Effect of laser printer emission exposure on human health – Examination of six patients including ESR measurements

Volker Mersch-Sundermann , Winfried Ebner, Julia Hurraß and Richard Gminski

Institut für Umweltmedizin und Krankenhaushygiene / Department of Environmental Health Sciences, Freiburg University Medical Center, Freiburg, Germany

Introduction

Laser printers and copiers are widely used in offices and private homes. However, information on health effects possibly related to their emissions is sparse. Therefore, the aim of this study was to elucidate acute biological effects in patients following short-term exposure to laser printer emissions (LPE).

Material and Methods

Study design

Six patients were examined. They were exposed to laser printers emissions (printer no. 1-5) for 0.5 h in a test room. Organic gases (total organic carbon, TOC), VOCs and particulate matter (PM) were continously monitored.

Total organic carbon (TOC) and VOCs

TOC was monitored continuously with a photoacoustic field gas-monitor (INNOVA 1412, LumaSense Technologies, Ballerup, Denmark). VOCs in indoor air were sampled by Tenax TA. The organic compounds were desorbed thermally and subsequently analyzed by GC/MS.

Submicrometer particle (SMP)

SMP number concentrations, i.e. particles with diameters of 10 – 1000 nm, were measured by a condensation particle counter (CPC, Model 3007, TSI Inc. ST. Paul, USA) based on the isopropyl alcohol envelopment of particles in its counting chamber.

PAH analysis

PAH analysis was performed according to the US EPA Method 8100 using gas-chromatography/flame ionization detection (GC/FID) to quantitate the PAHs found in extracts sampled for 8 h from test room air.

Transmission electron microscopy (TEM)

Transmission electron microscopy (TEM) combined with energy-dispersive X-ray spectroscopy (EDX) was used to investigate particles emitted in the air sampled with polycarbonate capillary-pore filters through which a known volume of air has been drawn.

Examination of patients

Lung function parameters, exhaled NO, eosinophil cationic protein (ECP), ROS in blood and blood cells with ESR and subjective irritation of eyes, nose and throat using VAS were examined in six patients before, after and partly during exposure.

Exhaled NO

Exhaled NO was measured according to the European Respiratory Society (ERS) with a hand-held device (NioxMino, Aerocrine, Solna, Sweden).

ESR measurement

To measure directly the generation of reactive oxygen species (ROS) in various biological samples Electron Spin Resonance (ESR) spectroscopy with spin trapping technique was used.

VAS examination

Symptom ratings were performed using 0-100 mm visual analogue scales (VAS) graded from ‘not at all’ (0 mm) through ‘hardly at all’ (6 mm), ‘somewhat’ (26 mm), ‘rather’ (48 mm), ‘quite’ (72 mm), ‘very’ (90 mm), to ‘almost unbearable’ (100 mm). The eight symptoms to be rated were (1) ‘discomfort in the eyes: burning, irritated, or running eyes’; (2) ‘discomfort in the nose: burning, irritated, or runny nose’; (3) ‘discomfort in the throat or airways’; (4) ‘breathing difficulty’; (5) ‘smell of emissions’; (6) ‘headache’; (7) ‘dizziness’; (8) ‘fatigue.’

Results

[1] Transmission electron microscopy (TEM)

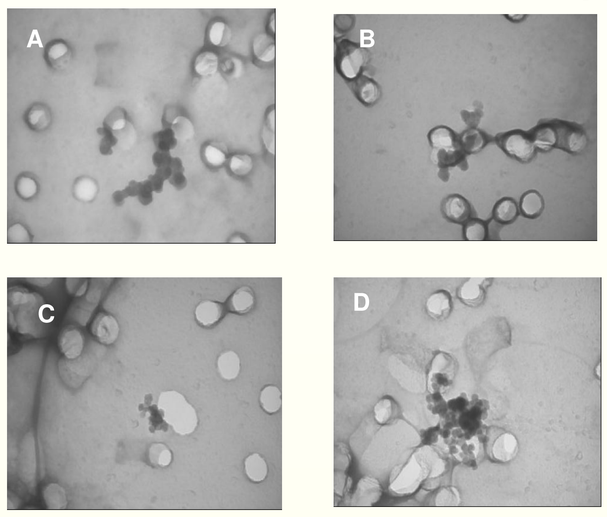

Fig. 1: TEM pictures of sampled air particles. (A) and (B) from laser printer 1; (C) from laser printer 3 and (D) from laser printer 5. Magnification 40000x. Length of edge of each picture is equivalent to 2000 nm. Aggregates found on the filters by EDX were predomionantly Fe as an ingredient of the toner powders used (magnetite).

[2] VOCs measurement

Tab. 1: Only minor amounts of VOCs were emitted by laser printers during exposure.

Conc. of VOCs [µg/m³]	Printer 1	Printer 2	Printer 3	Printer 4	Printer 5
n-Octanal	10.1	L.Q.	L.Q.	L.Q.	L.Q.
n-Nonanal	14.7	L.Q.	L.Q.	L.Q.	L.Q.
Benzaldehyde	L.Q.	8.0	17.5	14.6	15.0
1,2-PGMM	L.Q.	L.Q.	9.6	L.Q.	L.Q.
Decamethylpenta-cyclosiloxane (D5)	L.Q.	L.Q.	L.Q.	4.6	L.Q.
Benzene	L.Q.	L.Q.	4.7	L.Q.	L.Q.
o-Xylole	L.Q.	7.4	12.3	14.3	L.Q.
p-Isopropyltoluene (p-Cymol)	11.1	L.Q.	L.Q.	L.Q.	L.Q.

L.Q.: limit of quantitation

[3] Total organic compounds (TOC), Submicrometer particles (SMP), PAHs

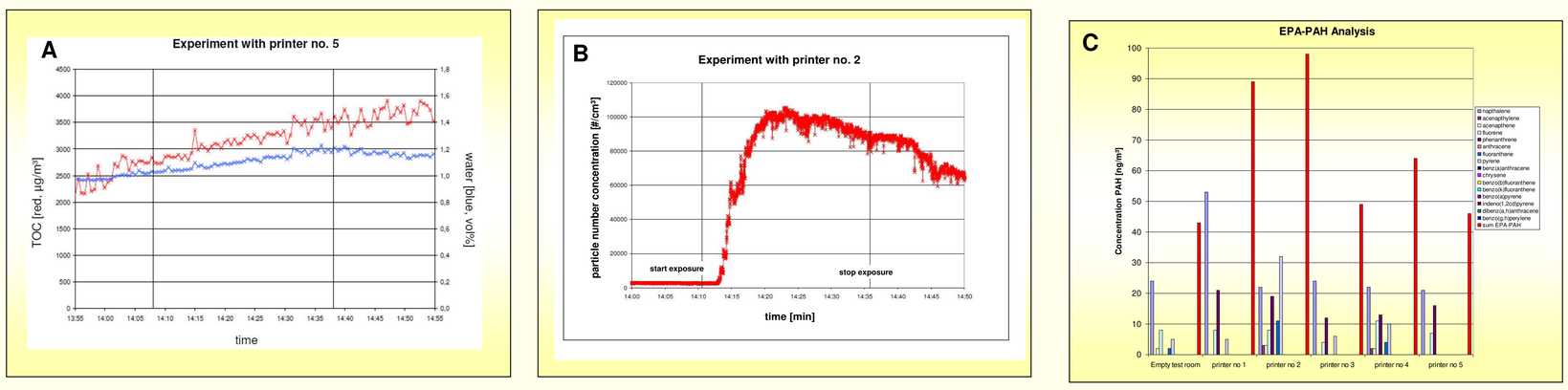

Fig. 2: Increase of TOC (A) and SMP (B) during exposure. The increase of PAHs (C) were found after a sampling time of 8 h during printing compared to the empty test room.

[4] Acute biological effects in patients (NO, VAS)

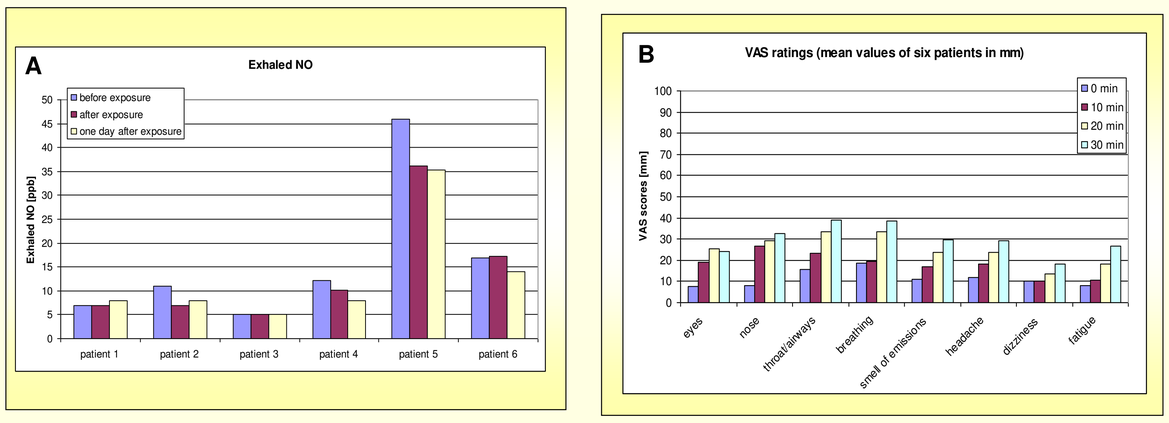

Fig. 3: Acute biological effects in six patients. No effects were observed on exhaled NO, as a marker of inflammation in bronchi and alveoli (A). All VAS ratings were at a high level, however, did not exceed 48 mm (B).

[5] Acute biological effects in patients (ECP, ROS)

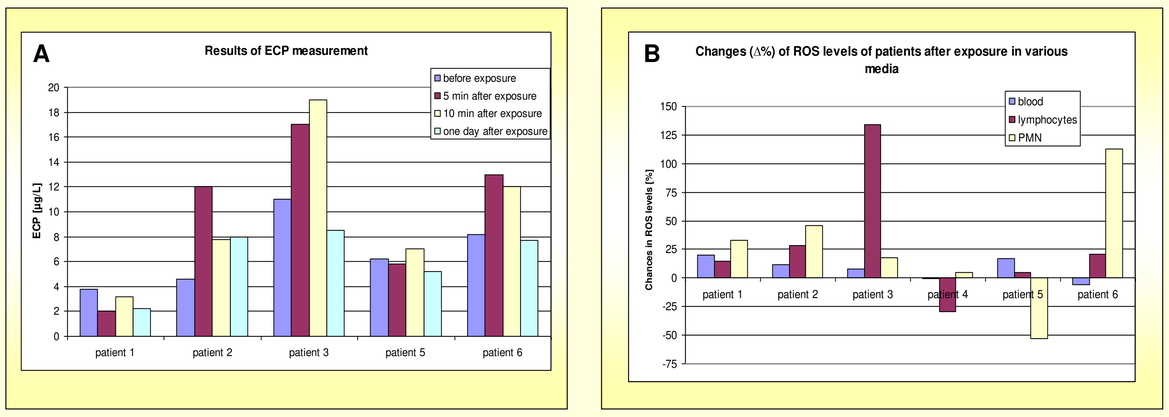

Fig. 4: Acute biological effects in six patients. Three of 5 patients showed an increase of ECP levels after exposure to LPE (A). Three patients showed an increase in ROS levels in all three media (blood, lympho-cytes, polymorphic mononuclear cells, PMN), five patients in in at least 2 media (B).

Summary

Ambient monitoring of the test room air revealed that minor amounts of some VOCs (Tab. 1) and specific PAHs (Fig. 2 C) were emitted, whereas high levels of SMP of up to 100,000 particle/cm^3 were measured in the air during printing (Fig. 2 B). No effects were observed on pulmonary function or exhaled NO (Fig. 3 A). All VAS ratings were at a high level, however, did not exceed the expression “rather” (Fig. 3 B). Three patients showed an increase in ROS levels in all three media (blood, lymphocytes, PMN). In the other 3 patients the changes of the ROS levels were not uniformely (Fig. 4 B). Three of 5 Patients showed an increase of ECP levels (Fig. 4 A). Our results indicate that SMP may increase in rooms where laser printers are used. ECP in serum and ROS measured in whole blood, lymphocytes and PMN may be useful parameters for bio effect monitoring of human exposure to laser printer emissions.