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Assessing allergenicity in urban parks: A nature-based solution to reduce the impact on public health

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ABSTRACT

Urban parks play a key role in the provision of ecosystem services, actively participating in improving the quality of life and welfare of local residents. This paper reports on the application of an index designed to quantify the allergenicity of urban parks in a number of Spanish cities. The index, which records biological and biometric parameters for the tree species growing there, classifies parks in terms of the risk they pose for allergy sufferers, graded as null, low, moderate or high. In this initial phase, the index was applied to 26 green areas in 24 Spanish cities; green areas varied in type (urban park, historical or modern garden, boulevard, square or urban forest), size 1–100 ha), geographical location, species richness, number of trees and tree density (number of trees / ha.). The data obtained were used to calculate the percentage of allergenic species in each park, which varied between 17–67%; density ranged from 100 to 300 trees/ha. The index values recorded ranged from a minimum of .07 to a maximum of .87; a significant correlation was found between index value and both number of trees and tree density. Taking an index value of .30 as the threshold considered sufficient to trigger allergy symptoms in the sensitive population, 12 of the parks studied may be regarded as unhealthy at any time of the year. Corrective measures to mitigate the impact of pollen emissions include the implementation of nature-based solutions at various levels: planning and design, handling and management, and strengthening of urban green-infrastructure elements. The index proved to be a useful tool for environmental analysis, and complies with the principles of portability and scalability central to current and horizon scientific research.

1. Introduction

Urban parks play a key role in the provision of ecosystem services, actively participating in improving the quality of life and welfare of citizens (Latinopoulus et al., 2016; Livesley et al., 2016). One of the main functions of these green infrastructure elements is to improve air

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quality by reducing the presence of gases and particulate matter (PM) (Beckett et al., 2000; Dzierzanowski et al., 2011). Moreover, parks have a direct effect on the welfare of local residents (Carrus et al., 2015), and the aesthetic value of green areas is undeniable (Shackleton et al., 2015); these considerations account for the accelerated greening process in which many cities have been immersed in recent decades (Jim, 2013; Grant, 2012).

However, offsetting this positive balance of services and functions, certain factors or hazards may have a negative impact on the quality of life and the health of the local population (von Döhren and Haase, 2015). Pollen emissions from urban vegetation during the reproductive process are one of the main ecosystem disservices which transversely generate significant economic, social, environmental and, most important, health costs (Cariñanos and Casares-Porcel, 2011). According to data from the World Health Organization, 30% of the world population suffers from some form of allergic reaction to pollen emissions (Pawankar, 2014), and annual spending on the palliative treatment of allergy symptoms in the United States alone has been estimated at several billion dollars (Weis et al., 2001). Moreover, allergy-related health issues are among the most common reasons for absence from work and school (Blaiss, 2010), especially in urban environments where interaction with other pollutants prompts a severe worsening of symptoms (Bosh-Cano et al., 2011).

Since urban environments are the main scenario for allergic episodes, it is there that the causes must be identified and solutions sought. A recent review of the major causes of increased urban pollinosis highlighted as one of the chief factors the inadequate design and planning of green areas (Cariñanos and Casares-Porcel, 2011). This does not necessarily mean that landscape and environmental criteria are not taken into account in the aesthetic design of these spaces (Gómez et al., 2004; Wolch et al., 2014), or that they do not boast a broad range of species (Vlachokostas et al., 2014); but it does mean that they have failed to address certain factors that exacerbate the allergenicity of ornamental plants (Cariñanos et al., 2016a). To date, the main measures implemented to deal with this issue have been: aerobiological sampling to determine the qualitative and quantitative composition of the pollen spectrum (Belmonte and Roure, 1991; González Parrado et al., 2014; Rodriguez de la Cruz et al., 2010); association of pollen counts with urban and peri-urban flora (Cariñanos et al., 2016b; Velasco-Jiménez et al., 2014; Belmonte et al., 2012); and the establishment of general guidelines for mitigating the impact of pollen emissions on the local population (Cariñanos and Casares-Porcel, 2011).

Given the need to prepare cities for the future effects of climate change (Baker, 2012; Leichenko, 2011) and for the population increases expected over the coming decades (Grimm et al., 2008), broader measures should be envisaged, aimed at improving the quality of life and health of citizens, strengthening their resilience and complying with the precepts governing the renaturing of cities with nature-based solutions (Connop et al., 2016). This paper reports on the application of an index designed to quantify the allergenicity of various elements of urban forests in a number of Spanish cities. The data obtained were used to identify the causes of increasing allergenicity in urban green spaces, and a set of nature-based solutions were put forward.

2. Materials and methods

2.1. Estimating the Index of Allergenicity of Urban Parks

The potential allergenicity of urban parks was calculated using the index of allergenicity of urban green zones (I_{UGZA}) developed by Cariñanos et al. (2014), which takes into account a number of biological and biometric parameters for tree and palm species growing in green spaces. Analysis of biological parameters enables a potential allergenic value (VPA) to be assigned to each species, while the biometric parameters enable estimation of their actual behaviour as a source of allergen emissions. VPA itself results from combining three natural variables: type of pollination, duration of the pollen season and intrinsic allergenicity of pollen grains. A list of biological parameters for the 100 most common tree species in Mediterranean cities is provided in Cariñanos et al. (2016a).

Biometric parameters were based on crown diameter and height; this facilitates calculation of allergen emission volumes by assimilating treetops to a geometric figure of similar shape.

Finally, in order to determine the relative value of allergen emissions in a given area or space, the values obtained were compared with those of a space with the same features and surface area, in which all trees planted had maximum values for all parameters, according to the following formula (Cariñanos et al., 2014):

$$I_{UGZA}=\frac{1}{maxVPAxS_T}\sum_{i=1}^{k} VPA\times S_i\times Hi$$

Where:

VPA= Potential Allergenicity Value for each species.

S_T= Surface area of the urban park.

k= number of species in the park.

S_i= Area occupied by each species in the park.

H_i= maximum height reachable by mature tree.

Application of the index yields a value of between 0 (null allergenicity) and 1 (maximum allergenicity). In principle, and given the findings of earlier studies (Cariñanos et al., 2014, 2016a), the threshold considered sufficient to trigger allergy symptoms in the local population was set to .30.

To supplement the data obtained by applying the index, species richness and Shannon´s diversity index (Shannon and Weaver, 1949) were calculated for each green space, in order to compare parks and explore possible correlations between these indices and allergenicity. Spearman non-parametric tests were performed to check for correlations between I_{UGZA} and other parameters, including: surface area, number of trees and tree density. In addition, the relationship between the variables studied (I_{UGZA}, Shannon's Index, surface area, number of trees, species richness, and tree density) was analysed using Principal Component Analysis (PCA) to rank parks as a function of the variables tested. All statistical analyses were carried out using R Software (R Core Team, 2016).

2.2. Selection of Parks: type and location

Since this study sought to cover a range of types and locations (Rall et al., 2015), green areas were selected with a view to ensuring a representative sample in term of number of tree species, design, types of space and climatic amplitude. In this initial phase, a total of 26 green areas located in 24 Spanish cities were analysed, including: urban parks, modern urban gardens, historic gardens, boulevards, squares and urban forests. The main features of each area, including annual maximum and minimum temperature and total rainfall for the period 1981–2010 (State Agency of Meteorology, AEMET, 2012) are detailed in Table 1.

The inventory of tree and palms was supplied in some cities (Barcelona, Cartagena, Cordoba, Huesca, Madrid, Palma de Mallorca, Salamanca, Santander and Valencia), by the Parks and Gardens Services of the respective Town Councils; while in the other cities, inventories were made by the authors themselves in visits to the different spaces, in the months prior to the completion of this study. Some of the most widely-used keys were used to identify the species: Los árboles y arbustos de la Peninsula Ibérica y Baleares (López González, 2006), Arboles en España, Manual de Identificación (López Lillo and de de Lorenzo Cáceres, 2001) Moreover, data on the following parameters were recorded in order to estimate the allergenicity index, with a view to identifying improvement strategies that should be