

POLLENS CAUSING ALLERGY AND THEIR MONITORING BY AEROBIOLOGY AND PHENOLOGY

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Allergies caused by inhalant allergens, particularly pollens, are steadily increasing in urban centers. It is known that atmospheric pollution is strongly related to the inflammatory disease of the upper and lower airways but it is equally important in the development of sensitization towards pollens. Particulate Matter (PM), sulfur dioxide (SO₂) and nitrogen dioxide (NO₂) have an enhancement function on the persistence of pollens in the air, increasing the concentration and duration of pollinosis. It is therefore essential to use air quality control methods in urban centers to monitor the presence of pollen and fine dust that can drive the doctor and the patient to improve prevention, a step of primary importance in the treatment of allergies. Aerobiology and phenology are essential tools to monitor pollen production. The opportunity for the patients to use social media as information sources, including teletext, sms, mail and social networks, as well as a wide range of apps, allows to have reliable information on the air we breathe and therefore to better manage the methods of prevention at our disposal.

Seasonal allergy to pollens is a disease in significant expansion in large cities, caused mainly by the presence of inadequate ornamental plants and aggravated by the ever-increasing atmospheric pollution that accentuates the sensitizing action of pollen on the respiratory mucous membranes (1).

A relationship between pollen granules and atmospheric pollutants has been demonstrated: on the one hand the granules absorb and transport airborne pollutants to the respiratory tract, increasing their concentration, and on the other hand common pollutants, such as particulate emissions from diesel engines act as carriers, transmitting pollen allergens and promoting the production of antibodies of the IgE class (2). The assessment of air quality is one of the most important issues and is of particular concern in the urban environment, where gas and particulate

matter sources are predominantly concentrated and where population density is a potential risk for human health (1).

Human influence on pollen production

While pollen occurs naturally, pollen emissions are very much affected by human activities, particularly by air pollution resulting from human activity and by planting of trees that are unsuitable because of their sensitizing capacity (birch, cypress, European hornbeam, olive trees), in immediate proximity of people's homes. Tables I-III provide an overlook on the most common types of allergenic plants in Italy.

The production of allergenic pollen is also significantly affected by planting, mainly for ornamental aim, of highly allergenic trees and plants.

Key words: pollen allergies, air pollution, pollen monitoring, aerobiology, phenology

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Using birch tree as an example, approximately 25% people with hay fever are allergic to birch tree pollen, yet it is possible to see birch trees planted in many cities in central and northern Europe. Similar phenomena are observed for other trees such *Alnus*, *Corylus*, and *Cupressaceae*. In addition, many new or non indigenous allergenic species of plants arrived in Europe, for example Rome, where noteworthy changes in the local flora were observed (3). A well-known example is ragweed which is spreading across Europe and is highly allergenic. Also largely cultivated plants, such as spruce, olives and oilseed rape contribute to the aggravation of allergies.

Finally, climate change represents a possible threat for a patient affected by allergy. Climate change also affects pollen season and its distribution is a major concern.

Pollution and pollinosis

According to recent studies, air pollution is significantly exacerbating the aggression of pollen. Because of higher concentrations of carbon dioxide (CO₂) in the air, plants grow faster, produce more fruits and consequently affect people with allergy more importantly. Moreover, plants stressed by air pollution produce more aggressive pollen grains because of the

Table I. Tree pollens: name, allergens, habitat

Tree pollen	Allergens	Habitat
Hazel (<i>Corylus avellana</i> L. - Betulaceae)	Cor a1	Hazel is commonly present in cities in parks and gardens
Cypress (<i>Cupressus sempervirens</i> L.; <i>Hesperocyparis arizonica</i>) (<i>Cryptomeria japonica</i> D. <i>Taxus baccata</i> L. <i>Juniperus communis</i> L. – Cupressaceae)	Cup a1 Cry j1 Cry j2 Jun a1 Jun a2 Jun a3	Cypress trees are commonly used in towns in parks garden, avenues, in cemeteries, in archaeological area and in sports facilities.
Alder (<i>Alnus glutinosa</i> L. – Betulaceae)	Aln g1	Alder lives near rivers or wet area.
Birch (<i>Betula verrucosa</i> Ehrh – Betulaceae)	Bet v1 Bet v2 Bet v4	Birch is common in northern Italy, not only in woods but also in cities, in parks and gardens
Plane (<i>Platanus hispanica</i> – Platanaceae)	Pla a1 Pla a2	Widely planted in alignment, in parks and schoolyards.
Olive (<i>Olea europaea</i> L. – Oleaceae)	Ole e1 Ole e2	In recent years olive trees are planted in town increasing pollen amount
Ash (<i>Fraxinus angustifolia</i> L. – Oleaceae)	Fra a1	Ash live in deciduous wood on temperate region, but sometime it occurs also in urban park
Oak (<i>Quercus</i> sp. – Fagaceae)	Que a1	Commonly present in cities in parks, green areas, avenues
Chestnut (<i>Castanea sativa</i> – Fagaceae)	Cas s1	Commonly present in cities in parks, green areas, avenues
Beech (<i>Fagus sylvatica</i> L. – Fagaceae)	Fag s1	It forms wide forest in Italy from 800 up 1700 a.s.l.
European hornbeam (<i>Ostrya carpinifolia</i> Scop. – Betulaceae)	Ost c1	Recently it is used in urban parks, in green areas

increase in the content of proteins causing reactions (4). The REVIHAAP report confirmed that other pollutants may worsen allergies as well (5). Co-exposure to grass pollen and particulate matter (PM) leads to stronger allergic responses and exposure to sulphur dioxide (SO₂) and nitrogen dioxide (NO₂) can worsen pollen allergy and enhance lung inflammation.

To know which and how many pollen grains are present in urban air, at least 30/m³ or more in some

case, pollen monitoring activity is commonly carried out in numerous cities in Italy as well as in the world (6). In each of the sampling sites, a Hirst sampler runs the entire pollen season. For these reasons, pollutant pollen monitoring can be considered an integrated tool in the broader context of air quality assessment.

Monitoring of pollens: sampling techniques

Air sampling techniques are numerous, depending

Table II. *Weeds pollen: name, allergens, habitat.*

Weeds	Allergens	Habitat
Ragweed (<i>Ambrosia artemisiifolia</i> L. – Asteraceae)	Amb a1	They grow in dry and sunny meadows, along the rivers, on the edge of the roads and generally in abandoned grounds
Mugwort (<i>Artemisia vulgaris</i> L. – Asteraceae)	Art v1 Art v3	Very common synanthropic plant, typical of the ruderal roots
Pellitory (<i>Parietaria judaica</i> L. – Urticaceae)	Par j2	It can grow in semi-shade (light woodland) or no shade. It prefers dry or moist soil. Pellitory colonises walls, ways, trap-doors
English plantain (<i>Plantago lanceolata</i> L. – Plantaginaceae)	Pla l1	It is present in uncultivated areas, along the streets, fields, vineyards, and ruderal environments

Table III. *Grass pollen: name, allergens, habitat.*

Grass (Poaceae)	Allergens	In Italy there are more than 450 different species. Grasses are annual, biennial, or perennial plants that are usually herbaceous but may be woody in some genera. They may be terrestrial or aquatic. Grasses live everywhere in our towns, in gardens, in flowerbeds, in meadows. So if these spaces are not well managed cutting grasses before flowering they produce a lot of pollen.
Cock's foot (<i>Dactylis glomerata</i> L.)	Dac g7	
Perennial ryegrass (<i>Lolium perenne</i> L.)	Lol p1 Lol p2A Lol p5B Lol p5A Lol p11	
Meadow fescue (<i>Festuca elatior</i> L.)	Fes e7	
Kentucky blue-grass (<i>Poa pratensis</i> L.)	Poa p1 Poa p10 Poa p12 Poa p13	
Yorkshire fog (<i>Holcus lanatus</i> L.)	Hol l1	
Oat (<i>Avena sativa</i> L.)	Ave s1 Ave s1s	
Timothy grass (<i>Phleum pratense</i> L.)	Phl p1 Phl p2 Phl p4 Phl p5b Phl p6 Phl p7 Phl p11 Phl p12	
Sweet vernal grass (<i>Anthoxanthum odoratum</i> L.)	Ant o1	
	Cyn d1	
Bermuda grass (<i>Cynodon dactylon</i> L.)		

on the different purposes and for each particular biotic particle, it is possible to use a specific sampler. If a universal sampler does not exist, it is sure that for the same particles, for example pollens and spores, it is possible to count on a method and instrument commonly used in all the aerobiological network. This sampler is the Hirst spore trap (7) that was designed to record pollen grains and fungal spores and other biological particles. This instrument allows a morphological identification of different particles in function of time. Thus, it is possible to know pollen concentration day to day and in some cases, hour by hour. Air enters through a 2x14 mm intake orifice and impacts onto a collection surface that advances 2 mm per hour. It is possible to have daily monitoring by depositing particles on a slide, or weekly monitoring by depositing particles on transparent tape (melinex). Two Hirst sampler models are available, Burkard and Lanzoni; they are similar, the only difference is on the medium coated on tape, i.e. paraffin on the first sampler and silicon fluid on the second one (8).

The sampler sucks air with a flow of 10 litres per min, comparable to the mean breath rate of an adult in rest condition. Particle identification is carried out under a light microscope using different magnification. Pollen grains are normally stained with fuchsin for a better examination. Pollen counts are converted in pollen concentration and weekly reports are produced during the year.

The standardisation of pollen monitoring allows the comparison of data between sites, such as temporal and spatial variations in diurnal and daily concentrations and seasonal characteristics (e.g. timing and intensity of pollen seasons), as well as trends over time (e.g. in relation to land use and climate change). However, it is recognised that the pollen spectrum varies between sites in different biogeographical areas, which could still cause identification to be problematic (9).

In Italy in 2008, a regulation was written named Norma UNI 11108 2004 (10) and successively at the European Aerobiology Society, minimum requirements for monitoring activity were approved (11). More recently, a new European regulation "CEN/TS 16868:2015", is in the phase of approval (12).

Pollen grains only represent a small fraction of the total amount of viable biological particles present in the

air, but pollens are the most important aeroallergens in the outdoor environment. Environmental applications of aerobic monitoring are many and the most known is certainly allergic-related: aerobiology is used in the field of allergology as a useful assessment tool for respiratory allergies. Exact knowledge of the true level of aerodynamic particles is of great importance from a diagnostic point of view, to correlate pollen presences with patient history and response to diagnostic tests and also as useful indication for proper pharmacological treatment.

Modern advances in molecular analysis could improve information for allergy sufferers and health care professionals (13, 14).

Importance of pollen monitoring

Patients and doctors should be helped in understanding how symptoms change during a pollen season; this may help to identify the individual co-factors facilitating symptomatic manifestations and consequently, disease self-management. To this end, many scales, indexes or scores have been created to measure the severity of allergic rhinitis and the impact of this disease on the patient's daily life. The most frequently used approaches are symptom scores (SS), medication scores (MS) and combined symptom-medication scores (SMS) (15, 16). Methods to measure and monitor the severity of allergic rhinoconjunctivitis are of increasing relevance for diagnosis and intervention trials.

Most methods are based on diaries filled out by the patient, who each day answers the same list of disease-related questions. These diaries generate SS, which are based on the values of the individual symptoms (e.g. by summation) (17). However, to date there is no universally accepted system to measure symptoms.

Information technology (IT) nowadays facilitates a more efficient and easier patient monitoring (18). Another important tool in aerobiological monitoring activity is the possibility to carry out phenological observations. Phenology studies the periodical rhythms of the biological events and their relationships with the environment, especially the climate. As the timing of phenological events and especially flowering is strongly affected by meteorological factors, it has been observed that plant phenological responses correlate

with climatic change. Moreover, the knowledge of the phenological stages of the plants, such as the flowering time, can be an important tool for agricultural economics (e.g. pesticides and fertilizer applications, choice of varieties of plants, crop yield) (19). For some of the pollen types (e.g. *Platanus*, *Quercus*, *Olea* and *Plantago*), there is an association between flowering phenology and airborne pollen records. In general, aerobiological observations about the pollen season are strongly influenced by the taxon, the location and the large-scale weather conditions (20-22).

Phenological studies have shown that airborne pollen results from both local and distant sources, although the pollen peaks usually appear when local sources are shedding the greatest amounts of pollen (23).

CONCLUSION

The great and constant work that is behind aerobic sampling has an important recognition in the disclosure and publication of the data. However, the increased availability of information on pollen concentration requires careful reckoning on the correct and useful ways of disseminating them from producers and of their responsible use.

The wide variety of communication modes, i.e. information panels, teletext, sms, mail, social networks, such as Facebook, My space or Twitter and a wide range of apps are the new tools that currently drive pollen information.

REFERENCES

1. ARPAV 2004. Il monitoraggio aerobiologico nel Veneto: i pollini allergenici. ISBN 88-7504-074-5.
2. Knox RB, Suphioglu C, Taylor P, Desai R, Watson HC, Peng JL, Bursill LA. Major grass pollen allergen Lol p 1 binds to diesel exhaust particles: implications for asthma and air pollution. *Clin Exp Allergy* 1997; 27(3):246-51.
3. Celesti Grapow L, Alessandrini A, Arrigoni PV. Inventory of the non-native flora of Italy. *Plant Biosystems* 2009; 143(2):386-430.
4. U.S. EPA. A Review of the Impact of Climate Variability and Change on Aeroallergens and Their Associated Effects (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-06/164F, 2008.
5. Review of evidence on health aspects of air pollution – REVIHAAP project: final technical report. WHO/Europe, 2013.
6. Zaum, 2017 Worldwide Map of Pollen Monitoring Stations. <https://www.zaum-online.de/news-press/news/news/article/39013.html>.
7. Hirst J. M. An automatic volumetric spore trap. *Annal of Applied Biology* 1952; 39(2):257-65.
8. Mandrioli P, Comtois P, Levizzani V. *Methods in Aerobiology*. 1998; ISBN 88-371-1043-X.
9. Oteros J, Orlandi F, García-Mozo H, et al. Better prediction of Mediterranean olive production using pollen-based models. *Agronomy for Sustainable Development* 2014; 34(3):685-94.
10. UNI 11108:2004 “Metodo di campionamento e di conteggio dei pollini e delle spore fungine aerodisperse” 2004.
11. Galan C, Smith M, Thibaudon M, Frenguelli G, Oteros J, Gehrig R, Berger U, Clot B, Brandao R. Pollen monitoring: minimum requirements and reproducibility of analysis. *Aerobiol* 2014; 30:385-95.
12. Thibaudon M, Galán C, Bonini M, Röseler S, Fernández-González D. Ambient air- Sampling and analysis of airborne pollen grains and fungal spores for networks related to allergy- Volumetric Hirst method. 2017; (CEN/TS 16868:2015).
13. Smith M, Berger U, Behrendt H, Bergmann KC. Variation of the group 5 grass pollen allergen content of airborne pollen in relation to geographic location and time in season. *Chem Immunol Allergy* 2014; 100:228-33.
14. Cecchi L, Dell’Albani I, Frati F. Towards a global vision of molecular allergology: A map of exposure to airborne molecular allergens. *Eur Ann Allergy Clin Immunol* 2013; 45(S2):17-23.
15. Bousquet J, Khaltaev N, Cruz AA, et al. Allergic Rhinitis and its Impact on Asthma (ARIA) 2008 update (in collaboration with the World Health Organization, GA(2)LEN and AllerGen). *Allergy* 2008; 63(86):8-160.
16. Häfner D, Reich K, Matricardi PM, Meyer H, Kettner J, Narkus A. Prospective validation of ‘Allergy-

- Control-SCORE™: a novel symptom–medication score for clinical trials. *Allergy* 2011; 66:629-36.
17. Florack J, Brighetti MA, Perna S, et al. Comparison of six disease severity scores for allergic rhinitis against pollen counts a prospective analysis at population and individual level. *Pediatr Allergy Immunol* 2006; 27:382-90
 18. Voukantsis D, Karatzas K, Jaeger S, Berger U, Smith M. Analysis and forecasting of airborne pollen-induced symptoms with the aid of computational intelligence methods. *Aerobiologia* 2013; 29:175-85.
 19. Dimou M. Comparison of phenological, aerobiological and melissopalynological patterns of *Olea europaea*. *Apidologie* 2011; 43(1):103-12.
 20. Estrella N, Menzel A, Krämer U, Behrendt H. Integration of flowering dates in phenology and pollen counts in aerobiology: analysis of their spatial and temporal coherence in Germany (1992-1999). *Int J Biometeorol* 2006; 51(1):49-59.
 21. Jato V, Rodriguez-Rajo FJ, Alcazar P, De Nuntiiis P, Galan C, Mandrioli P. May the definition of pollen season influence aerobiological results? *Aerobiologia* 2006; 22:13-25.
 22. Kmenta M, Bastl K, Kramer MF, Hewings SJ, Mwange J, Zetter R, Berger U. The grass pollen season 2014 in Vienna: A pilot study combining phenology, aerobiology and symptom data. *Sci Total Environ* 2016; 566-67:1614-20.
 23. Tormo R, Silva I, Gonzalo A, Moreno A, Pérez R, Fernández S. Phenological records as a complement to aerobiological data. *Int J Biometeorol* 2011; 55(1):51-65.