

Pollen Aerobiological Monitoring with the personal volumetric air sampler (PVAS). Correlation with a fixed Hirst type sampling station

23713

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SUMMARY. Monitorings both with a fixed Hirst type volumetric sampler, placed on the balcony of the Medicine Division in Lanciano City Hospital and with a portable volumetric sampler PVAS type by Burkard, placed outside the dwelling-houses of the examined patients have been carried out simultaneously. This has given us further information about the quantity of pollen that single patients affected by pollinosis inhale. Preliminary controls on the capture efficiency of both samplers have been conducted. The results of this survey have shown that the symptom score cards of the eight patients enrolled for the study, have always been well correlated with the average daily pollen concentration of the fixed station (Pearson correlation), and the data obtained by the two samplers have pointed out remarkable differences in the pollen concentration. According to the PVAS, placed near patients, the concentrations were twofold to sixfold as compared to those of the fixed station. This was probably due to the different height of the samplers. However, owing to the short sampling time (30 min.), we aren't able to draw any conclusions. Nevertheless we do hope that more and more patients will undergo this test, so that with several daily surveys over longer periods, we will have more information on the real pollen exposure of single patients. We will verify the threshold of symptoms onset, which is only theoretical nowadays, in the monosensitized patients. Such a program will allow us to carry on useful research both in the respiratory physiopathological and in the allergological fields.

Key words: aerobiological monitoring, P.V.A.S., pollination.

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INTRODUCTION

The aerobiological pollen monitoring performed with Hirst type volumetric samplers is of great help in the clinical studies of patients affected by pollinosis. In fact with these samplers it is possible to measure the pollen airborne concentrations, expressed in grain per m^3 of air, just at the patients' working place.

These parameters are extremely useful to evaluate the symptoms, and carry out the aetiological diagnosis on the patients affected by pollinosis living in the territory where the sampler is located or in other sites geographically and climatically similar.

Clinical controls performed during these years have pointed out that the symptoms score card of patients can be correlated, in most cases, with the daily pollen average values monitored. However, the quantity of pollen inhaled by single patients varies both in quality and mostly in quantity compared to the data obtained at the fixed station. The exposure difference is linked both with the movement of the patient in the area and with biological factors, too. Thus pollen grains are not uniformly distributed in the atmosphere because of the different vegetation producing different pollen concentration according to the urban areas in which the patients are.

In order to gain exhaustive information about the quantity of pollen inhaled by a single patient, a portable volumetric sampler can be used. Patients were given this PVAS so that the investigation could be completed in a useful and dynamic way. The pollen concentration monitored by these appliances, placed either at the patient's house or at his working-site or in those places where patients mostly complain of allergy symptoms, reflect in a more reliable way the real exposure of the patients.

The different pollen concentration detected with the portable sampler, and the fixed ref-

erence station confirms the difference in exposure. Pollen concentrations close to the daily average exposure of the patient can be obtained by performing careful and repeated monitoring. The correlation of these parameters with the symptom score card allows us to obtain only theoretical data on the symptoms threshold (rhinitis and/or asthma).

We have carried out an aerobiological and clinical survey with a portable sampler to verify some of these hypotheses and to standardize a methodology for the utilization of these apparatuses.

MATERIALS AND METHODS

A study has been carried out, using along with the fixed station, a Burkard Personal Volumetric air sampler (PVAS). Preliminarily, a flow meter was used to ascertain that the PVAS aspiration flow corresponded to the standard of 10 liters of air/minute. Then the PVAS aspiration capture efficiency was checked and the aspiration flow was registered until the complete battery exhaustion (Fig. 1a). This happened both on a humid and cold day (temp. 7°C, R.H. 75%) and on a mild day (temp. 18°C, R.H. 62%).

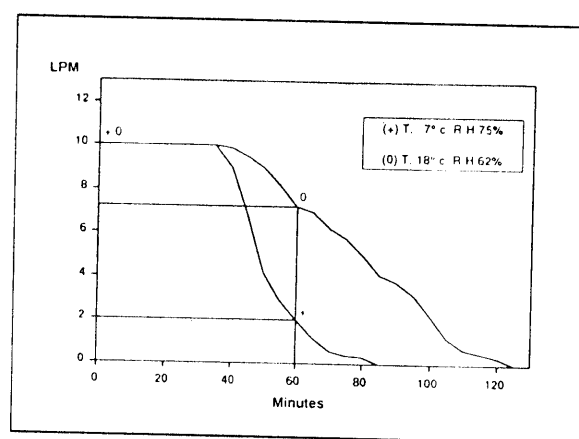


Figure 1a. Aspiration flow of a Burkard personal volumetric air sampler (PVAS).

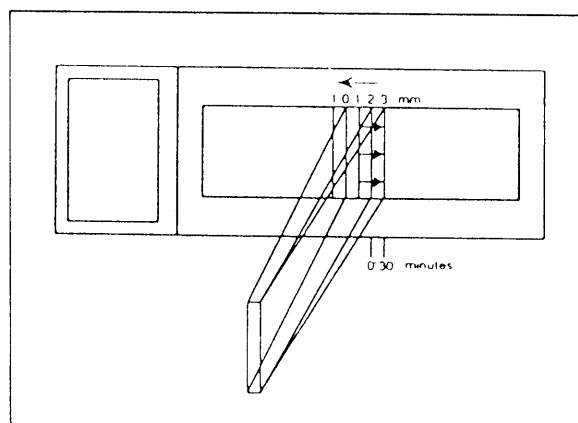


Figure 1b.

The sampling which such appliance was carried out at a constant volume of ten liters of air per minute for thirty minutes. A flow decrease to 7.5 liters per minute on a mild day and to 2 liters per minute on a cold/humid day was observed after one hour. The apparatus ceased working after one hour and a half, two hours after being switched on.

The sampling was carried out on a slide utilizing silicone fluid as adhesive coating. The reading of the sampled surface was performed with a light microscope after a treatment with glycerin jelly and basic fuchsin. The next step was to verify whether the data obtained using the PVAS overlapped or could be correlated with a fixed VAS. Placing the two air samplers on the same terrace, the results of a sampling lasting 30 minutes were compared using each time a new melinex strip on the VAS and counting by means of a light microscope all pollen grains present on both slides.

On the slides mounted on the PVAS the pollen grains were distributed on an area of approximately 1.5*14 mm., while those mounted on the fixed VAS covered a greater area (3*14 mm) since the melinex strip rotates at a speed of 2 mm./hour. In 30 min. 1 mm. is covered and pollen grains are settled on a 3 mm strip.

The results obtained are reported in Tab. I. In this table the values of the total pollen count and grain concentration per cubic meter of air of both air samplers are given. The values have been analyzed with 2-way Anova with repeated measures using SAS statistical package (SAS Institute, Cary, NC).

Table I. 30 minutes data comparison between a fixed V.A.S. and a portable volumetric air sampler located at the same site, on 3 different days.

	Total pollen count		Grain concentration per m ³ of air	
	Fixed V.A.S.	P.V.A.S.	Fixed V.A.S.	P.V.A.S.
07-04-90				
time 10-10.30				
Fagaceae	16	13	52.8	42.9
Graminaceae	1	2	3.3	6.6
Urticaceae	5	6	16.5	19.8
Cupressaceae	4	2	13.2	6.6
Corylaceae	1	0	3.3	0.0
Salicaceae	3	5	9.9	16.5
08-04-90				
time 10-10.30				
Fagaceae	23	19	75.9	62.7
Graminaceae	11	8	36.3	26.4
Urticaceae	18	15	59.4	49.5
Cupressaceae	16	12	52.8	39.6
Corylaceae	0	0	0	0
Salicaceae	1	0	3.3	0
13-04-90				
time 11.30-12				
Fagaceae	4	2	13.2	6.6
Graminaceae	1	2	3.3	6.6
Urticaceae	4	6	13.2	19.8
Cupressaceae	2	1	6.6	3.3
Corylaceae	0	0	0	0
Salicaceae	3	25	9.9	16.5

However, this comparative model was not adopted in routine allergic patient monitoring practice since the sampling strip could not be replaced each time the study was performed. It was therefore necessary to make a comparison with the strip used for ordinary weekly sampling. Following this outline every Monday, before the weekly pollen count of the fixed station was performed, the starting point of the comparative sampling was identified on the melinex

strip with a ruler positioning the samplers close to each other on the same balcony. By means of a microscope it was possible to verify that the better data correspondence was obtained reading on the Melinex strip a well defined 3*14 mm area and dividing the data obtained by three. Owing to the strip rotation, both the pollens collected during the sampling time close to this investigation (30 min.) as well as those sampled during the preceding and the following 30 minutes were present. The data obtained in this way from the fixed VAS are actually the average values referring to one hour and a half sampling but they are fairly comparable to the pollen counts obtained from the PVAS. This comparison takes into account a variability factor that depends on the weather during the thirty minutes preceding the comparative sampling and the following ones but which can be certainly considered as neglectable when referred to the short sampling time. This comparison offers the possibility to integrate the pollen count of a fixed station with other parameters necessary to study allergic patients from the clinical point of view. For the clinical survey 8 patients, affected by pollinosis, were enrolled. Four of these were allergic to Urticaceae and four to Gramineae. They were all resident of Lanciano's area and diagnosed from the allergological point of view with in-vivo and in-vitro tests. They have had severe symptoms in their dwelling-places. These patients were then given a diary and being told to note down the allergic symptom score and simultaneously they had to turn on the PVAS when they were more heavily affected by symptoms. Sampling had to be carried out for 30 minutes recording the starting sampling time on the house's balcony at a minimum height of two meters above ground level. The patients was recommended to be very close to the air sampler during the above-mentioned 30 minutes.

The apparatus had to be given back as soon as possible, so the sampled slide could be with-

drawn, batteries could be recharged and the working efficiency controlled for further use. Slide reading was performed on Mondays afternoon together with the strip sampled in the fixed station. The correlation between the symptom score card and the daily pollen average concentration of the fixed station was then evaluated. The data obtained for every patient have been graphically represented and hence the Pearson correlation coefficient has been calculated. Thanks to it we quantified the correlation degree existing between the two variables to evaluate the meaning of the association itself. Pearson correlation coefficient is an index with values included in the interval -1 and $+1$.

As far as the coefficient value is concerned, the nearer to the unit, the higher is the link between the variables. Positive values show a direct association, that's to say if the values of a variable are enhanced, the values of the other do the same. Negative values show the opposite association, as a variable is enhanced the other decrease. Data corresponding to patients affected by allergies to Gramineae have been studied with the ALLFIT program that is specific for the treatment of those data relating to dose/response curves. By the term dose/response curves we mean those groups of symmetrical sigmoidal curves equipped with a plateau for the response to dose 0, and one for the response to an infinite dose and a central phase of an almost linear trend. This type of curve is described by

$$\text{the equation } y = \frac{a - d}{1 + (x/c)^b} + d \text{ where «y»}$$

stands for the awaited response, «x» stands for the concentration or dose, the parameter «a» is for the highest response and the parameter «d» is for the lowest one. The parameter «b» corresponds to the angular coefficient of the tangent in «d» point of the central phase.

Parameter «c» corresponds to ED50, namely to the necessary concentration to have 50% of responses between the «a» and «d» values. The

program has been developed in such a way to allow the contemporary study of curve groups. Several choices for the initial conditions exist for this analysis.

The random implementation of initial parameters «a, b, c, d» can be shared by the curves group or individually calculated for each of them. At the beginning of the analysis of the curve's group, parameters are always calculated individually. From the value detected in this first step it is possible to decide if curves must share all or some of the parameters.

E.g. we can choose to share parameters «a» and «d» concerning the plateau if results are similar, as well as it is possible to share parameter «b» so that central phases of all curves are parallel.

RESULTS

1) Upon assessment of the same capture efficiency for both samplers, the statistical test, used to analyze pollen count and concentration data (Tab. I, II), revealed no-statistically differences between the two data sets referred both to the pollen count of one single day and for the following trials.

2) Examined clinical cases emphasize a high concordance between the symptom score cards of patients and the average daily pollen concentration of the fixed station (Fig. 2, Fig. 4). The value of the Pearson index correlation «r» correlation is between 0.65-0.70 for the symptoms and pollen concentrations of *Parietaria officinalis* L. (Urticaceae). The correlation between symptoms scores of patients allergic to Gramineae and the daily pollen average concentration monitored by the fixed apparatus is higher, with «r» value between 0.80 and 0.90 allowing us to consider such a situation as dose/response effect where the dose is represented by the pollen concentration and the response by the symptoms of allergic patients (Fig. 3).

Table II. Comparative data between a fixed V.A.S. equipped with weekly sampling strip and a personal volumetric air sampler located at the same site.

	Total pollen count		Grain concentration per m ³ of air	
	Fixed V.A.S.	P.V.A.S.	Fixed V.A.S.	P.V.A.S.
20-04-90 time 12.30-13				
Fagaceae	2	1	6.6	3.3
Graminaceae	1	2	3.3	6.6
Urticaceae	7	9	23.1	29.7
Cupressaceae	1	0	3.3	0
Corylaceae	0	0	0	0
Salicaceae	0	0	0	0
26-04-90 time 10.30-11				
Fagaceae	15	11	49.5	36.3
Graminaceae	3	1	9.9	3.3
Urticaceae	22	25	72.6	82.5
Cupressaceae	2	3	6.6	9.9
Corylaceae	0	0	0	0
Salicaceae	2	1	6.6	3.3
13-04-90 time 11.30-12				
Fagaceae	2	0	6.6	0
Graminaceae	6	3	19.8	9.9
Urticaceae	9	12	29.7	39.6
Cupressaceae	7	5	23.1	16.5
Corylaceae	0	0	0	0
Salicaceae	1	0	3.3	0

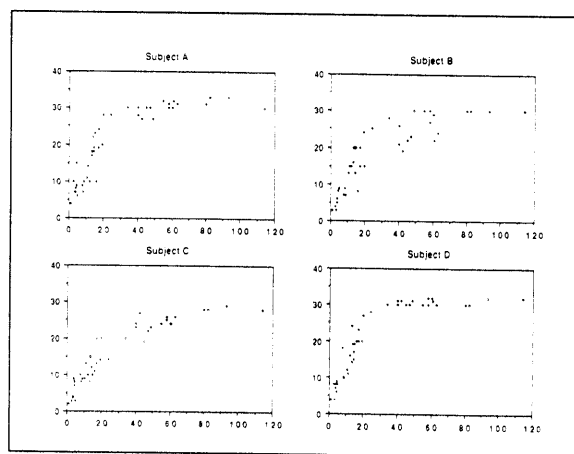


Figure 2. Gramineae daily average concentration and symptom score.

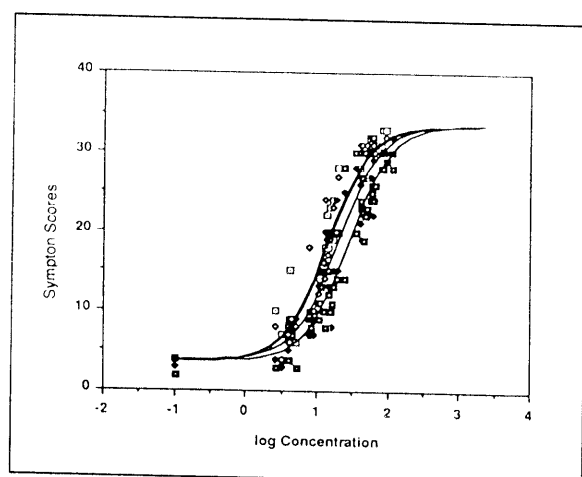


Figure 3. Gramineae concentration and symptom scores.

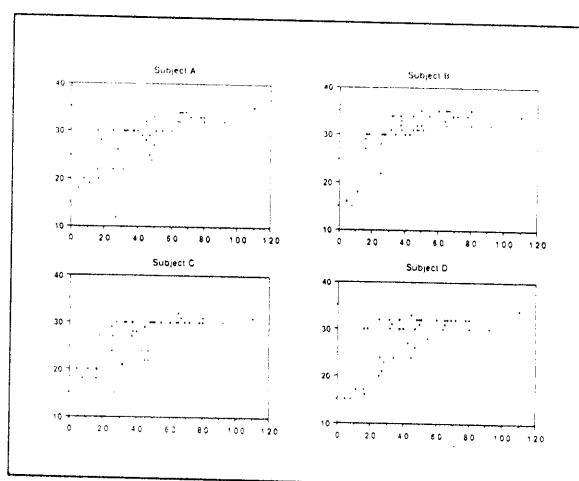


Figure 4. Parietaria daily average concentration and symptom score.

In the first step, data have been analyzed so that the implementation of parameters «a, b, c, d» was done individually for each curve. The data obtained led us to share parameter «d» in the second step, and to share parameter «b» every time with similar results (Tab. III).

These have allowed us to state that the last analysis, that's to say the one where parameters «a, b, d» have been shared (same plateau with dose 0, with infinite dose and parallelism of the central phase for all the curves) resulted to be the best one. Therefore the data are well represented by curves of the dose/response type, and there is a real relationship between the concentration (or dose) of stimuli that the patients undergo and the symptoms they feel. Moreover sharing parameters allows us to state that the highest and lowest values and the trend of symptoms during the test are the same for all the subjects. The pollen concentration detected by PVAS on severe allergic symptoms onset is very high on the average, from twofold to sixfold compared to the values recorded over the same sampling period by the fixed station. According to these preliminary data it is possible to state that the pollen monitoring with PVAS is extremely useful to verify the pollen exposure to the patient during the day. If such a survey is often carried out during the day and, for several weeks, we would be able to obtain information (real exposure, etc...) which is extremely useful

Table III. Test for reliability of various models.

Curves	Parameters Shared							
	None							
	F	P	All d		All a, b		All a, b, d	
			F	P	F	P	F	P
1	1.14	0.5484	1.14	0.579	1.21	0.426	1.26	0.336
2	1.85	0.012	1.84	0.012	1.81	0.014	1.66	0.036
3	0.63	0.062	0.64	0.068	0.63	0.056	0.59	0.028
4	0.61	0.046	0.61	0.044	0.58	0.024	0.67	0.098

both in the respiratory physiopathological and in allergological fields. The survey we performed reflects only one of the operational aspects of these PVAS which in monosensitized patients is essentially the *quantitative* respiratory troubles due to close presence of plants whose pollen production had to be verified. From the allergological point of view we must study also patients with *qualitative* sensitization problems, namely severe pollinosis linked with the presence of anemophilous and entomophilous pollens that are not sufficiently monitored with the fixed station sampling and often not tested. The aerobiological information obtained plays an important role for better interpreting the symptoms and to perform easier aetiological diagnosis.

The only disadvantages of PVAS are the following: short operation time, namely only thirty minutes at the volumetric sampling standard of ten liters of air per minute due to the battery exhaustion; long charging period of approximately 12 hours. In fact this allows a daily sampling

only. However, apparatuses equipped with rechargeable nickel cadmium batteries lasting four hours are being manufactured. Thanks to them it will be possible to perform even multiple samplings all day long, for example two hours in the morning and two hours in the afternoon, if necessary also in a different environment by simply replacing only the slide. Therefore the allergic patient can be studied through data that correspond more and more to the natural volumetric sampler, the respiratory tract. Such new knowledge will be useful and necessary to perform more correct diagnosis and treatment.

REFERENCES

- DE LAN A., MUNSON P.J., RODBARD D., (1978) — *Simultaneous analysis of families of sigmoidal dose-response curves: application to bioassay, radioligand assay, and physiological dose-response curves*. Am. J. Physiol., **235**:E97-E102.
- SAS Institute Inc. SAS/STAT User's Guide, Version 6, fourth edition, Cary NC: SAS Institute Inc., 1989.