessed in terms of their impact on health [4, 5]. Climate and, in this particular case, temperature, are often overlooked due to difficulties in assessing its impact on the quality of life. However, climate is worth analyzing, especially at the local level, as this is the only way to evaluate the phenomenon of heat islands generated by large cities and agglomerations [6] and their impact on the quality of life of a given area [8]. Moreover, due to the regional and local importance of the phenomenon of temperature increase in urban agglomerations, it is a factor that should be carefully monitored and included in an overall assessment of life conditions of an area. The results presented in this paper indicate that a correlation exists between areas of increased temperature and areas where human impact is more noticeable. This correlation is obviously a typically "urban" characteristic of the temperature factor, and its spatial pattern is usually consistent with the population density of the area and its degree of urbanization [7, 8]. Thus, a lower quality of life is to be expected in areas with increased temperature. This statement is substantiated by earlier research on quality of life in conditions of elevated temperature [9]. The next step should be an analysis of the spatial distribution of deaths in the area because, according to earlier research [10-12], there is a correlation between the mortality rate and the average temperature increase in a given area.

References

1. XU Y. QIN Z. WAN H. Spatial and Temporal Dynamics of Urban Heat Island and Their Relationship with Land Cover Changes in Urbanization Process: A Case Study in Suzhou, China, J Indian Soc Remote Sens, **38**, (4), 654, **2010**.

2. CAMILLONI I., BARROS V. On the Urban heat islands effect dependence on temperature trends, Climatic Change **37**, 665, **1997**.
3. ŁUPIKASZA E., WIDAWSKI A. Climate conditions in the Metropolitan Association of Upper Silesia (In:) Dulias R. Hibszer A. (Eds) Metropolitan Association of Upper Silesia, a geographical outline, Polish Geographical Society, Katowice Division, Sosnowiec, 90, **2008** [In Polish].
4. ABSALON D., ŚLESAK B. The effects of changes in cadmium and lead air pollution on cancer incidence in children. Sci. Total Environ. **408**, (20), 4417, **2010**.
5. CORBURN J. Urban land use, air toxics and public health: Assessing hazardous exposures at the neighborhood scale. Environmental Impact Assessment Review **27**, 145, **2007**.
6. REN C., TONG S. Temperature modifies the health effects of particulate matter in Brisbane, Australia. Int. J. Biometeorol., **51**, 87, **2006**.
7. AIKAWA M., HIRAKI T., EIHO J., MIYAZAKI H. Characteristic Air Temperature Distributions Observed in Summer and Winter in Urban Area in Japan. Environ Monit Assess, **131**, 255, **2007**.
8. AIKAWA M., HIRAKI T. Characteristic seasonal variation of vertical air temperature profile in urban areas of Japan. Meteorol. Atmos. Phys. **104**, 95, **2009**.
9. HUANG J. Prediction of air temperature for thermal comfort of people in outdoor environments, Int. J. Biometeorol., **51**, 375, **2007**.
10. HU W., MENGERSEN K., MCMICHAEL A., TONG S. Temperature, air pollution and total mortality during summers in Sydney, 1994-2004. Int. J. Biometeorol., **52**, 689, **2008**.
11. KOWALSKA M., ZEJDA J. E., SKRZYPEK M., OŚRÓDKA L., KLEJNOWSKI K., KRAJNY E., WOJTYLAK M., HUBICKI L. Air Pollution and Daily Mortality in Urban Katowice, 1994-95 and 2001-02. Pol. J. Environ. Stud., **17**, 5, **2008** [In Polish].
12. NAFSTAD P., SKRONDAL A., BJERTNESS E. Mortality and temperature in Oslo, Norway, 1990-1995. European Journal of Epidemiology **17**, 621, **2001**.