Quantitative Characterization of Nanoparticle Emissions from Office Machines with Printing Function

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Introduction & Motivation

Laserprinters and photocopiers may be substantial sources of gaseous emissions as well as emitters of fine and ultrafine particles (Bake & Moriske, 2006). Symptoms as asthma and pseudo allergic inflammations of the respiratory tracts, irritations of the skin and eyes, headache and sick building syndrome have been linked to these emissions (Kagi, 2007; Jaakkola, 2007). Thus, quantities and composition of particulate emissions from office machines must be characterized in order to establish a database for the evaluation of possible health risks and for prevention measures.

Neither qualitative nor quantitative details of those particle emissions are understood in full detail. Main shortcomings of test methods used:

- different environments (outdoor, test chambers, offices),
- different instrumentations and measuring ranges
- different measuring conditions (e.g. air exchange aerosol background level)
- different methods of data analysis
- almost no comparability between measured data from different sources in the lab and “on site”

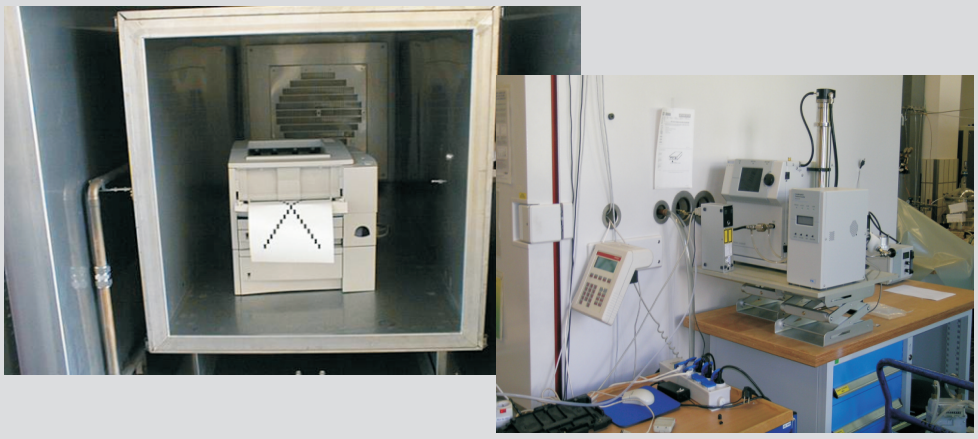

Fig. 1
Laserprinter mounted in a 1 m³ environmental test chamber (left), chamber exterior view with particle spectrometers (right).

Experimental Approach

All particle emission measurements were performed under controlled conditions in a stainless-steel emission test chamber (ETC), especially designed for the measurement of gaseous and particle emissions, using a SMPS (TSI 3936) and a laser particle counter (Grimm LPC 1.108). Both particle spectrometers operate at 1 l/min sample flow and have a combined measuring range from 10 nm to 20 µm particle diameter.

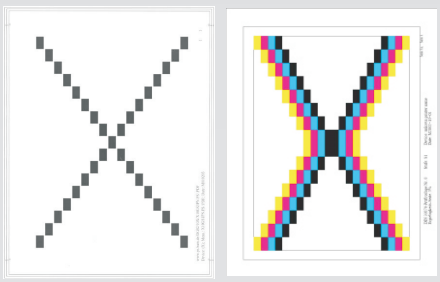

Fig. 2
DIN A4-print patterns, left: monochrome, 5 area-% coverage; right: colored, 20 area-% coverage.

Steps of test protocol:

Step	Test Phase	Measured data	Duration
1.	AER* = 1 h^{-1}	ETC Background	1 h
2.	Testsubject in ETC	ETC Background	< 10 min
3.	Conditioning of closed ETC	ETC Background	1 h
4.	Test device power on	VOC, Particles, O_3	1 h
5.	AER = 4.4 h^{-1}	VOC, Particles, O_3	15 min
6.	Printing**	VOC, Particles, O_3	10 min
7.	Follow up phase	VOC, Particles, O_3	1 h

* AER = Air Exchange Rate
** Printing of a fixed number of copies of a standardized print pattern with either 5 area-% black covering or 20 area-% coloured covering during step 6.

Results

Following strictly the above test protocol, the repeatability of the detailed qualitative and quantitative particle emission behaviour of laser printers is very good, as shown in Fig. 3 for two laser printers from different manufacturers. The diagrams reveal particle size distributions versus time during printing and after. Pink boxes indicate the printing periods. The colour code marks the particle concentration levels (the respective concentration maxima of each measurement was set to 100 % for better comparison). The data have not been corrected for air exchange.

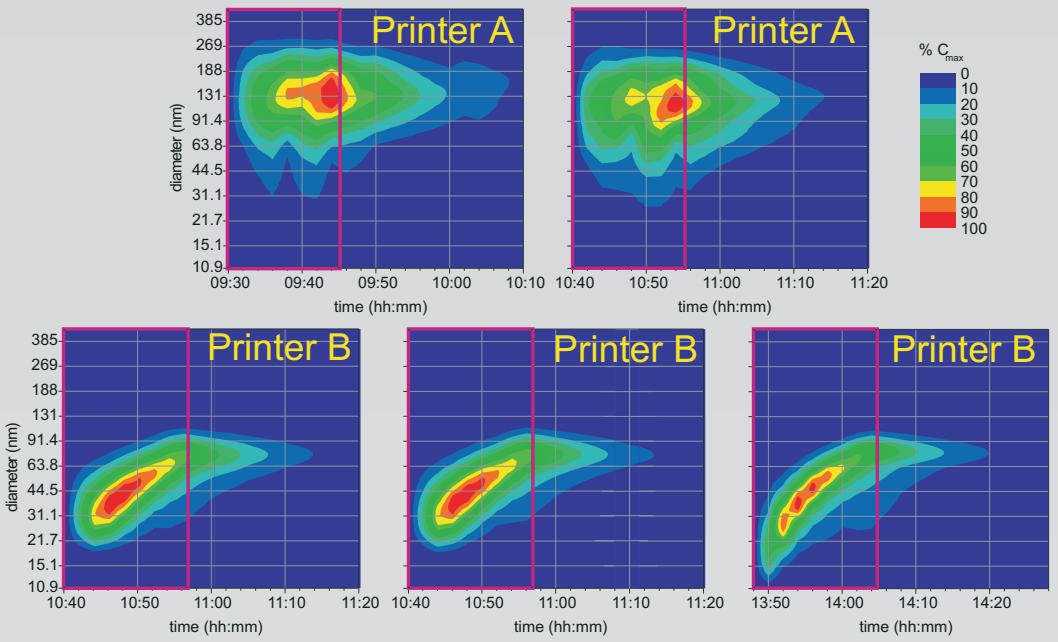

Fig. 3
Comparison of particle emission characteristics for two different laserprinters.

The repeatability of the particle emission behaviour of each of the printers is good. There are no substantial particle emissions observable above 500 nm diameter. As toner powder particles usually have diameters above 3 µm there is no direct emission of toner powder from laser printers observable. Both printers show remarkable differences:

- The size distribution maximum of printer A is much higher as for printer B,
- Printer B clearly shows a time dependency of the particle emission behaviour, while printer A does not.

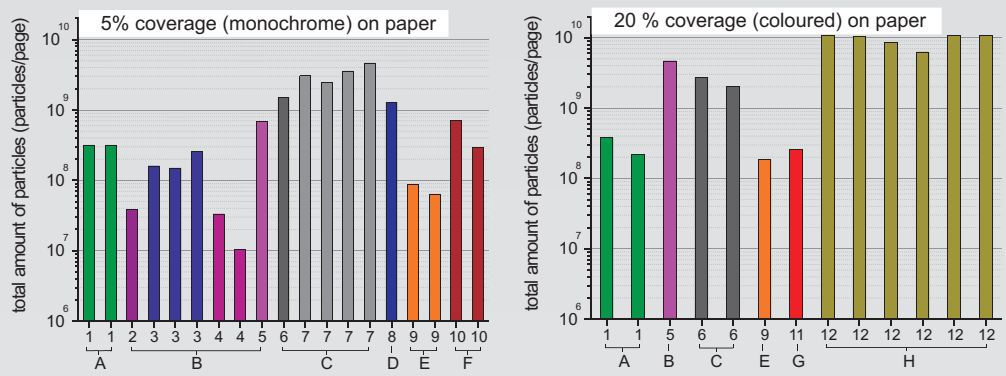

Fig. 4
Total amount of particle emission per printed page for different laserprinters in monochrome (left) and coloured (right) mode. Same figures refer to same laser printer types and same letters refer to same manufacturers (Seeger et. al. 2006).

The total amounts of particles emitted per printed page differ by more than two orders of magnitude, depending on laser printer types and manufacturers. Again, the repeatability of data is good. The amount per page does not depend significantly on the printing mode (monochrome or coloured). All these findings have to be considered in the estimation of health risks and measures for emission reduction.

This work was supported by the German Federal Environmen Agency (UBA, 204 95 373).

Sources:

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