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Two faces to the greenery on housing estates–mitigating climate but aggravating allergy. A Warsaw case study

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ABSTRACT

Interest in the climate and an awareness of the beneficial cooling influence exerted on it by biologically-vital areas is growing, as climate change progresses, hot weather is more frequent as well as the urban heat island more intense. It is necessary to protect existing greenery in the cities and to introduce new planting. However plants in a warmer climate can produce larger amounts of pollen and are more readily able to initiate an allergic reaction among those prone to them. That means—not every greenery is advantageous for humans in the cities. In the research two housing estates built at different times and differ in type, density and age of buildings, as well as in the composition and the percentage of biologically vital area and the species planted were examined. Detailed inventory of tall greenery entailed the trees and shrubs and next their assumed allergenic potential was made. Cooling effect likely is derived from the difference in greenery, but the other factors such as differences in the density of buildings and spatial organization of the estate could also influence it. The older estate with the ratio of biologically vital areas of 54.3% is characterised by more favourable local climate than the newer estate, with the ratio of biologically vital areas equals 40.7% and young vegetation. On the newer one the perceptible thermal conditions did not differ significantly compared with the city centre. Unfortunately, on Koło Estate trees creating mild thermal conditions are also the trees promoting allergies most severely: birches, poplars and limes. And they are planted usually around playgrounds and kindergarten. The trees of high allergenicity should be partially removed, even risking small worsening thermal conditions.

1. Introduction

1.1. City climate and vegetation

In Poland, as in the world as a whole, the period since the 1980s has brought an ever greater number of studies concerning the influence of biologically vital areas on the aerosanitary, thermal and humidity-related conditions actually present in urban areas, as well as those perceptible to human beings. Thanks to the shade they cast, but also because of the non-artificial surface they represent as regards heat balance, areas of greenery, and in particular more extensive areas of green space, bring about a reduction in both ground and air temperatures (Sukopp, 1990; Spronken-Smith and Oke, 1998; James et al., 2009; Kuchcik, 2003; Gill et al., 2007; Błażejczyk et al., 2014a,b).

Thus trees in general, and broadleaved trees in particular, play a major positive role in meliorating the urban climate (Hamada and Ohta, 2010; Chang and Li, 2014). Work done in the temperate zone in the 1980s revealed that – at the height of the growing season – the effect of the shade cast by sugar maples (*Acer saccharum*) of average dimensions was to reduce irradiance by about 80% (Heisler, 1986). Even when leafless, the trees in question were able to reduce irradiance by nearly 40%.

While it is mainly such tall vegetation that exerts an influence on thermal conditions in a town or city, the vegetation in question does not have to comprise large numbers of trees in park conditions, as trees on housing estates or in domestic gardens also have an effect (Chiesura, 2004; Cameron et al., 2012). Recent studies conducted in Sweden showed a significant reduction in total and direct shortwave radiation in the shade of a single deciduous tree, even when lacking foliage. The mean ratio of direct total radiation below the canopies of trees of different species varies from 8.8% below a foliated small-leaved lime (*Tilia cordata*) or 16.2% under a silver birch (*Betula pendula*) to 61.2% beneath a leafless birch or 77.4%

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beneath a lime likewise lacking foliage. Dense, foliated crowns of single trees are almost impermeable to solar radiation, with only 1–5% of the incident direct beam and 8–15% of total radiation reaching the ground in the shade cast by them (Konarska et al., 2014). Another experiment conducted in Freiburg, Germany, showed that – on a clear and sunny day, between 10 and 16 Central European Time (CET) – the amount of incoming short-wave radiation was only one-fifth as great under the canopy of an ash tree (*Fraxinus excelsior*) as at an unshaded site. The average physiologically equivalent temperature (PET) – which could assess the thermal comfort of human beings during those hours – was 4.6 °C lower under the tree canopy, while the mean radiant temperature (Tmrt) was lower by even 24.8 °C (Mayer et al., 2009).

Park greenery also assimilates carbon dioxide and produces oxygen, of which shortfalls are often to be noted in urban areas (Kuttler and Strassburger, 1999; Demuzere et al., 2014). Even small groups of trees, or lines of them along a street, can reduce both noise and levels of pollution in the near-ground layers of air (Streiling and Matzarakis, 2003).

Trees also emit large amounts of water vapour to the atmosphere (for example 150,000 l/year in the case of a large oak, *Quercus* sp.—Hanson, 1991). On average, relative humidity is 3–8% higher in city parks than in nearby heavily built-up areas, with the difference increasing to between 5 and 20% in the summer months (Makhelouf, 2009).

Overall, parks – whose role in shaping climatic conditions is greater in the growing season – are treated as islands of cool and moisture that can also reduce levels of both air pollution and noise. Nevertheless, the size of the impact is found to depend on both the nature of the parks themselves and the climatic zone in which they are located (Kossowska-Cezak, 1978; Spronken-Smith and Oke, 1998; Shashua-Bar and Hoffman, 2000; Cheng et al., 2010; Oliveira et al., 2011). For example, the influence of the most popular type of urban greenery – the lawn – on the surrounding area depends mainly on size. Where a lawn covers 1000 m^2, the lowering of air temperature is only detectable near the ground, and does not extend far beyond the immediate vicinity. Only where a lawn covers as much as 3000 m^2 or so, does an impact on rather more distant areas begin to be felt (Kopacz-Lembowicz et al., 1984; Robbins et al., 2001).

A positive impact of vegetation is that many species of tree, for example Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*) and Larch (*Larix* spp.), but also certain kinds of shrubs, release the so-called phytoncides, i.e. volatile substances with bactericidal properties that have a healing effect where the respiratory system is concerned, as well as a stimulatory effect on the nervous system. Equally, certain species like willow (*Salix* sp.) emit large amounts of hydrocarbons, which may react with oxides of nitrogen released by vehicles on roads to further exacerbate problems with harmful photochemical smog (Chameides et al., 1988; Kuttler and Strassburger, 1999; de Abreu-Harbich et al., 2015).

1.2. *Urban planning strategies and the climate*

Interest in the climate and an awareness of the beneficial cooling influence exerted on it by biologically-vital areas is growing, as climate change progresses and there are ever-more-frequent periods of very hot weather (Field et al., 2012; WHO/WMO, 2012; Kuchcik, 2013; Smith et al., 2014). Climatic conditions are taken account of in the urban-planning strategies of many cities (Scherer et al., 1999; Eliasson, 2000; Alcoforado et al., 2009; Global Climate Change—Adaptation and Mitigation: The New Challenge Facing Urban Climatology, 2010), with scientists seeking to establish a minimum proportion of green space required for good environmental performance in both cities as whole spaces (Hagen and Stiles, 2010) and individual urban neighbourhoods more limited in size (Szulczewska et al., 2014).

Strategies seeking to protect the climate or improve the living conditions of inhabitants of urban areas often entail new planting, this also extending to green roofs, green facades or more generally an increase in the share of the given area covered in greenery (James et al., 2009; Gago et al., 2013; Fassbinder, 2014). While strategies of this kind can prove very effective in combating the heat island phenomenon, an inappropriate choice of plant cover may reduce the quality of life of local residents drastically, where the latter suffer from allergic reactions to plant pollen (allergic rhinitis, allergic conjunctivitis, asthma and urticaria). This makes it particularly important that plants be chosen appropriately, in order not to aggravate symptoms of allergy.

1.3. *The potential of plants in the climatic conditions of a city to aggravate allergies*

The most typical feature of the climate in urbanised areas is a temperature elevated beyond that noted in the suburbs or beyond the city borders. In turn, many studies make it clear that plants in a warmer climate can produce larger amounts of pollen than their counterparts in cooler regions. An increase in levels of carbon dioxide is shown to have a similar impact (Cecchi et al., 2010; Ziska and Beggs, 2011). Additionally, factors typical for urbanised areas like elevated ambient temperature, elevated carbon dioxide levels and increased concentrations of anthropic pollutants [e.g. sulphur dioxide, nitrogen dioxide, carbon monoxide, ozone and airborne particulate matter (PM)] affect plant physiology, causing an increase in allergen production. Pollen grains released in such an environment contain more allergen proteins on their external surfaces than do those produced in cooler settings (Bryce et al., 2010; Beck et al., 2013; Todea et al., 2013). For all the above reasons, pollen is more readily able to initiate an allergic reaction among those prone to them. The proteins referred to may also change the nature of the reaction, encouraging easier binding with the IgE antibodies responsible for allergic reactions of the immediate type (Cuinica et al., 2014). In a warmer climate, plants also start to pollinate earlier, and continue to release pollen over longer periods. This necessitates further modification to anti-allergic pharmacology therapy schedules and specific immunotherapy calendars (with early implementation and prolonged administration) (Bielory et al., 2012).

Typical pollen grain diameters range from 15 to 40 μm (Moore et al., 1991; D'Amato et al., 2007; Rapiejko et al., 2007; Wrońska-Pilarek and Jagodziński, 2009). Such a diameter allows pollen grains to reach only the upper region of the respiratory tract to trigger rhinoconjunctival symptoms. Only particles smaller than 10 μm can penetrate the respiratory tract down to its deeper structures to provoke asthma seizures. However, while pollen grains are extremely resistant to fragmentation, allergens can easily be transferred from them onto smaller (PM_{10}, $PM_{2.5}$) particles, in this way reaching every compartment of the respiratory tract readily (D'Amato, 2001). Increased plant allergenic activity and air pollutants can therefore act synergistically, and thus ensure a dramatic impairment of the quality of life of subjects susceptible to airborne allergens. It is also hypothesised that a combinations of these factors can not merely trigger respiratory tract allergy symptoms, but can also promote allergisation in the portion of the population so far unaffected by allergies, thanks to their facilitation of allergen penetration into the respiratory tract (Bryce et al., 2010; Lovasi et al., 2013). The deeper the allergen can reach into the respiratory tract, the greater the area of mucosa affected, the longer the allergen can reside inside the organism, the more severe the allergy symptoms that can be triggered and the easier the allergisation. Air pollution itself facilitates allergisation by irritating the respiratory