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Introduction:

The role played by urban green spaces has changed over the years: their function has ceased to be merely decorative, and they have become an essential element in any sustainable city model (Chiesura, 2004). This being so, a number of measures need to be implemented in order to improve urban environmental conditions and minimise the adverse impact of these spaces on the quality of life of certain residents (Millenium Ecosystem Assessment, 2005; Nowak and Dwyer, 2000; Escobedo et al., 2000; Cariñanos & Casares 2011). This paper outlines a preliminary approach to estimating the allergenic potential of urban green spaces and to illustrate the practical application of the index, a case study was carried out in an urban park in the city of Granada, in south-eastern Spain.



Images of the García Lorca Park in the Granada Town (Google Earth, Virtual Earth)

Allergenicity Index :

The index theoretical principles:

1. In urban landscapes, the plant species used as ornamentals in parks, gardens, tree-alignments or open green spaces in the broad sense, are the most common cause of pollen allergies.
2. The allergenic potential of most plant species used in urban landscaping is documented and available via bibliographical databases (Mari et al., 2009; Ogren, 2002).
3. In wind-pollinated species, the intensity of the pollen emissions is related to the size of the plant (trees and shrubs) and surface coverage (ground cover species). A larger volume of crown enhances the emission, since larger species tend to have more branches, blossoms and stamens per unit of surface area (Friedman, 2009).
4. The amount of pollen released into the air is proportional to the number of individuals of a single species in any given area.
5. Where two species have similar allergenic potential, the species with the longer pollination period will prompt allergic symptoms over a longer interval.

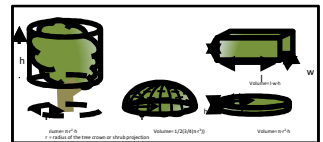
Therefore, the worst-case scenario in terms of the allergenic potential of an urban space would clearly be a space in which design are one or several species of large size, with high allergenic potential, long flowering period and high pollen emissions.

Thus, when constructing the Index must be taken into account the intrinsic characteristics of each species, *ie.* characteristics related with the biological properties of the organisms (Wüster, 1998), and certain aspects of its activity as a source of allergenic particles related to the design of the green area: number of specimens, size, presence of hedgerows, meadow surfaces, etc... The result of this combination of parameters is the following Urban Green Zones Allergenicity Index (IUGZA):

$$IUGZA = \frac{1}{378 \times S_T} \sum_{i=1}^K n_i \times ap_i \times pe_i \times ppp_i \times S_i \times H_i$$

Where:

- k = number of species
- n_i = number of individuals belonging to the i-species
- ap_i = 0, 1, 2, 3, or exceptionally 4 for main local allergens (Allergenic potential of the i-species)
- pe_i = 1, 2, 3 (Pollen emissions of the i-species) values: 0) dioecious female plants; 1) insect-pollinated species; 2) species that may be insect- or wind-pollinated; 3) wind-pollinated species,
- ppp_i = 1, 2, 3 (Duration - PPP-Weeks. Duration of the main pollination period of the ith species)
- H_i = Height of the crown in meters, [2, 6, 10 y 14 (16)] or plant size for grass and small shrubs.
- S_i = Surface area in m² covered by the i-species
- S_T = Total surface area of the park in m².
- 378 = 3 x 3 x 3 x 14 (Maximum value of ap, x pe, ppp, x H_i)



Comparison between the volume (V) of the 3 considered cases: a tree, a isolated shrub and one mass shrub, clipped hedge or grass surface. Ii-occupied surface.

Park IUGZA= 0,13761

Area of Study:

The case study was carried out in the city of Granada, located in the southeast of the Iberian Peninsula (37° 11' N, 3° 35' W) (Figure 1). The city covers a surface area of 88.02km², and lies at an altitude of 738 m a.s.l., in a wide depression formed by the River Genil and the valley of the Sierra Nevada mountain range. This location gives rise to a continental Mediterranean climate, generally cool with freezing winters and hot summers, and with an average annual temperature of 15.1°C, according to data for the period 1971-2000. Rainfall tends to be sparse: average annual rainfall for the same period was 357 mm (AEMET).

The García Lorca Park is the city's main green spaces and one of the most visited. This park was selected because it is representative of Mediterranean city parks in terms of size, and because both species diversity and design are well-suited to illustrating the application of the Index. The park, with a surface area of 71.500 m², is located to the south of the city, in an area known as the "Vega de Granada", an area of fertile plains devoted until recently to farming. It includes the "Huerta de San Vicente", land historically owned by the family of the poet García Lorca.

The identification and quantification of species in the park was performed in situ over the course of numerous visits in the 2012 spring. Data were also collected on the size, structure, design and predominance of relevant plant formations (e.g. single-species stands, living screens, tree-lined avenues), on species distribution, ornamental elements and lawn coverage. Additional data such as measurements of spaces (sidewalks, total surface area, buildings) was furnished by images and measurements obtained using Google Earth and Autocad.

Conclusions:

This Index highlights diversity as a key aspect of park design, in terms of minimising allergenic potential. Taxonomic, morphological, and biological diversity can help to minimise the impact of highly-allergenic species. The index can also be used to encourage corrective measures in specific areas of the park; these might include avoiding the planting of mainly male trees in dioecious species, the use of singles species to form hedges or to line avenues, and the establishment of cross reactions between species belonging to the same family. The expression of allergenicity in terms of an abstract number facilitates comparisons and enables the application of the index to different green spaces, even in other geographical areas.



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