Universität Salzburg

Department of Materials Engineering and Physics - Division of Physics and Biophysics
Radiation and Environmental Biophysics Working Group

Experimental Investigations of Sensitivity of Lichens to Diesel Exhaust under Laboratory Conditions

EAC-2012 Granada European Aerosol Conference 2-7 Sept 2012

U. Langmann[1], G. Brunauer[1], R. Türk[1], W. Hofmann[2], P. Madl[2]

[1]Department of Organismic Biology, University of Salzburg, A-5020 Salzburg, Austria
[2]Department of Materials Research & Physics – Division of Physics and Biophysics - Working Group of Radiation and Environmental Biophysics, University of Salzburg, A-5020 Salzburg, Austria

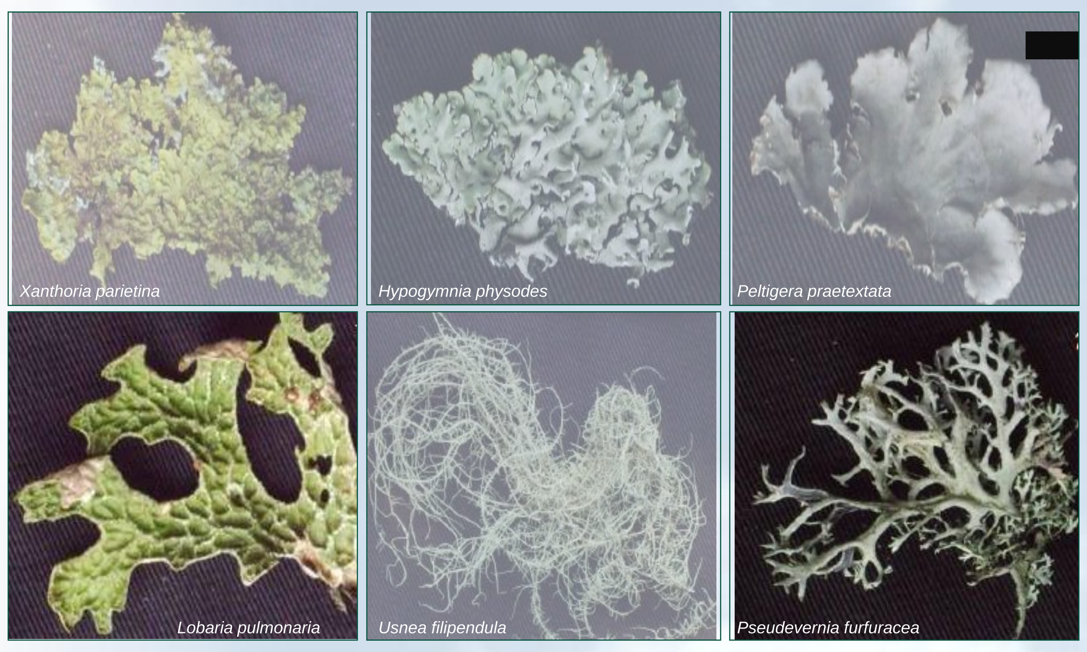


Fig. 1: lichen samples:
Xanthoria parietina, Hypogymnia physodes, Peltigera praetextata (cyanobaterial lichen), *Lobaria pulmonaria, Usnea filipendula, Pseudevernia furfuracea*

Abstract

Lichens are reliable indicators for air pollution as the lichen vegetation reacts very sensitively to an increased exposure to atmospherically generated nitrogen-compounds as well as to traffic exhaust and other airborne pollutants. Especially the noxious effects of diesel exhaust are hotly debated. In the present study we are investigating the effects of diesel exhaust on the symbionts of six lichen species with different pollutant sensitivity (Fig. 1). We measured chlorophyll fluorescence to detect changes in the efficiency of photochemical reactions; in parallel CO_2-exchange rates were recorded to monitor vitality. The investigations provided explicit data, which demonstrated the adverse effects on photosynthesis of the lichens' photobionts: First data suggested that diesel exhaust treatment notably affected the proton-gradient at the membrane between photosystem II and ATP-Synthase. The experiments also showed that treated lichens were able to recover to some extent during episodes of clean air exposure. - To our knowledge this is the first study measuring the impact of diesel exhaust on biomonitors under laboratory conditions excluding environmental factors that could incontrollably modulate the results.

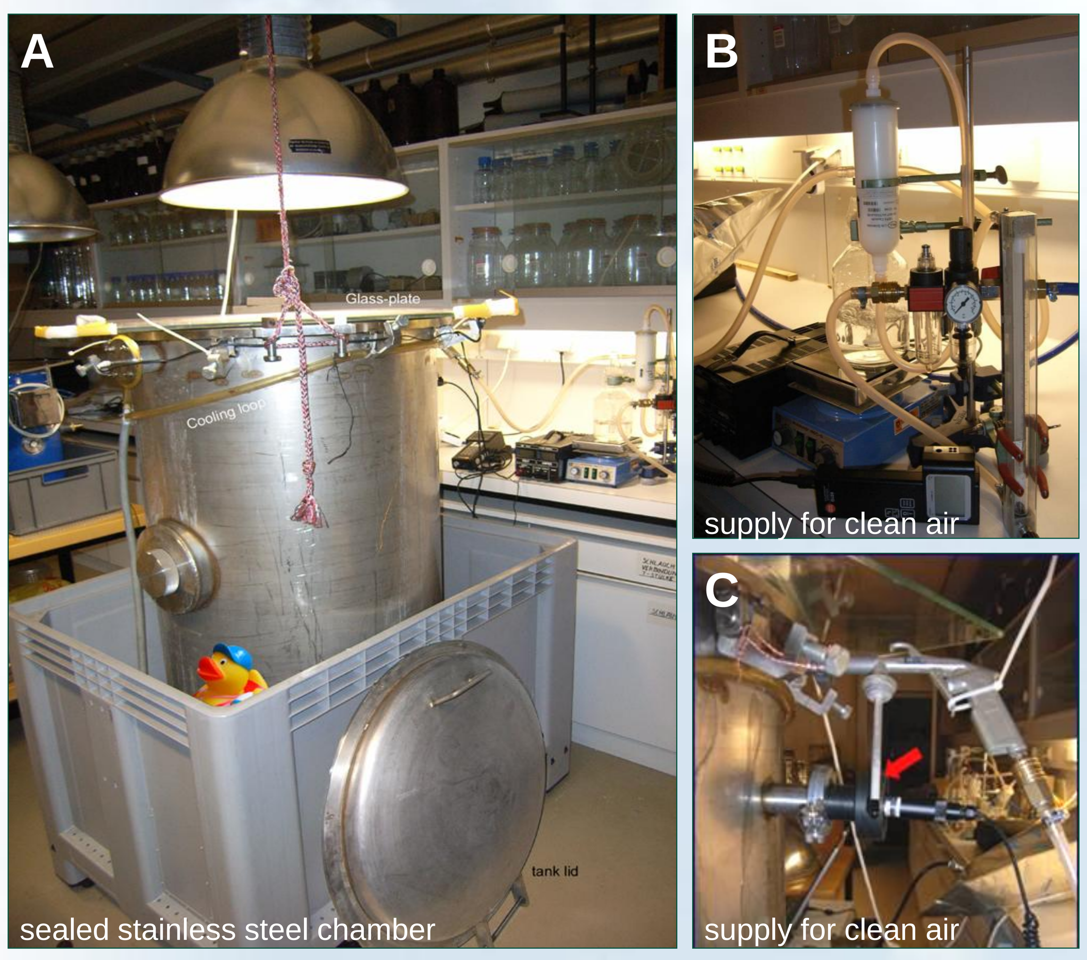


Fig. 2 A-C: Experimental setup

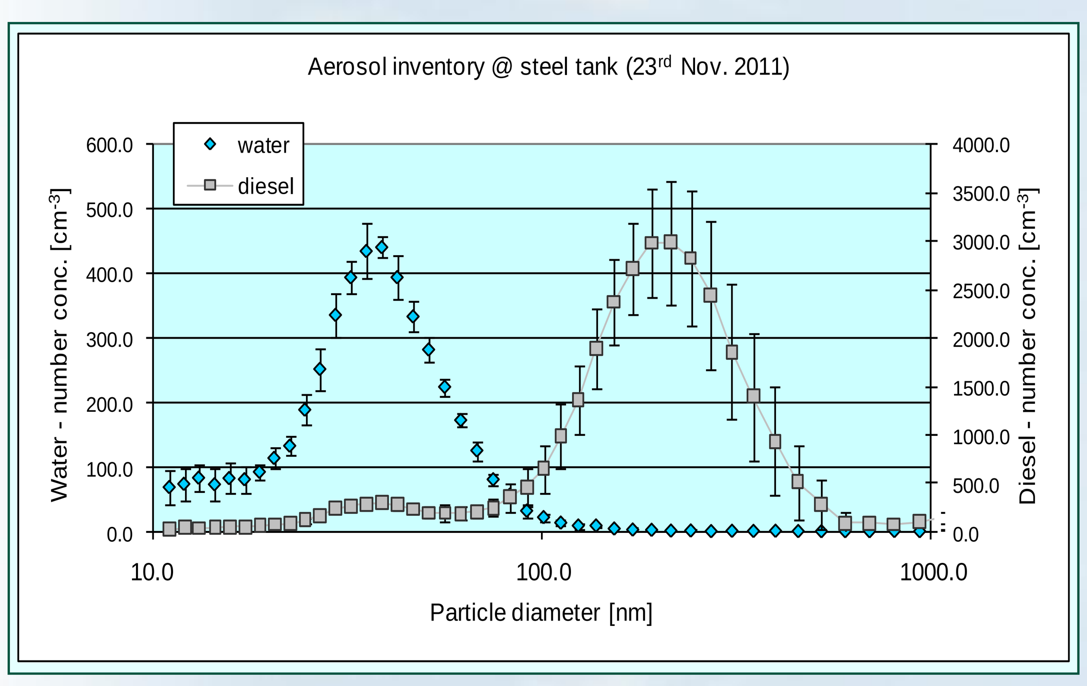


Fig. 4: Aerosol inventory in the steel chamber

Materials and Methods

Experimental setup (Fig. 2 A-C):

➢ Sealed stainless steel chamber approx 1 m³ volume.

The closed chamber guarantees the exclusion of other influences than diesel exhaust.

➢ light source at the top: Master HPI-Plus 400 W/745 HOR E40 lamp; day phase: 10 hours, night phase: 14 hours

➢ at the side: Tedlar-bag with freshly harvested diesel exhaust from a VW transporter T5 TDI LR respectively clean air

➢ in front: opening for the net with lichen-samples

Measurements (Fig 3 A-D):

➢ Particle inventory of humidified air (GMD @ 50 nm); diesel exhaust particles (with a GMD @ 350 nm) measured with an SMPS

➢ photosynthetic activity of lichens measured by chlorophyll fluorescence with WALZ Imaging-PAM and WALZ Mini-PAM

➢ Vitality of lichens determined by CO_2 gas exchange measurements

➢ measurements for three weeks simulating the rhythmic rush hour cycles of a local highway with typical diesel-particle-concentration (Fig. 4 and Fig. 5).

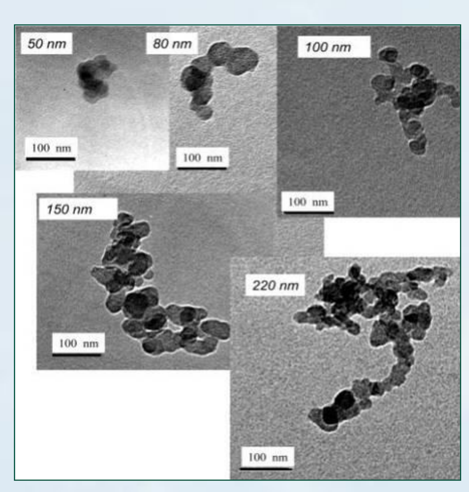
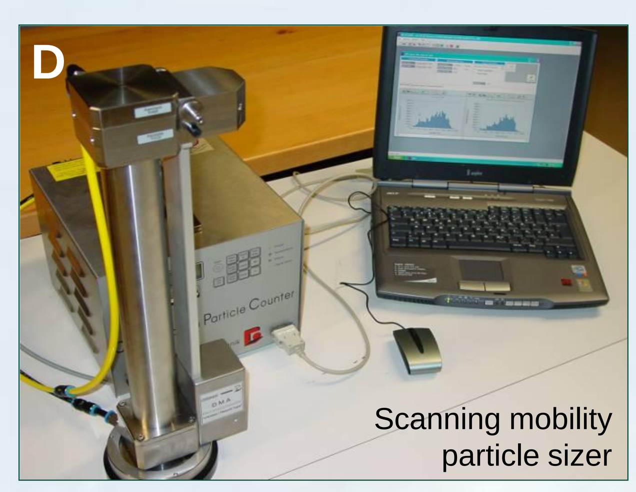


Fig. 5: Diesel particles (K. Park, 2003)



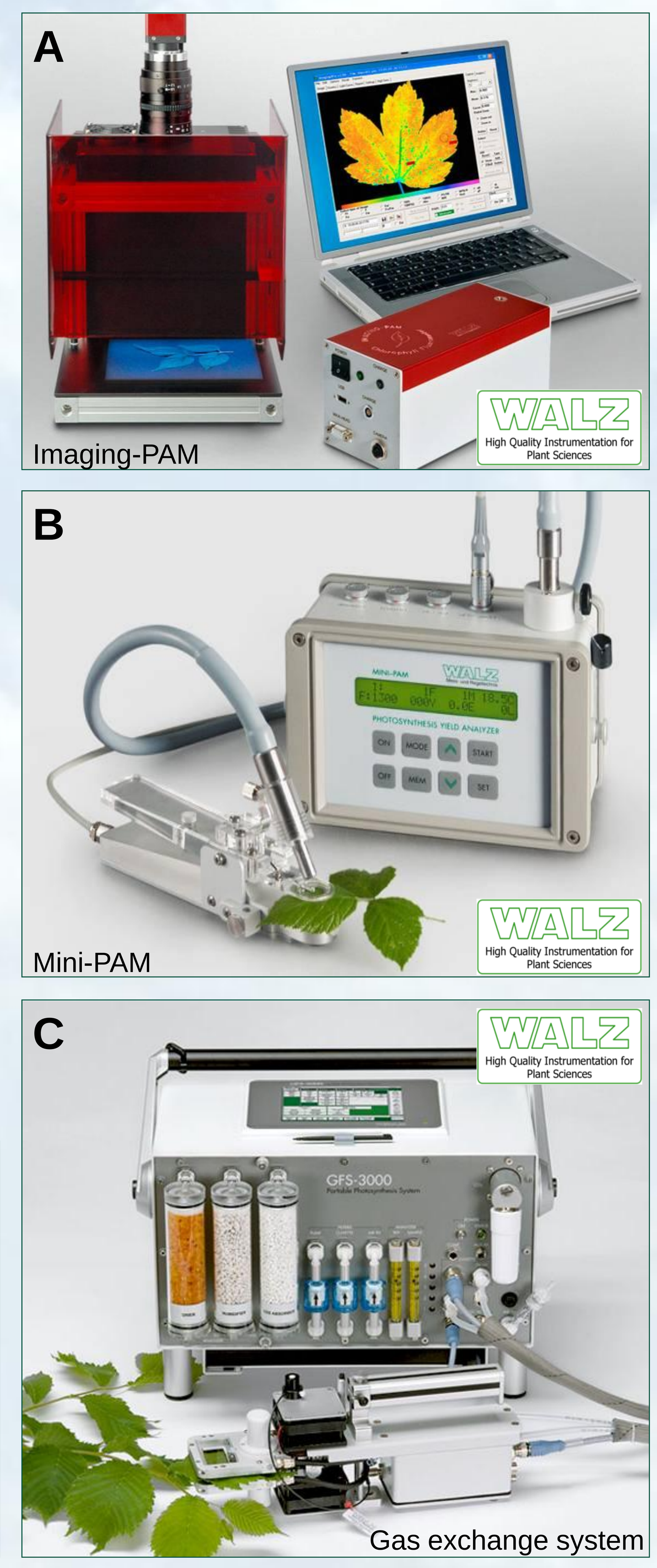


Fig. 3 A-D: Measuring setup

Results and Discussion

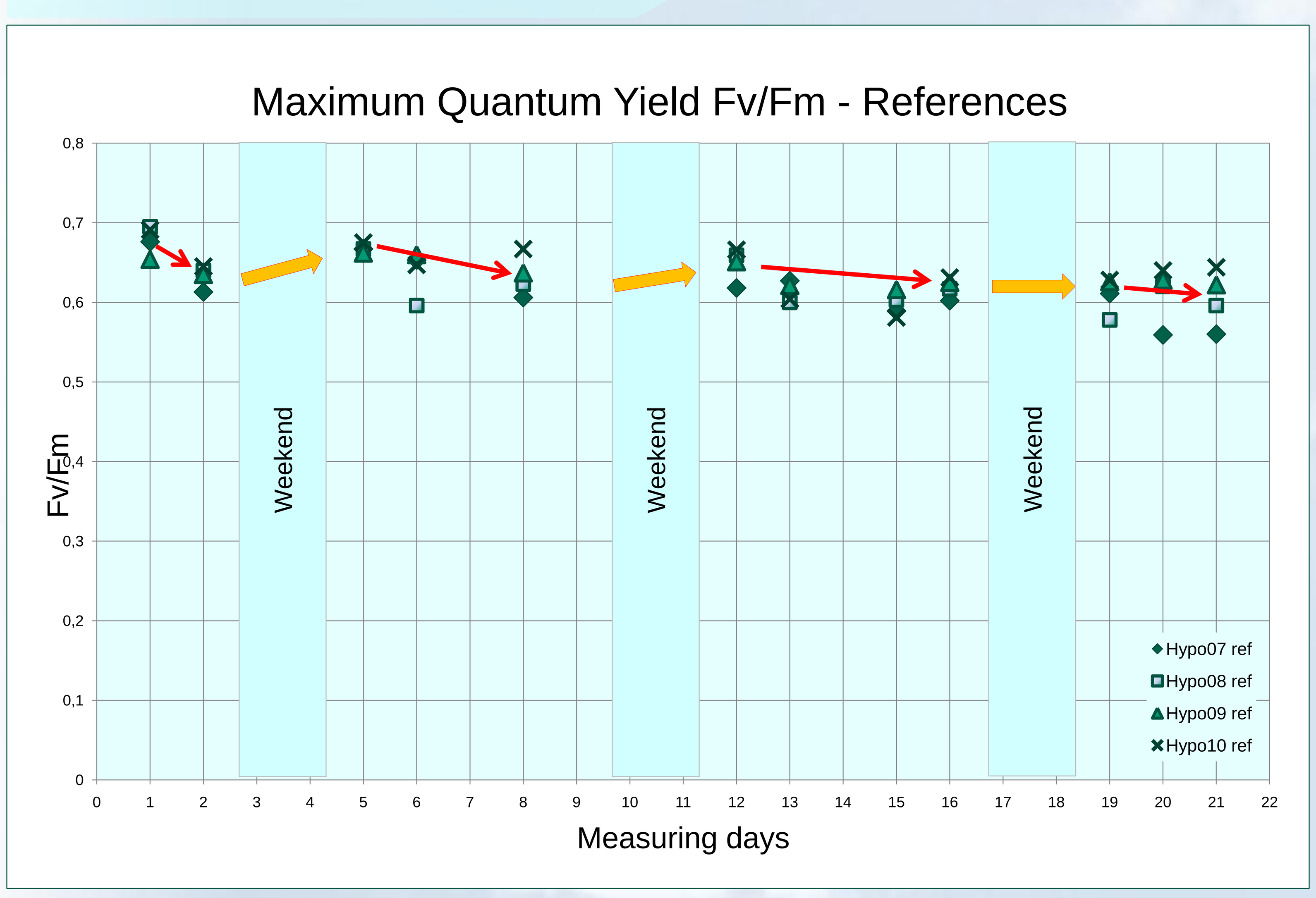


Fig. 5: Maximum Quantum Yield Fv/Fm of references kept in the steel chamber (Fig. 2) without exposure

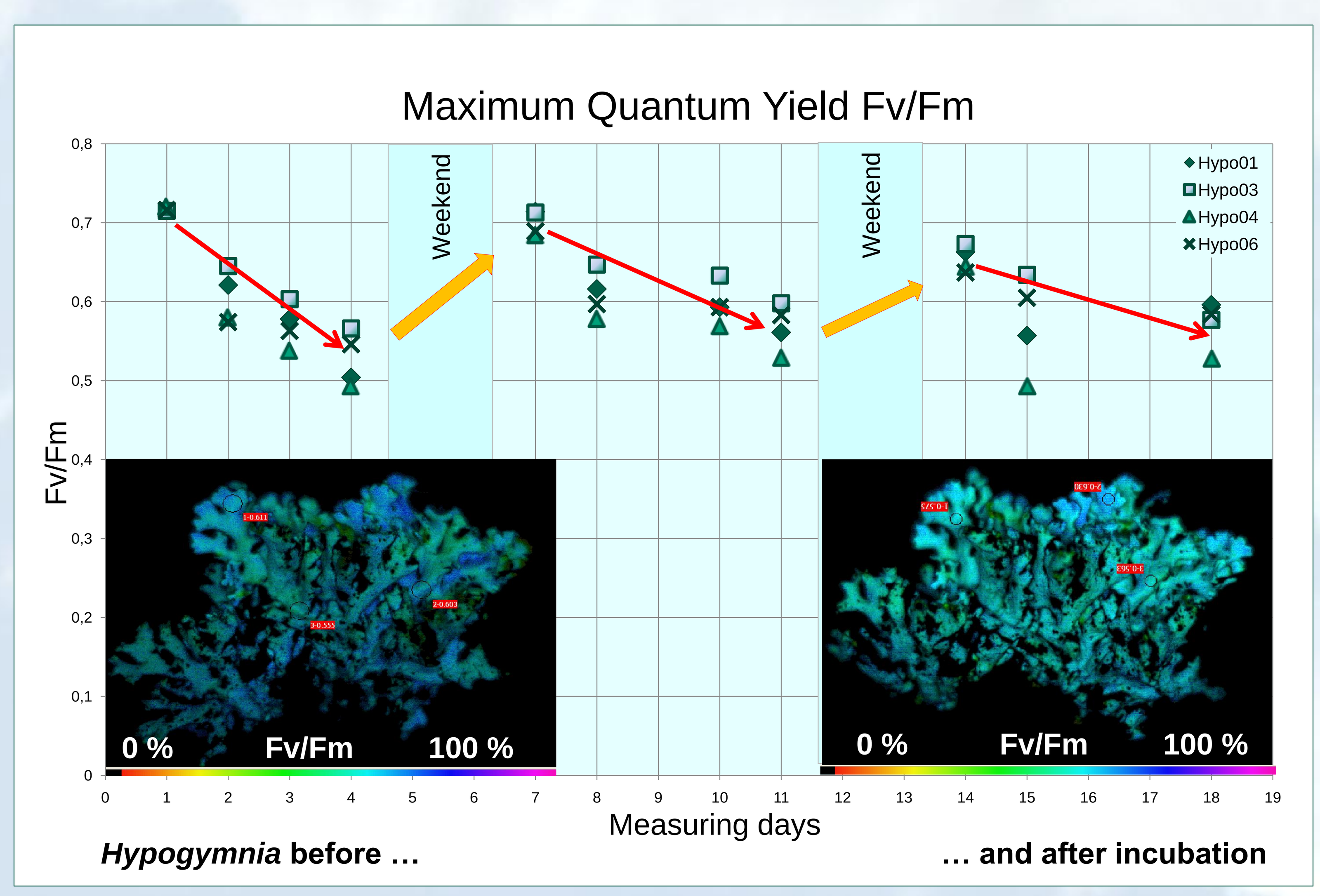


Fig. 6: Maximum Quantum Yield Fv/Fm of treated samples exposed in the steel chamber (Fig. 2)

During the three weeks laboratory campaign the decreasing rates of the maximum quantum yield of photosystem II (Fv/Fm) showed the negative effect of diesel exhaust on lichen-samples (see also WALZ Imaging PAM false-colour images in Fig. 6). During the weekends without exposure to diesel exhaust the lichens seemed to regenerate, but they did not recover to their initial starting values. Treated samples showed changes in Fv/Fm-values for maximum quantum yield and in I_k-values (value for efficiency of photosynthesis; not shown) and suggested that the proton-gradient between PSII and ATP-Synthase was adversely affected, which led to lower yields of ATP and NADPH.

Hence the photobiont of the lichens was no longer able to maintain its metabolism, it slowly degenerated and so did the mycobiont as it depended on the photobionts carbohydrate-synthesis. The development of the photosynthetic efficiency of reference samples showed that an incubation without diesel exhaust had a rather limited effect on photosystem II.

Acknowledgements

The authors wish to thank the WALZ company for the possibility to use Imaging PAM and the Landesregierung Salzburg for financial support

References

HEINZELMANN E. (2007) Highway exhaust aerosols and their effects on alpine lichen populations, Diploma-Thesis, Paris Lodron Universität Salzburg, Fachbereich Organismische Biologie

MADL P., HEINZELMANN E., HOFMANN W., TÜRK R., (2010), Motorway exhaust aerosols and their effects on epiphytic lichen populations, Gefahrstoffe Reinhaltung der Luft, Springer-VDI-Verlag, Düsseldorf, **4**:147-153