# Assessing the Necessity of Continuous Sampling for Understanding Hourly Pollen Concentration Variability ?

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## Abstract

Although considered a golden standard in aerobiology, continuous long-term sampling of bioaerosols is resource demanding. The aim of this study was to explore whether, if needed, intermittent sampling could replace continuous one without major loss of information. Hourly pollen concentrations obtained by averaging 56, 28, 14 and 7 equidistantly distributed 1.07-minute concentrations of *Ambrosia* airborne pollen were compared. The analysis revealed that majority of information on trends and magnitude in hourly concentrations is captured even if the sampling is not continuous. The correlations were high for all intermittent sampling arrangements, but absolute percentage error increased with the decrease of samples used for calculating hourly concentration.

*Keywords*: intermittent sampling, average hourly concentrations, saving resources, pollen measurements

Continuous sampling is the golden standard in aerobiology. Hirst type volumetric samplers allow obtaining hourly concentrations of measured particles (Hirst et al. 1952), which are then averaged to get daily concentrations (Galan et al. 2014). However, continuous sampling of high volumes and operation in environments with high quantity of suspended particles would lead to saturation of the sampling medium which limits the sampling time and prevents long term continuous monitoring. This is the most prominent in impactors and cyclone samplers where impaction surface is small (Cox and Wathes 1995).

Similarly, the resources of operational automatic bioaerosol monitors are limited. For example, BAA500 uses magazines for sample carriers (Oteros et al. 2015), while the life time of UV lasers, commonly used in automated flow cytometers like PAA-500 (Crouzy et al. 2016) and WIBS-4 (O'Connor et al. 2014) have limited number of shots. This notably increases the maintenance cost for measurements in conditions with high concentrations of airborne particles (e.g. vicinity of source) and during long-term monitoring. The aim of this study was to explore to what extent replacing continuous by intermittent sampling affects variability in hourly pollen concentrations.

The concentrations of *Ambrosia* airborne pollen, expressed as pollen grains per cubic metre of air (pg $m^{-3}$), were obtained from the experiment dedicated to exploring *Ambrosia* pollen emission characteristics (Sikoparija et al. 2018).

Measurements of airborne pollen concentrations at 0.5 m and 5.5 m above the *Ambrosia* pollen source allowed simultaneous collection of different quantities of suspended pollen in the atmosphere. The length of the sampling surface, the duration of sampling and the width of the sampling orifice determine the temporal resolution of collected samples. In commonly used Hirst type samplers (e.g. Lanzoni VPPS2000, Lanzoni VPPS2010, Burkard "Pollen and Spore trap", Burkard Scientific "Pollen and Spore trap", Burkard Scientific "SporeWatch") the perimeter of the drum that holds the tape for sampling is 336 mm and the sampling orifice is 14 mm x 2 mm.

Therefore, full drum rotation enables taking maximum168 temporally resolved samples, each being collected on 2mm length of sampling surface (336 mm / 2 mm = 168 samples of 2 mm).

Sampling was performed by using Burkard Scientific SporeWatch samplers in which clock device enables adjusting the time for full rotation of the drum. For 12 hours (6-12 AM CEST on 1st September 2015 and 6-12 AM CEST 2nd September 2015) the full rotation of the drum was set to 3 hours (180 minutes) which provided that each 2 mm of sampling surface corresponds to 1.07 minutes sampling (180 minutes / 168 samples = 1.07 minutes). As a result, 56 samples per hour (each giving 1.07-minute pollen concentration) were collected. Hourly pollen concentrations calculated by averaging 56, 28, 14 and 7 equidistantly distributed 1.07-minute concentrations were compared (Figure 1). Since Kolmogorov-Smirnov test confirmed normal distribution of analysed hourly concentrations, Pearson product-moment correlation coefficients (r) were calculated to asses direction and strength of relationships (i.e. simultaneous increase or decrease) between concentrations obtained by continuous sampling and those from averaging 28, 14 and 7 equidistantly distributed 1.07-minute concentrations. Paired sample t-test was used to compare difference in the quantity of pollen recorded by continuous and different intermittent sampling approaches. The difference in magnitude of hourly pollen concentrations was described by absolute percentage error (%). Its dependence from the quantity of pollen and coefficient of variation (%) in 1.07-minute values per hour was explored by regression analysis i.e. adjusted coefficient of determination (adjusted $R^2$) and probability (p) values.

Although earlier study of high-resolution pollen concentrations revealed notable variance in atmospheric pollen concentrations (Sikoparija et al. 2018), this variability is usually hidden by averaging data to 1-hour resolution. There is notably less pollen recorded at 5.5m above the source but the signal correlated to values recorded below at 0.5m above the source (Figure 2). The analysed hours captured the range of variability in the magnitude of hourly pollen concentrations, from 101 pg $m^{-3}$ to 46948 pg $m^{-3}$. Hours with both high (280%) and low coefficient of variation (85%) of 1.07-minute concentrations were explored. Also, hours when no pollen is recorded in

more than half 1.07-minute concentrations were analysed. The comparison of average hourly concentrations confirmed that majority of information on trends and magnitude is captured even if the sampling is not continuous.

The analysis revealed high positive statistically significant correlations between hourly concentrations obtained by continuous sampling and those obtained by equidistant 28 samples (Pearson r = 0.993), 14 samples (Pearson r =0.970) and 7 samples (Pearson r =0.849) per hour, but as expected the correlation decreases with the decrease in number of samples taken for calculating average hourly concentration. In addition, paired sample t-test confirmed that the differences in the average pollen concentrations obtained by continuous and intermittent sampling were not statistically significant. Absolute percentage error increased with the decrease of samples used for calculating hourly concentration, on average 10%, 20% and 39% for 28, 14 and 7 samples per hour respectively. We observed the highest absolute percentage error of 143% for the case of 7 samples per hour. Further, regression analysis showed that the absolute percentage error does not depend on the amount of pollen in the air but for all intermittent sampling approaches it depends on the degree of variation in 1.07-minute concentrations during hour (Figure 3).

This study confirmed that for assessment hourly pollen concentrations, continuous sampling can be replaced by intermittent one. Already 14, equidistantly arranged, 1.07-minute samples per hour were enough for capturing both the magnitude and the trends of hourly *Ambrosia* pollen concentrations. The effect of sampling on hourly pollen concentrations should be confirmed for other pollen types, but already these results support intermittent sampling as the mean for saving resources (e.g. laser shots, sample carriers, sampling medium) in long term aerobiological monitoring.

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