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AIRY GreenTech GmbH
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Braunschweig, 26.11.2018

Test report No. MAIC-2018-4946

(This test report replaces the test report MAIC-0216-2684 from 23.06.2016)

Customer: AIRY GreenTech GmbH, Hamburg.

Object of the test: Investigations of the air cleaning effect of AIRY plant systems for two selected air pollutants.

Contents:

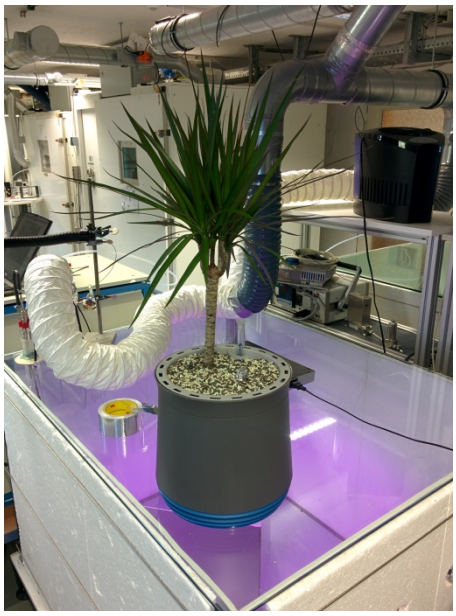
This report comprises 12 pages.

Sample description

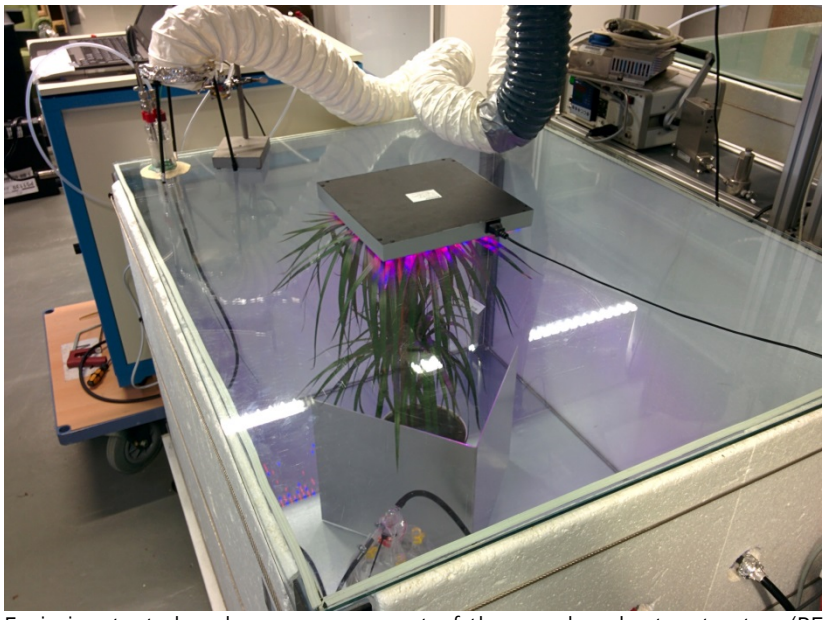
WKI No.	Sample received	Description	Product-No.	Supplier-Code	Date stamp
P51460	29.04.2016	AIRY system/soil/dragon tree	n.a.	n.a.	n.a.
P51461	29.04.2016	AIRY system/special substrate/dragon tree	n.a.	n.a.	n.a.
P51462	29.04.2016	Reg. plant pot/soil/dragon tree	n.a.	n.a.	n.a.

(Sample P51460: n.a./not packed; Sample P51461: n.a./not packed; Sample P51462: n.a./not packed)

Notice: Sample material for emission tests cannot be retained for repeated tests, it will only be stored for identification and documentation purposes.

Preparations for the experiments of the AIRY system with soil (left, P51461) and the AIRY system with special substrate (right, P51461).



Emission test chamber measurement of the regular plant pot setup (P51462)

Experimental

The three tested samples consist of a plant pot each equipped with two dragon tree plants. Due to the limit height of the emission test chamber, the higher plant had to be removed before the test. The remaining stump was sealed by emission-free aluminum tape.

The experiments were performed in a 1 m³ emission test chamber made of glass. The chamber was operated at 25°C. The initial relative humidity of the chamber was 50%. The humidity in the chamber was differently affected by adding the plant systems into the chamber. Condensation on chamber surfaces was not observed. The chamber contained a sealed glass vessel that contained a stable and well-defined atmosphere of toluene and xylene. Both compounds were dosed into the chamber from this vessel by a mass-flow controller. The chamber was also equipped with a 15 W LED plant lamp (blue/red LED only) that was operated for 12 h a day. Prior to the experiment, the lamp was tested with a UV meter (Hönle UV Technology) in order to evaluate the light spectrum. Area sensors for UVA (UVA (330 nm - 400 nm), UVB (290 nm - 330 nm) and VIS (380 nm - 550 nm) were used. The analysis showed that the lamp did not emit UVA and UVB light. Only these light fractions can be absorbed from glass chamber. Thus, the lamp could be operated outside of the chamber to prevent interferences with lamp emissions (e.g. from circuit boards). In order to prevent a directed air flow at the plant pot and to achieve a well-mixed chamber air, a deflection plate was placed between sample and mixing fan (target velocity on sample surface of 0.3 m/s).

Each sample was tested for 120 h in the emission test chamber. The development of the air concentrations of toluene and xylene was continuously monitored via a proton-transfer-reaction mass spectrometer (PTR-MS) at a time resolution of 1 min. The mass traces for m/z 93 (toluene) and m/z 107 (xylene) were recorded. After each test, the sample was removed from the chamber and the chamber was operated for 24 h in order to check the stability of the formaldehyde dosing (Fig. 1).

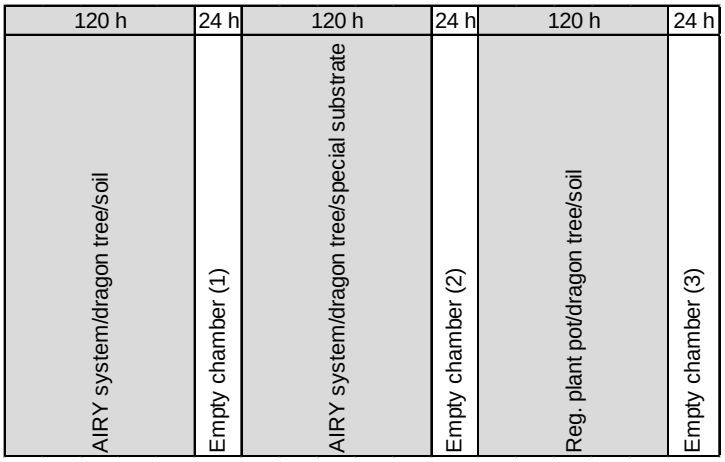


Figure 1: Flow chart of the measurements

The results of each test of the three samples were set in relation to the air concentrations in the empty chamber to calculate the specific reduction factor.

Results

The quantitative test results can be found on the next page.

Dosing

The development of the air concentration in the empty chamber provides insight into the efficiency of the dosing (Fig. 2-3). The target concentrations for the volatile organic compounds were quite high. For toluene approx. 4 ppm and for xylene approx. 1 ppm could be achieved. While the dosing of toluene was nearly constant during the whole experiment (Fig. 2) the xylene concentration showed a lowered equilibrium concentration after removing the second sample from the chamber. Thus, the dosing was adjusted afterwards.

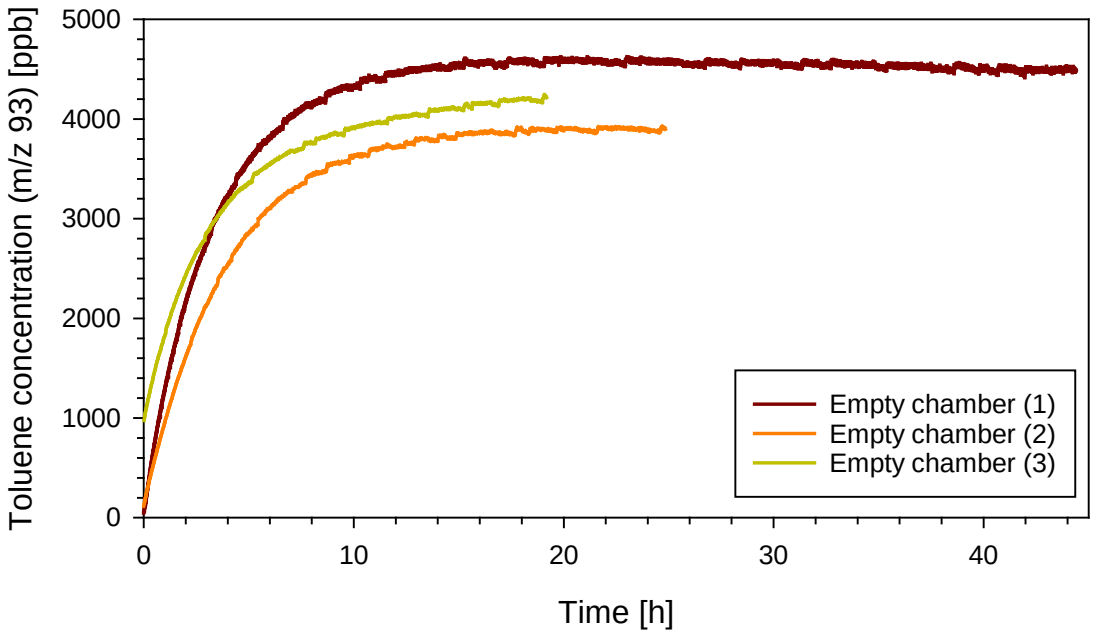


Figure 2: Development of the toluene concentration in the empty chamber after removing the sample.

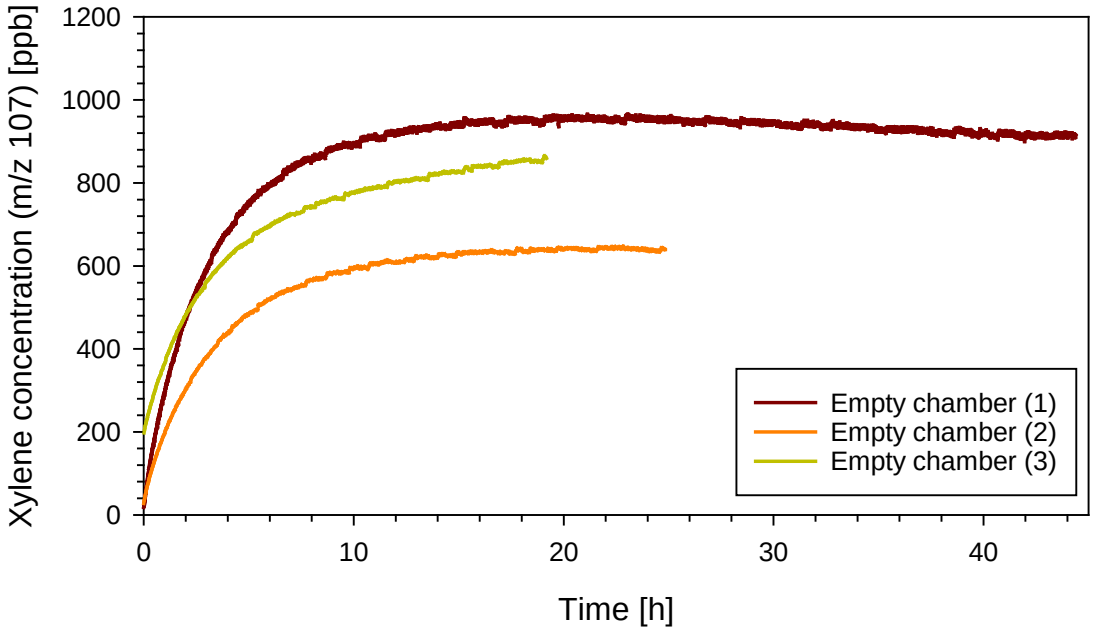


Figure 3: Development of the xylene concentration in the empty chamber after removing the sample.

Toluene/xylene exposure experiment

Regarding the influence of the three tested systems on the compounds in the chamber air there is a significant difference between the two AIRY systems and the regular plant pot. For both systems that were equipped with an AIRY plant pot a lower toluene and xylene concentration was observed in comparison to the empty chamber (Tab. 2). In contrast, the concentrations of both compounds were higher in case of the regular plant pot than in the blank chamber measurements. The fact that this observations is not caused by a dosing artefact can be observed from Fig. 7 which shows the development of toluene in the empty chamber before and after the experiment.

The quantification of the reduction effect is associated with uncertainties due to fluctuations in the chamber concentrations. On the basis of the blank chamber measurements the necessary concentration difference for a statistically significant deviation can be estimated. In case of toluene the confidence interval is 4047±453 ppb (80% probability). The 50th percentiles of the loaded test chamber concentrations are beyond the interval limits and, thus, the probability that the results of the empty chamber and the loaded chamber are different is larger than 80%. In case of xylene the interval is 771±173 ppb (80% probability). Here, the median concentrations of the AIRY system with special substrate (P51461) and the regular plant pot (P51462) are beyond this interval. Therefore, it cannot be statistically excluded that the difference between the loaded

chamber and the blank chamber is caused by coincidence. For this reason, the reduction effect is only quantified for the two samples P51461 and P51462.

Tab. 2: Statistics of the concentration development of toluene and xylene during the performed experiments. All concentrations are given in ppb.

	Toluene			Xylene		
	Median	Max.	Mean* / Std. deviation	Median	Max.	Mean* / Std. deviation
AIRY system/soil	3205	3601	3161 ± 336 (11%)	747	842	732 ± 93 (13%)
Empty chamber (1)	4520	4621	4221 ± 789 (19%)	930	966	875 ± 156 (18%)
AIRY system/special substrate	2719	3033	2723 ± 213 (8%)	510	595	515 ± 50 (10%)
Empty chamber (2)	3738	3919	3308 ± 888 (27%)	613	648	551 ± 134 (24%)
Reg. plant pot/soil	4711	5185	4649 ± 536 (12%)	1059	1278	1050 ± 166 (16%)
Empty chamber (3)	3883	4234	3566 ± 746 (21%)	771	865	713 ± 152 (21%)

* including increase of concentration; analysis is not limited to the equilibrium concentration.

The quantification of the reduction effect on the basis of the median concentration provides a similar toluene reduction factor for both AIRY systems of approx. 30% (P51460: 29%, P51461: 27%). In case of xylene, the calculated reduction factor is lower at approx. 17% (P51461).

Overall, it has to be considered that the target concentrations of both compounds were intended to be substantially higher than typical concentrations in the indoor environment. Possible adsorption effects for the regular plant pot could not be determined since a higher concentration than in the empty chamber was observed. As no dosing artefact was observed, it can be assumed that the plant pot or the soil released the respective compounds. The system P51462 was conditioned in a meeting room for two weeks prior to the experiment. Therefore, the uptake of toluene and xylene due to a previous contamination is unlikely.

The Box-Whisker-plots used in Fig. 4-6 show the 95th percentile (this means that 5% of the data points are smaller or equal to this value) and the 5th percentile with the two dots. The box and the two whiskers show (from high to low) the 90th percentile, the 75th percentile, the median (50th percentile), the 25th percentile and the 10th percentile.

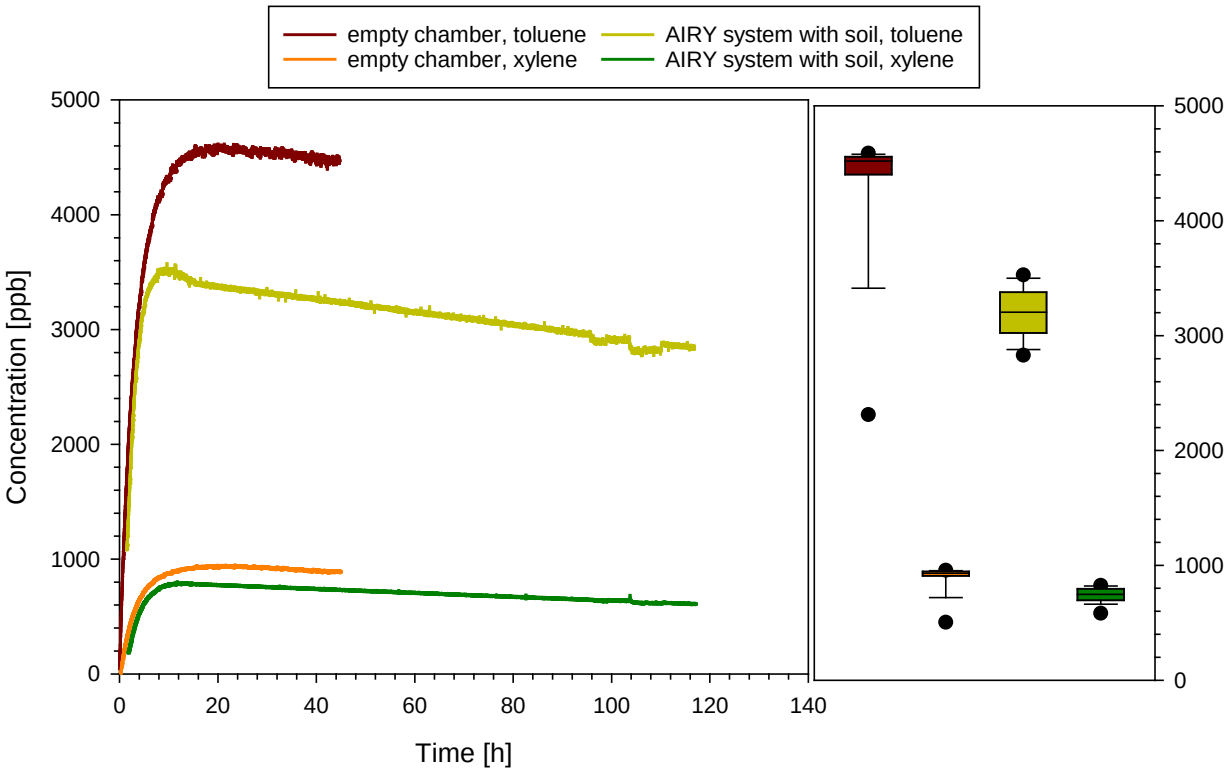


Figure 4: Development of the concentration of toluene and xylene during the test of the AIRY system with soil and dragon tree (P51460) in comparison to the empty chamber.

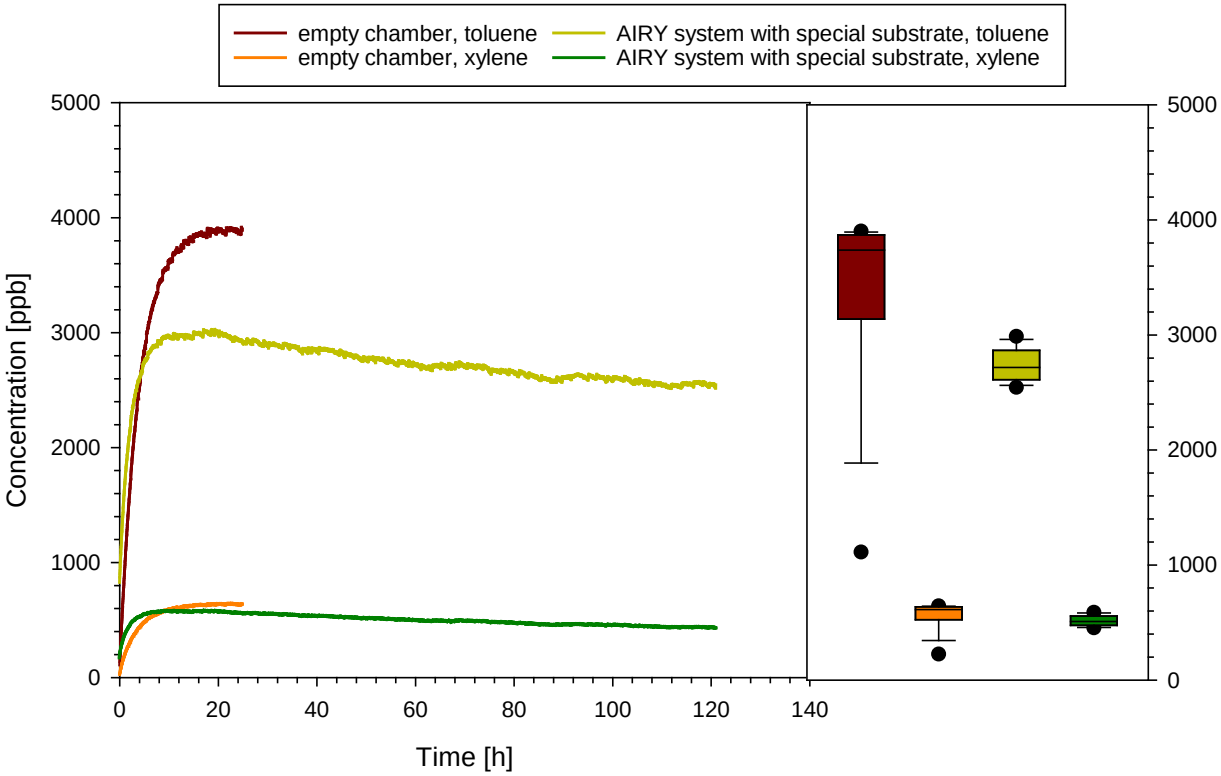


Figure 5: Development of the concentration of toluene and xylene during the test of the AIRY system with special substrate and dragon tree (P51461) in comparison to the empty chamber.

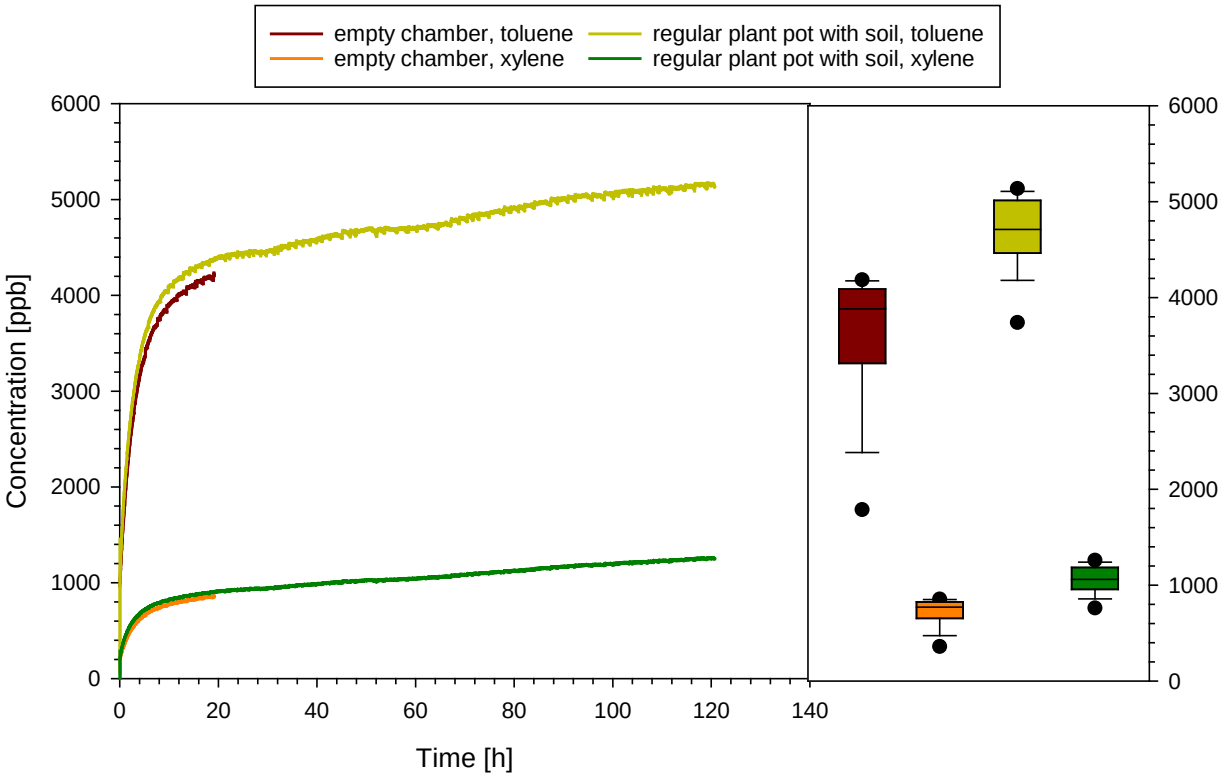


Figure 6: Development of the concentration of toluene and xylene during the test of the regular plant pot with soil and dragon tree (P51462) in comparison to the empty chamber.

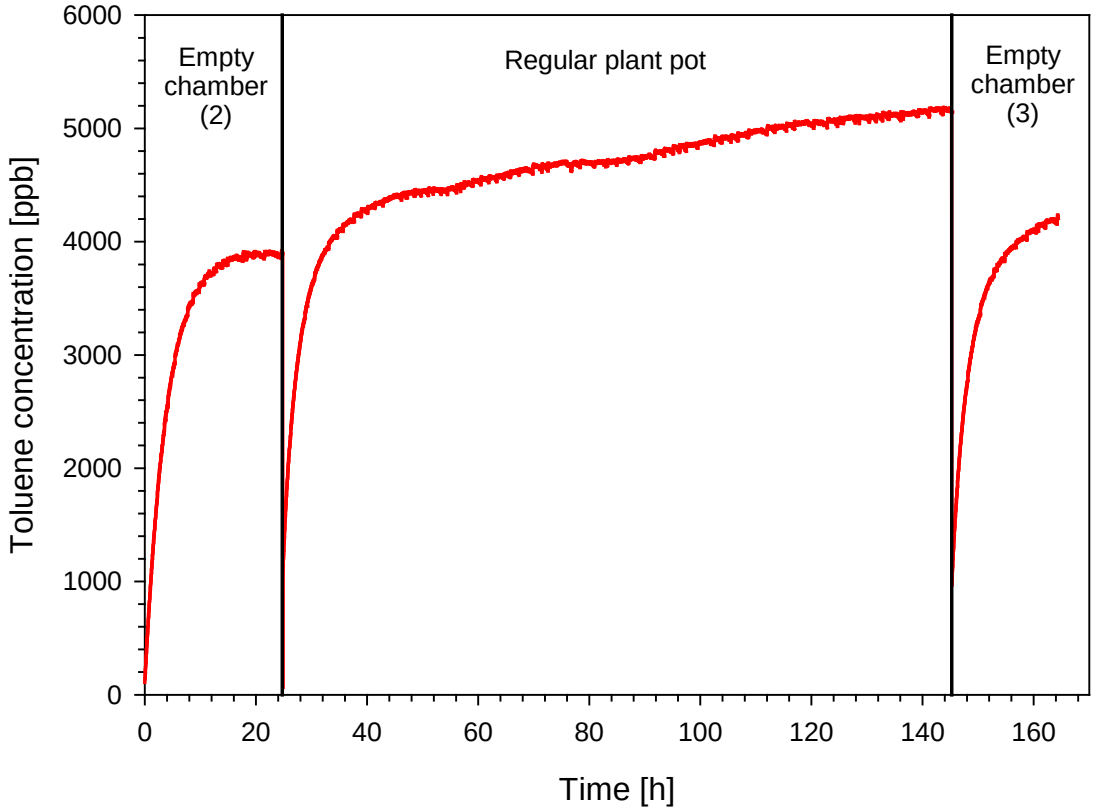


Figure 7: Development of the toluene concentration during the experiment with the regular plant pot in comparison to the empty chamber measurements before and after the experiment.

Conclusions

The AIRY plant pot systems with two different substrates as well as a regular plant pot with soil were equipped with a dragon tree each and exposed against a substantially elevated concentration of toluene and xylene. The concentrations of both air pollutants were much higher than usual concentrations in the indoor environment.

Both AIRY systems caused a reduction of the air concentration of toluene by approx. 30%[1]. For the AIRY system with special substrate a reduction of 17%[1] was also observed for xylene. In case of the AIRY plant pot with soil a lower concentration of xylene was observed in the chamber but the reduction could not be verified statistically.

A reduction effect was not observed for the regular plant pot system for both compounds.

Officer in charge

C. Fauck

For the department

Dr. E. Uhde

[1] statistical probability >80% (see page 6)