# Fully Automized System for Pollen ConcentrationMeasurement in Ambient Air

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**Abstract** − For the first time a fully automated system for the analysis of pollen concentration in ambient air has been built and was successfully tested. Principle of operation, range of application and present status of performance are described. The technology used in the system has the potential for further applications in the analysis of other airborne particles.

**Keywords** : bioaerosols , pollen concentration, pollen forecast, automatic measurement,

## 1. INTRODUCTION

In the recent years, pollen allergies have become a wide-spread disease. Every year during the blossoming season, about 12 million citizens of the Federal Republic of Germany alone (every seventh person!) suffer from acute symptoms that may reach from allergic rhinitis to life-threatening anaphylactic shocks. For their daily routine, allergic persons strongly depend on up-to-date information on pollen counts in their area, e. g. to adjust their daily medications or behaviour.

Pollen allergies are caused by airborne pollen, and the state-of-the-art technique for counting the various pollen taxa is the so-called Burkard trap. These units take in ambient air and guide it onto a piece of adhesive tape where pollen and other aerosole particles are deposited. The tape will be analyzed by human operators under a light microscope. This kind of analysis requires a high degree of experience and concentration, which – due to the ubiquitous human factor – cannot always be guaranteed. Some pollen taxa differ from their sizes alone, which cover a range between about 10 µm to 150 µm, others can only be discriminated by judging minute details. As this is a time-consuming analysis, the daily pollen information to patients will thus rely on data from the previous day.

## 2. INNOVATION AND TECHNICAL SOLUTION

This work describes the pollen monitoring system BAA500, realized by the Helmut Hund GmbH, Wetzlar, in cooperation with the Fraunhofer Institute for Applied Information Technology (FIT), Sankt Augustin, and with the Fraunhofer Institute for Toxicology and Experimental Medicine (ITEM), Hannover (Fig. 1).

**Fig. 1:** Hund pollen monitoring system BAA500

Equipped with an automated pollen deposition and handling system and with an automated microscope in combination with an image analysis system, the BAA500 is capable of determining and counting six allergologically relevant pollen taxa and, at the present stage, 14 taxa that have no allergological effect, as well as 5 types of particles of other provenances (spores,fibers) , compare table 1.

The aerosoles are sampled (according to size) in a three-stage virtual impactor. Its aerodynamic design ensures that all particles with aerodynamical diameters of more than 11 µm are deposited onto a specimen carrier. This carrier uses a humidity stabilized gel cushion to pick up and immobilize the aerosole particles.

In the first step of analysis the cushion is heated to melting, making sure that all particles sticking to the surface sink into the gel and are separated to individuals (surface tension driven). After this, the sample is ready for analysis by an automated 3D-microscope.

| Allergologically relevant | Allergologically not relevant |
|---|---|
| Hazel (Corylus) | Maple (Acer) |
| Alder (Alnus) | Beech (Fagus) |
| Birch (Betula) | Yew (Taxus) |
| Grass without Rye (Poaceae) | Oak (Quercus) |
| Mugwort (Artemisia) | Hornbeam (Carpinus) |
| Ragweed (Ambrosia) | Rye (Secale) |
| | Willow (Salix) |
| | Cottonwood |
| | Sycamore |
| | Ash |
| | Nettle |
| | Plantain |
| | Goosefoot |

**Tab. 1:** Pollen taxa determined and counted by the pollen monitoring system.

The microscopic image is taken using a semiplanachromatic objective SPL 20/0.50 (Hund) and a ½” CCD camera with a resolution of 1.2 megapixels . The sample is illuminated with an LED at 530 nm wavelength and a microscope condenser with NA 0.9. With a scanning stage stacks of 70 images with a z-distance of 1.5 µm are recorded. For a full coverage of the sampling area, a grid of 350 of these stacks has to be taken.

In the first image analysis step the data of each image stack are reduced by optimizing the contrast across all images and combining the result in one synthetic 2D-image. This image contains all layers of maximum sharpness in the single images. Figure 2 shows an example for a single image in the plane of maximum sharpness, Fig. 3 the corresponding synthetic image with the background deleted. From these synthetic images, all aerosole particles (objects) are extracted in a two-step segmentation process. Afterwards, the classification algorithm calculates 70 different form- and texture features. Based on these feature vectors, the objects are classified by the trained classificator (Fig. 4).

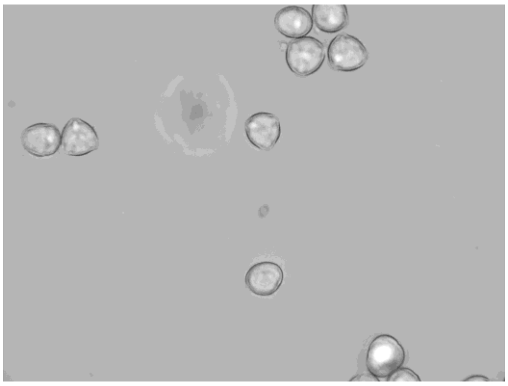

**Fig. 2:** Single stack image, plane of maximum sharpness.

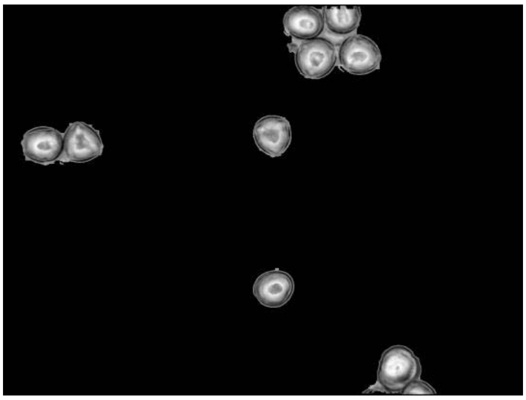

**Fig. 3:** Synthetic image.

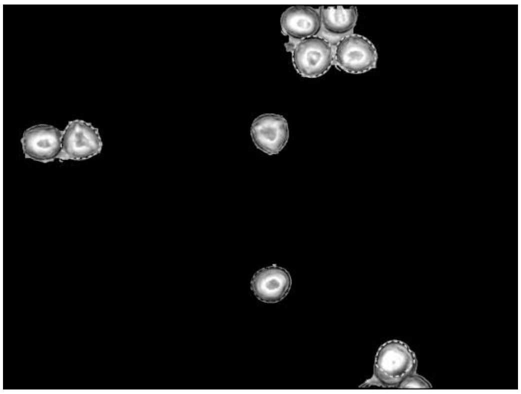

**Fig. 4:** Synthetic image with segmented and classified pollen (dashed contours).

The sampling intervals of the Pollen Monitor can be adjusted by the operator and can take any value starting from one hour. The device thus consumes a maximum of 24 sample carriers per day which are stored in a reusable magazine cassette. The total number of sample carriers guarantees autonomous operation over a time interval of two weeks at 1 sample/h. The two magazine cassettes containing new and used sample carriers, respectively, can easily be changed by the operating personnel.

## 3. RESULTS

The training of the classicator was done in the blossoming seasons 2010/2011 with natural pollen samples. Up to now data of more than 50,000 individuals have become part of the training basis in the recognition software. Figures 2 – 4 show typical images from these training procedures.

Results on the presently reached reliability of the classification process are given in Tab. 2. The relevant statistical measures are:

$$RECALL = \frac{Number(correctly\ classified\ pollen)}{Number(pollen\ classified\ by\ human)}$$

$$PRECISION = \frac{Number(correctly\ classified\ pollen)}{Number(pollen\ classified\ by\ computer)}$$

| | Precision % | Recall % |
|---|---|---|
| | | |
| Hazel | 87 | 96 |
| Alder | 99 | 96 |
| Birch | 93 | 92 |
| Grass | 88 | 91 |
| Mugwort | 39 | 66 |
| Hogweed | 97 | 81 |
| | | |

**Tab. 2:** Test results of classification pro-cess in case of allergologically relevant taxa

To guarantee these results, however, quality assurance of the overall process from air intake to classification is mandatory. This is why the evaluation and the improvement of the quality of the entire analysis is an ongoing project. Significant improvement is expected for mugwort, where the training basis will be improved in the 2011 season.

Pollen counts for the 2010 season at our company in Wetzlar/Germany are depicted in Figure 5.

## 4. DISCUSSION

With the BAA500, the first fully-automated pollen counter has been introduced into the market. It is designed to operate autonomously over 24 hours a day and 7 days a week. Its supply of sample carriers allows continuous operation for a period of more than two weeks before new magazine cassettes have to be inserted. The device is designed to work in a network of several pollen monitoring systems with which a spatially resolved pollen count will be possible

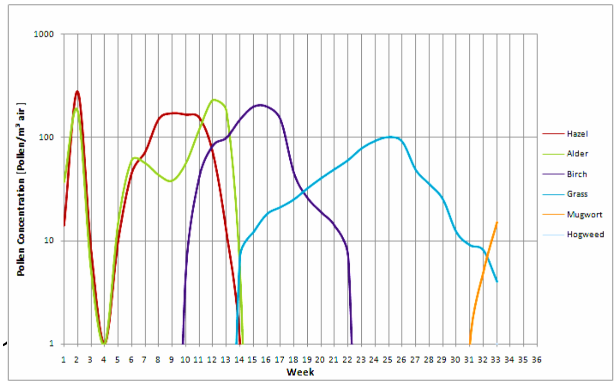


**Fig. 5:** Pollen concentration data for the 2010 season in Wetzlar/Germany

With the short time interval required to yield a counting result, the BAA500 will now allow reliable pollen forecasts with a significantly higher frequency (a higher level of actuality) in comparison to conventional methods.

The technology of BAA 500 is potentially capable of analyzing other bioaerosoles and should be applicable to such applications with a comparably small effort