

Diurnal variation of biological and non-biological particles in the atmosphere of Córdoba, Spain

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Abstract

In this work, the daily distribution of biological and non-biological particles in the atmosphere of the city of Córdoba, Spain, is analysed in order to know at what time of day the concentrations of solid suspended particles in the air is maximum. This knowledge can be useful for all those people who suffer of respiratory diseases and can help them to plan their outdoors activities. The concentrations of non-biological material have been estimated by using spectrophotometrical techniques. With this method, the amount of non-biological material is expressed in percentage of light absorbance in values oscillating from 0.00: absence of particles to 1.00: extreme presence of particles. As the absorption of light depends on the colour of the particle, it is also possible to distinguish dark particles (soot, diesel exhaust particles, sand) from hyaline or light coloured ones (pollen grains and several fungal spores types). The results have shown that the maximum peaks of material are achieved early in the mornings and late in the evenings. Aerobiological methodology has been used when dealing with material of biological origin. In this latter case, pollen grains and fungal spores have been differentiated from the rest of solid material. Due to their importance as agents causing pollen allergy in the area and the high percentage that they represent with respect to the total pollen spectrum, *Olea europaea* and grass pollen types have been differentiated from the rest of pollen types. The results show that the peaks of non-biological particles in the air throughout the day are related to the activities carried out by men in the city: commercial and working hours or social activities in the different seasons of the year. As regards the biological material, the pattern of fungal spores is clearly influenced by the climatic characteristics of the area, presenting the maximum concentrations in the late afternoon. The pollen grains follow a pattern coinciding with the diurnal maximum temperatures and sunshine hours. The values of the curve oscillate from 200 grains/m³ of air in night hours to maximum over 1000 grains/m³ at midday. The diurnal variation of *Olea europaea* is quite similar to this general pattern, presenting the maximum concentrations of pollen grains at central hours of day. The grasses show some differences due to the high number of species included in this family.

1. Introduction

The distribution of suspended solid particles in the air (SSP) varies throughout the day, due to not only to the direct influence of the meteorological parameters, but also to the periodicity of some of the emission sources. The connection that exists between the different meteorological parameters and the higher or lower

concentration of particles in the air has been already studied (Pasquill, 1961; Berjand, 1969; Munn, 1976; Franzen et al., 1995; Anderson et al., 1996; Buchdahl et al., 1996). However, depending on the background of the analyser and its purposes, the biological material is considered apart from the non-biological one. The airborne material (mainly pollen grains and fungal spores) is well studied in Aerobiology and most of

the techniques developed enable to know the daily variation of the particles.

Some studies reveal that the pollen presence in the air achieves a maximum coinciding with the hours of maximum sunshine and high temperatures, that is, between 10.00 a.m. and 15.00 p.m. (Galán et al., 1991; Trigo et al., 1997; Norris Hill and Emberlin, 1991). Regarding fungal spores, it is demonstrated that, depending on the climatic characteristics of the sampling area, just one peak of maximum concentration throughout the day (Mediavilla, 1995; Hjelmroos, 1993) or two peaks (Gregory, 1961; Makinen and Ratio-Lehtimäki, 1978) can be found.

Under the non-biological material term, both material coming from natural sources (fires, emanations, volcanic eruptions, land sand, earthquakes) and derived from human activities (traffic, factories) is included. They have been widely considered not only for its role in pollution, but also as causing agents in some respiratory diseases such as asthma (Corsico, 1993).

There are a wide number of instruments that measure dust concentrations (Gorner and Fabries, 1990). Many of them use the size as characteristic of differentiation, but it is impossible to determine the nature of the particles. Moreover, not all of them permit to know the concentrations of particles at different moments of day; that means that they provide only the total concentrations of the day.

Some previous attempts have been done in aerobiology to correlate the peaks of maximum concentrations of particle material that appeared in the samples, with traffic and movements of the population (Makinen, 1978; Dominguez et al., 1995; Cariñanos et al., 1998).

In this paper, theoretical patterns of daily variation of both biological and non-biological particles in the air are shown for the city of Cordoba. The total amount of biological content has been differentiated in pollen grains and fungal spores. Special attention has been paid to *Olea europaea* and grasses due to their importance as agents causing pollen allergies in the area and affecting more than 20% of the population (Dominguez et al., 1993a).

In relation to non-biological material, our interest has been focused on whether the pattern obtained during the working weekdays varies from that obtained for the weekends. The detected variations depend on the emission sources whose origin lies in the daily activities carried out by men (heating, chimneys, commercial traffic, industrial activities, etc). The diurnal

variation of the suspended particles during winter weekends as compared to summer ones has been also analysed.

2. Materials and methods

The atmospheric sampling was carried out in the city of Cordoba, South of the Iberian Peninsula (4° 45'W, 37° 50'N) during the years 1990, 1991 and 1992. The Mediterranean climate favours the flowering of plant species during most part of the year and the constant presence of fungal spores in the air. However, the torrential character of the typical rainfalls in the area, enhances the continuous renewal of the suspended solid load in the air during normal years. The changeable direction of winds can slightly affect the particle spectrum, with transport to the urban area of biological as well as non-biological material. In general, the prevailing winds come from West-Southwest in spring/summer and autumn and from East-Northeast in winter when absence of wind is more frequent.

Concerning the possible emission sources of particles into the air, there is a clear distinction between natural sources on the one hand, and those originating from the activities carried out by men on the other. The vast cultivated areas in the south of the province, in which olive trees, herbaceous crops for dry farming, as well as the natural vegetation are predominant, constitute a permanent source of pollen grains and fungal spores. Sand and dust of land origin come from natural sources as well. It is frequent to find Saharan dust that has been transported up to our latitude due to the trajectory of the prevalent winds (Reiff et al., 1986).

The rest of non-biological material must then come from the activities carried out by men, being the traffic of vehicles the main one. The city of Cordoba, which has a ratio of 0.5 vehicles/inhabitants, represents a node for goods transport, connecting the south to the central region of the country.

A suction volumetric trap (Burkard Manufacturing Co.) has been utilized for this investigation. It is highly suitable for this type of sampling, due to its high efficiency – approximately 100% – as it traps particles with sizes ranging from 4 to 100 μm (Emberlin and Baboonian, 1995). The sampler was placed on the flat roof of the Faculty of Sciences at the University of Cordoba and worked continuously during the three years.

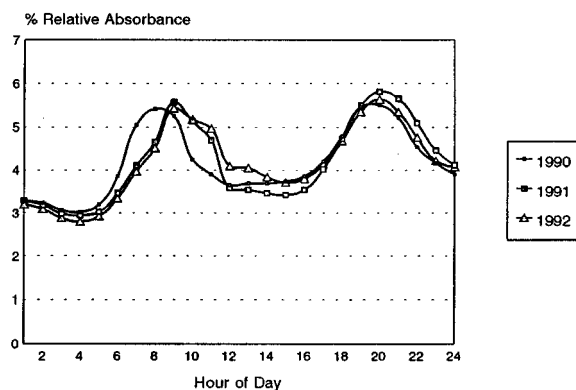


Figure 1. Diurnal variation of spectrophotometrical absorbance during the three years. Hourly mean values.

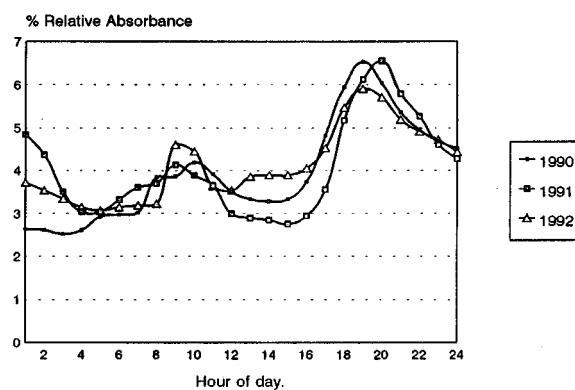


Figure 2. Diurnal variation of weekend spectrophotometrical absorbance. Winter pattern. Hourly mean values.

400 $\times$ magnification for optical microscopy has been used to analyse the material deposited on the samples, differentiating the biological particles (pollen grains and fungal spores) from the non-biological ones (dust, ashes, soot). The method of the four longitudinal traverses has been used as counting method (Dominguez et al., 1992). This method enables to know the concentrations of particles hour by hour and the result are expressed in pollengrains/m³ of air.

The evaluation of solid material has been done by using spectrophotometrical techniques (DU7 spectrophotometer, Beckman, Palo Alto, CA) as described in previous papers (Dominguez et al., 1995; Cariñanos et al., 1998). Once the instrument is previously calibrated using a non-exposed slide as reference, the major or minor concentrations of airborne particles can be determined by the strongest or less intense absorption of light. This absorption is expressed in percentage of absorbed light and is indicated on a numerical scale on one side of the graphic image. The absorption values oscillate from 0.00 to 1.00. The lowest values are referred to low presence of particles or light coloured-hyaline particles such as pollen grains and several types of fungal spores. The highest values correspond to a very high presence of dark particles (soot, dust and diesel exhaust particles).

To study the daily variation of the particles over the three-year period considered, days with no precipitation in which the mean value of absorbance or pollen grains-spores/m³/hour equals or is higher than the average of the whole period, have been selected.

3. Results and discussion

In the case of non-biological particles, whose concentration has been determined by spectrophotometry, we have obtained the diagrams corresponding to working days (Figure 1) on the one hand, and the ones corresponding to weekends on the other, during both winter and summer (Figures 2 and 3). The daily average absorbance value obtained for the three years has been 0.33. This value was slightly lower at winter weekends (0.31), but significantly higher at the summer ones (0.40).

Figure 1, in which working days are considered, shows an almost identical pattern of variation over the three years considered. All peaks are achieved in the morning, from 7.00 to 10.00h, as well as late in the evening, around 20.00h, with maximum values between 0.48 and 0.58 depending on the year. The lowest values are registered early in the morning between 4.00 and 5.00h (0.24 the first year, 0.25 the second and 0.22 the third), probably due to the condensing and also depositing effect that the high relative humidity of the air has on the particles at those hours. At noon a low value (0.29) was again detected.

It is evident that such a homogeneous pattern can only be due to constant daily activities. All possible emission sources were accurately checked: the occasional ones and those emitting particles of different nature from the one found in the samples were discarded.

Microscopy confirmed that most part of particles had a black colour and a non-organized structure, which was not of animal, vegetal or mineral kind. Therefore the particles were thought to be residues of partially burnt hydrocarbons, soot and ashes com-

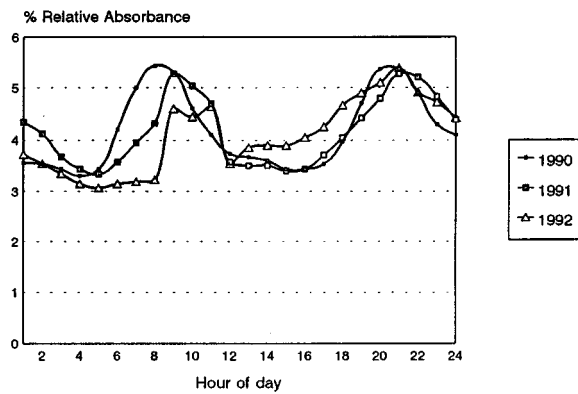


Figure 3. Diurnal variation of weekend spectrophotometrical absorbance. Summer pattern. Hourly mean values.

ing from the combustion engines of the vehicles. Our hypothesis seems then to be confirmed by the time pattern observed, the maximum absorbance peaks coinciding with the rush traffic hours, from 7.00 to 9.00 in the morning, that is, the beginning of the working day, and 20.00h. in the evening. Makinen (1978) already noticed daily variations in the content of dust in the atmosphere of Turku, which he related to human activities and movements of the populations twice a day.

In Figures 2 and 3, the intradiurnal variation corresponding to the weekends in two different seasons is shown. In the winter pattern (Figure 2) the values recorded early in the morning are high during certain years, the afternoon peaks have a higher intensity (above 5% of relative absorbance). The peaks obtained early in the morning may be due to the emissions by central heating plants. In the area considered thermal inversion of layers occurs quite frequently during winter (Torreño and Requena, 1997). This high atmospheric stability might impede the dispersion of particles and, as a consequence, an accumulation of them.

The evening peak shows values varying between 0.48 and 0.58 and occurs slightly earlier than that of the working days, probably owing to the kind of activities that people carry out at this time of the year, which include driving mainly within the city and returning back home soon before the sunset, at around 19.00h.

The summer diagram (Figure 3) is quite similar to that of the working days, although the morning maximum is recorded over a wider range of time. In some cases the evening peaks are delayed, until 21.00h. probably because, at this time of the year, people drive

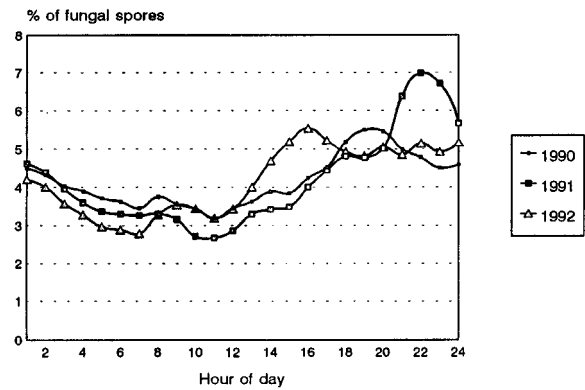


Figure 4. Diurnal variation of fungal spores in the air. Hourly mean values.

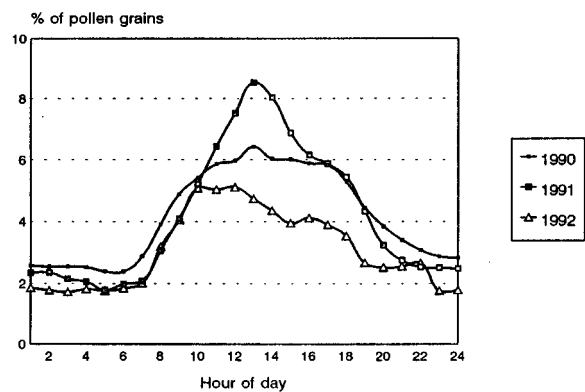


Figure 5. Diurnal variation of pollen grains in the air. Hourly mean values.

more often from inland cities to coastal areas. A longer journey, together with both a higher number of daylight hours and the longer stay inside the house as a consequence of the heat, delay the hour in which traffic in the city turns intense.

In the diurnal variation pattern for fungal spores (Figure 4) the maximum peaks are achieved in the afternoon, although at different hours from year to year: 19.00h in 1990, 22.00h in 1991, and 16.00h in 1992. This is probably due the species prevailing over the others. For this reason the late afternoon peaks coincide with the results obtained by Mediavilla (1995) for *Cladosporium* spores. Other authors have found only a single peak throughout the day (Padys et al., 1969) occurring at different hours and caused by the different climatic features of the area. The increase detected early in the morning, between 8.00–9.00h, may be due by the release of spores after the night interruption (Gregory, 1973).

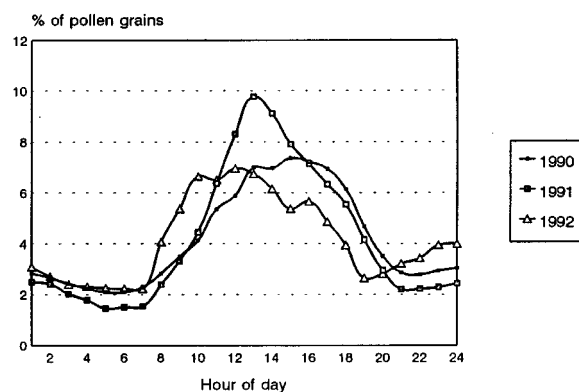


Figure 6. Diurnal variation of *Olea europaea* pollen in the air. Hourly mean values.

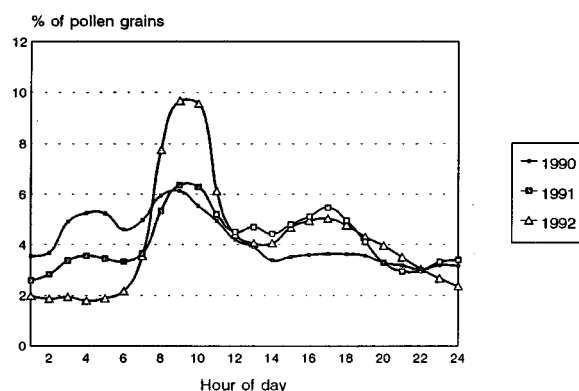


Figure 7. Diurnal variation of Grasses pollen in the air. Hourly mean values.

The concentration pattern followed by airborne pollen (Figure 5) presents a peak around noon and a minimum at night, which is a common behaviour for a great number of pollen types (Galán et al., 1991). The lowest values are measured early in the morning as a consequence of the negative effect of environmental humidity. This model, although very similar to the one obtained in relation to *Olea europaea* (Figure 6), differs greatly from the one obtained for grasses (Figure 7). The latter achieve the maximum peaks in the morning, around 9.00h. Some evening peaks and some peaks occurring early in the morning can be also observed and may be attributed to the great number of species belonging to this family.

Although the diagram has been worked out taking into account a great number of plant species, the pattern for the total amount of airborne pollen grains is usually marked by the daily variation shown by the most common species in the pollen spectrum. This is the case with the two pollen types that have been con-

sidered, as both constitute 80% of the total amount of pollen throughout the year, even though they are particularly abundant during spring time. In particular the olive pollen grains monitored in May 1991 accounted for 67.5% of the pollen totals of that year (Dominguez et al., 1993b).

4. Conclusions

Taking into account the diurnal variation followed by solid particles in the air, traffic seems to be responsible of the main emission source in a city like Córdoba, as the maximum concentrations coincide with the rush traffic hours during working days. Therefore these particles are thought to come from the partial combustion of the hydrocarbons utilised by vehicles, particularly the ones coming from diesel engines. At weekends, the peaks are still due to the traffic of vehicles in the city although the peak hours vary according to the period of the year taken into account.

In the case of biological particles, both pollen grains and spores show their minimum early in the morning, from 5.00 to 7.00h. The high relative humidity of the air during these hours, as well as the harmogate nature of the bioparticles, facilitate the absorption of water through their membranes making them heavier and favouring their deposition. For fungal spores peaks occur late in the afternoon, due to the climatic characteristics of the sampling area. For pollen grains instead, the highest concentrations are reached at midday. This variation is similar to the one obtained for *Olea europaea*, due to the high contribution of this pollen to the total amount of pollen throughout the year.

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