



Combustion engine exhaust – Current knowledge of adverse effects and underlying cellular mechanisms

Barbara Rothen-Rutishauser

BioNanomaterials
Adolphe Merkle Institute
University of Fribourg
Fribourg, Switzerland



Filtering diesel exhaust could make it worse

For those with allergies, supposedly cleaner fumes can mean worse lung function

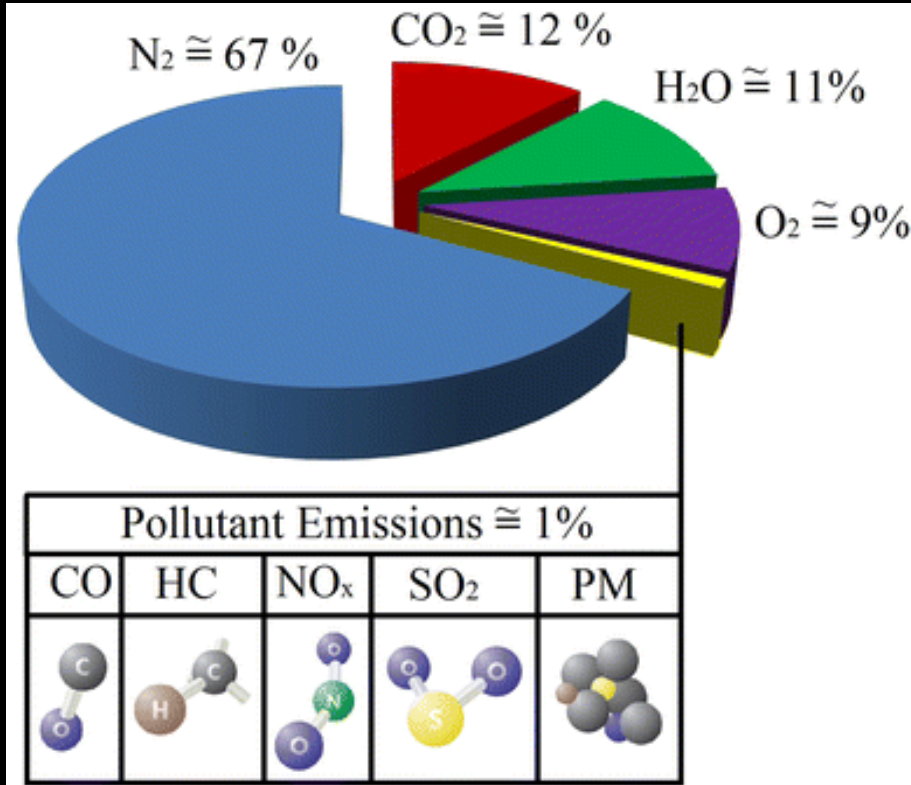
By Ula Chrobak | 18. April 2019

“Filtration of particles from diesel exhaust is not the perfect solution for preventing adverse health effects,” says John Balmes, a professor of medicine who studies the health impacts of air pollution at the University of California, San Francisco and peer reviewed the paper prior to publication. “We need to reduce exposure to the gaseous components of diesel exhaust.”

<https://www.popsoci.com/diesel-filter-worse-allergies/>



Engine exhaust components



Five main pollutant emissions from diesel engines:

- Carbon monoxide (CO)
- Hydrocarbons (HC)
- Particulate matter (PM)
- Nitrogen oxides (NO_x)
- Sulphur dioxide (SO_2)

Reşitoğlu et al. Clean Technologies and Environmental Policy 2015

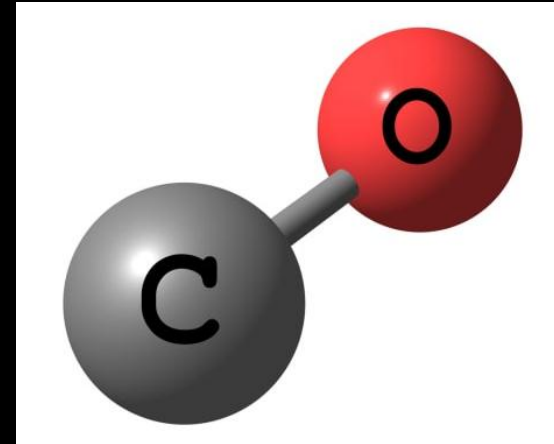


Adverse effects of pollutants

Carbon monoxide (CO)

- CO is an odorless and colorless gas
- Inhaled CO is an inhalation hazard due to its rapid complexation with hemoglobin, resulting in impaired oxygen delivery to tissues
- Despite systemic and cellular toxicity at high concentrations, CO has demonstrated cyto- and tissue-protective effects at low concentration (e.g., 250 ppm) in animal models of organ injury and disease

Ryter et al. Carbon monoxide in lung cell physiology and disease. Am J Physiol Cell Physiol 2018
Reşitoğlu et al. Clean Technologies and Environmental Policy 2015

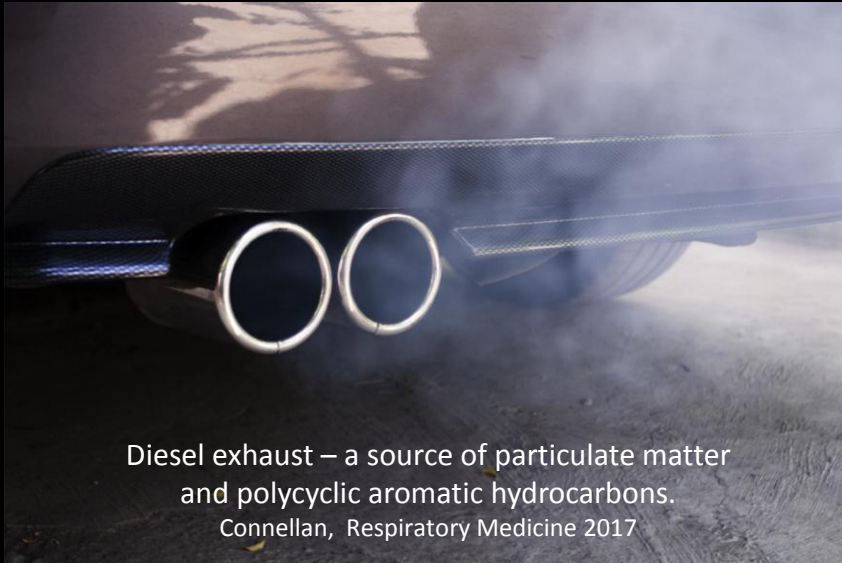


<https://melscience.com/US-en/articles/carbon-and-its-reactions-oxides-and-more/>



Adverse effects of pollutants

Hydrocarbons (HC)



Diesel exhaust – a source of particulate matter and polycyclic aromatic hydrocarbons.
Connellan, Respiratory Medicine 2017

- With other pollutant emissions, HCs play a significant role in the formation of ground-level ozone
- Lung diseases associated with hydrocarbon exposure
- Hydrocarbons are toxic with the potential to respiratory tract irritation and cause cancer

Reşitoğlu et al. Clean Technologies and Environmental Policy, 2015
Connellan, Respiratory Medicine 2017

- Risks of lung and bladder cancer were dose-dependent when quantitative exposure levels of polycyclic aromatic hydrocarbons were measured, and truly non-exposed groups were compared.

Mastrangelo et al. Environ Health Perspect 1996



Adverse effects of pollutants

Sulphur dioxide (SO₂)

- Sulphur dioxide (SO₂) is a colorless, reactive air pollutant with a strong odor
- High concentrations of SO₂ can cause inflammation and irritation of the respiratory system, especially during heavy physical activity.
- This gas can also react with other chemicals in the air and change to a small particle that can get into the lungs and cause similar health effects

<https://www.nps.gov/subjects/air/humanhealth-sulfur.htm>



The Halema'uma'u plume in Kilauea Crater at Hawai'i Volcanoes NP contains extremely high levels of sulfur dioxide, about 500-1,000 tones/day.



Adverse effects of pollutants

NO_x

- Nitrogen oxide (NO) and Nitrogen dioxide (NO₂) are considered as toxic
- NO₂ has a level of toxicity five times greater than that of NO and it is also a direct concern of human lung disease. NO_x can irritate the lungs and lower resistance to respiratory infection (such as influenza)

Reşitoğlu et al. Clean Technologies and Environmental Policy, 2015

- The meta-estimate for the change in lung cancer associated with a 10-µg/m³ increase in exposure to NO₂ was 4% (95% CI: 1%, 8%).

Hamra et al. Environ Health Perspect 2015

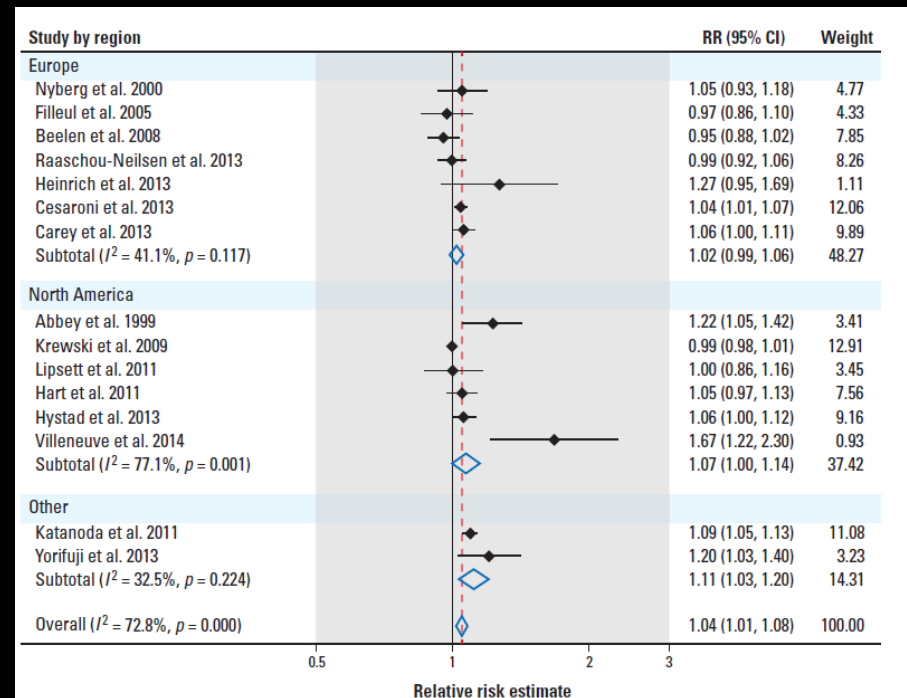


Figure 1. Forest plot of study-specific estimates of relative risk (RR) of lung cancer associated with a 10-µg/m³ increase in exposure to NO₂. The meta-estimate and weights in the forest plot are estimated from random effects meta-analyses.



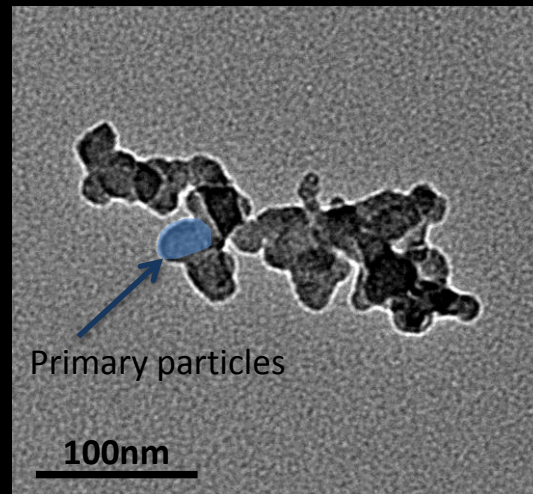
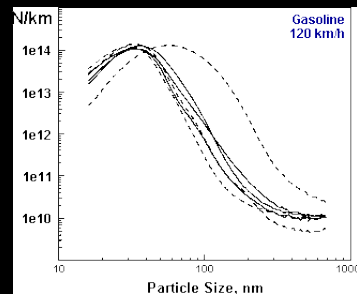
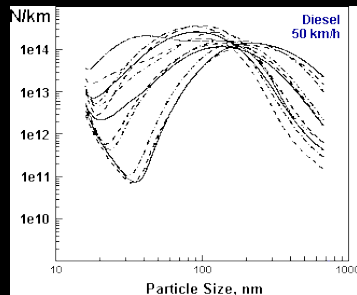
Adverse effects of pollutants

Particulate matter (PM)

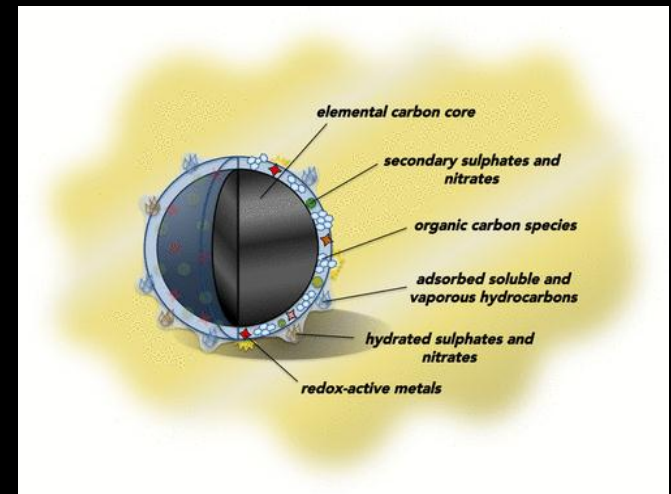
- Diesel particle emissions can be divided into three main components
 - Soot
 - Soluble organic fraction
 - Inorganic fraction
- Inhalation of these particles may cause to important health problems such as premature death, asthma, lung cancer, and other cardiovascular issues.

Reşitoğlu et al. Clean Technologies and Environmental Policy 2015

https://www.dieselnet.com/tech/dpm_size.php



Steiner et al. Arch Tox 2016



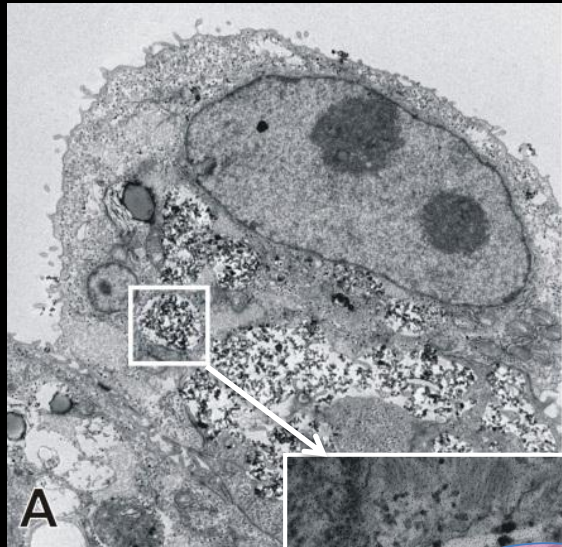
Stone et al. Env Health Persp 2017



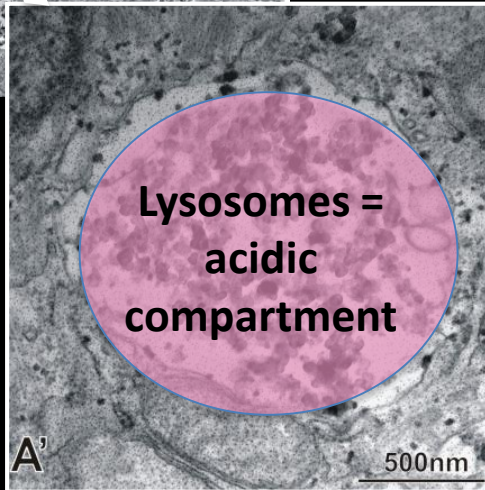
Adverse effects of pollutants

Particulate matter (PM)

Macrophage



Lysosomes =
acidic
compartment



Lehmann et al. Part
Fibre Toxicol 2010

Gen



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2007



Adverse effects of pollutants

International Agency for Research on Cancer



International Agency for Research on Cancer



PRESS RELEASE
N° 213

12 June 2012

IARC: DIESEL ENGINE EXHAUST CARCINOGENIC

Lyon, France, June 12, 2012 -- After a week-long meeting of international experts, the International Agency for Research on Cancer (IARC), which is part of the World Health Organization (WHO), today classified diesel engine exhaust as **carcinogenic to humans (Group 1)**, based on sufficient evidence that exposure is associated with an increased risk for lung cancer.

International Agency for Research on Cancer



PRESS RELEASE
N° 221

17 October 2013

IARC: Outdoor air pollution a leading environmental cause of cancer deaths

Lyon/Geneva, 17 October 2013 – The specialized cancer agency of the World Health Organization, the International Agency for Research on Cancer (IARC), announced today that it has classified outdoor air pollution as **carcinogenic to humans (Group 1)**.

<https://auto.howstuffworks.com/diesel-isnt-always-worse-polluter-than-gasoline.htm>



Adverse effects of pollutants

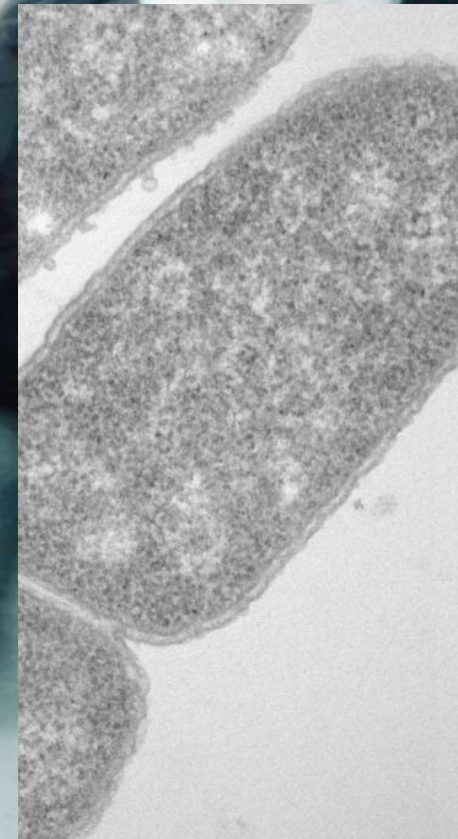
Models to study effects of complete engine exhaust



<https://blog.bhf.org.uk/esc-congress-highlights-part-one-e6079efde0e>



<https://www.datasci.com/products/inhalation-and-exposure-systems/buxco-inhalation-exposure-system>



Steiner et al. Env Sci Technol 2014

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Adverse effects of pollutants

Exposure of 3D lung cultures to complete engine exhaust



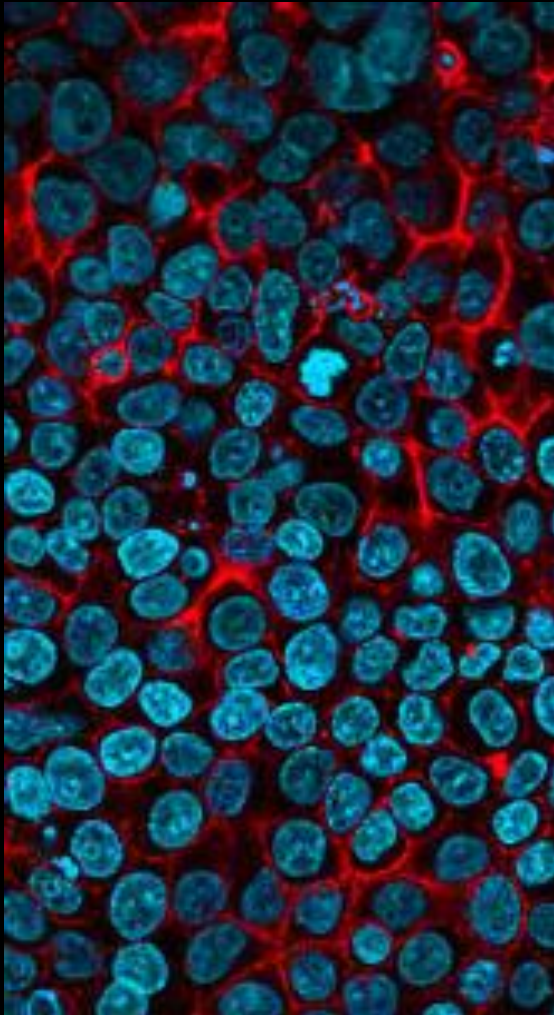
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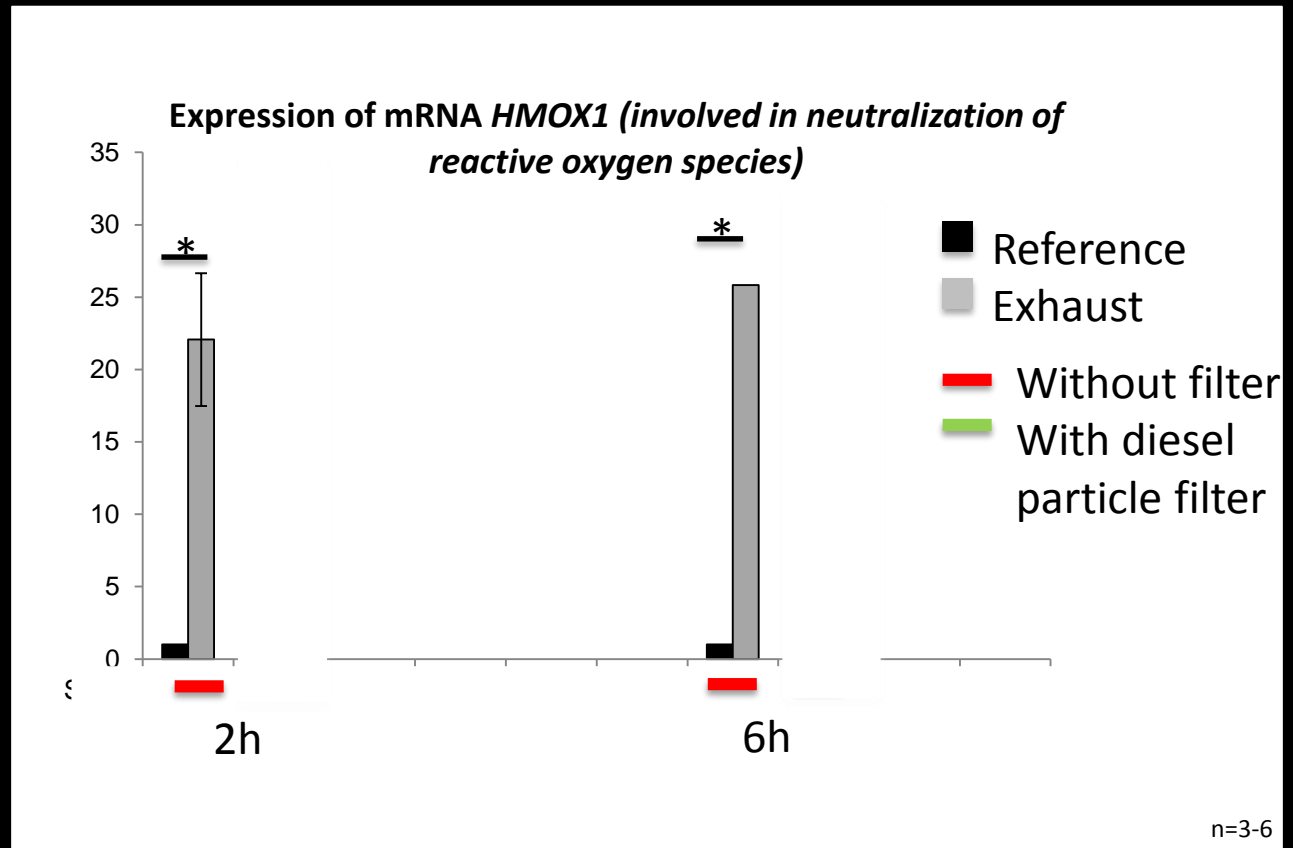
Adverse effects of pollutants

Exposure of 3D lung cultures to complete engine exhaust

3D lung cell model



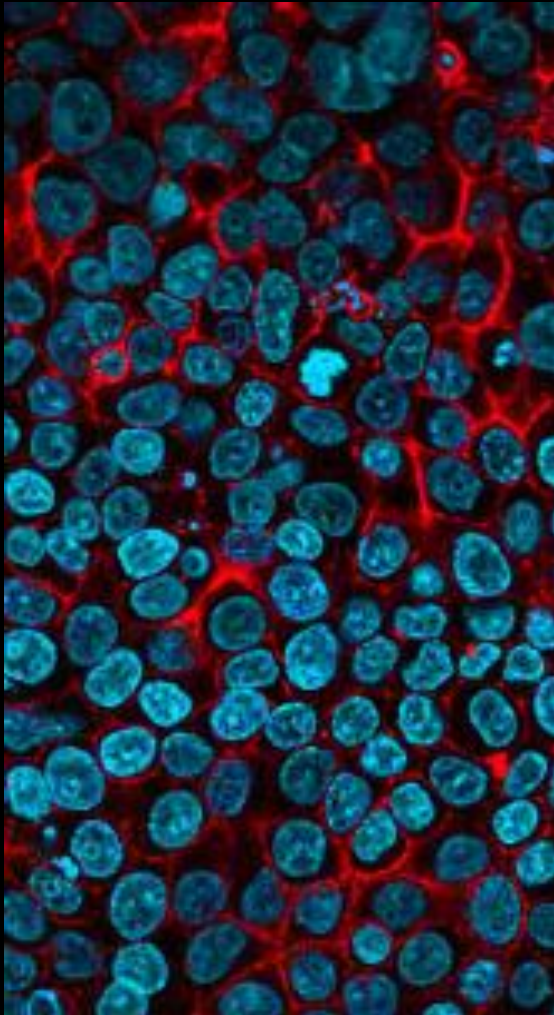
Oxidative stress response





Adverse effects of pollutants

Exposure of 3D lung cultures to complete engine exhaust



	Without filter (Gas and particles)	With filter (Gas)
Cytotoxicity	No	No
Oxidative stress (GSH and <i>HMOX1</i>)	↑	↑
Pro-inflammatory reactions (TNF α , IL8)	↑	No

Diesel particle filter significantly **reduces**
(pro-)inflammation *in vitro* but not oxidative stress

Steiner et al. Atmos Environ 2013

Similar results for gasoline particle filter studies

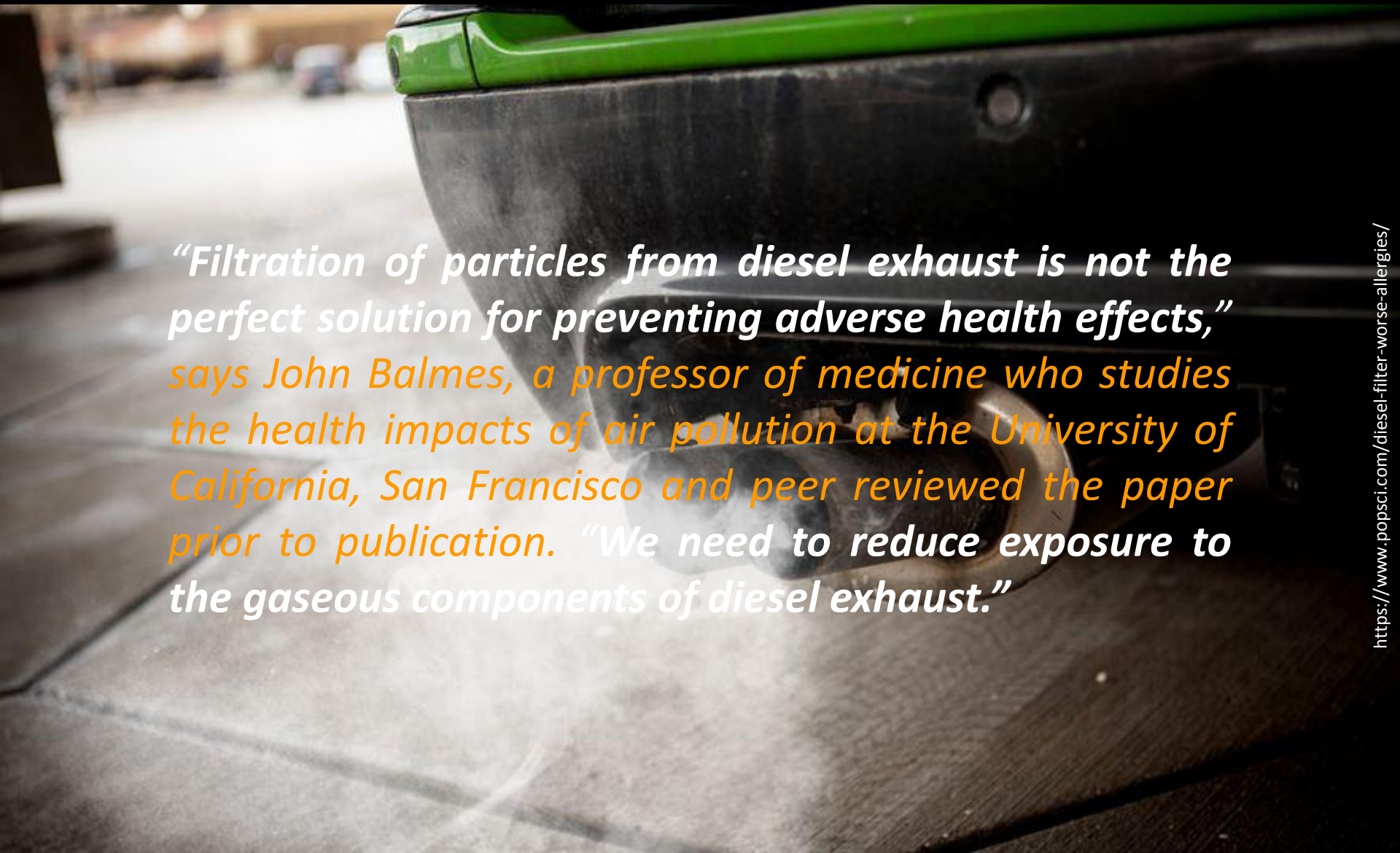
Bisig et al. Emiss Control Sci Technol 2015, Environ Pollut 2018



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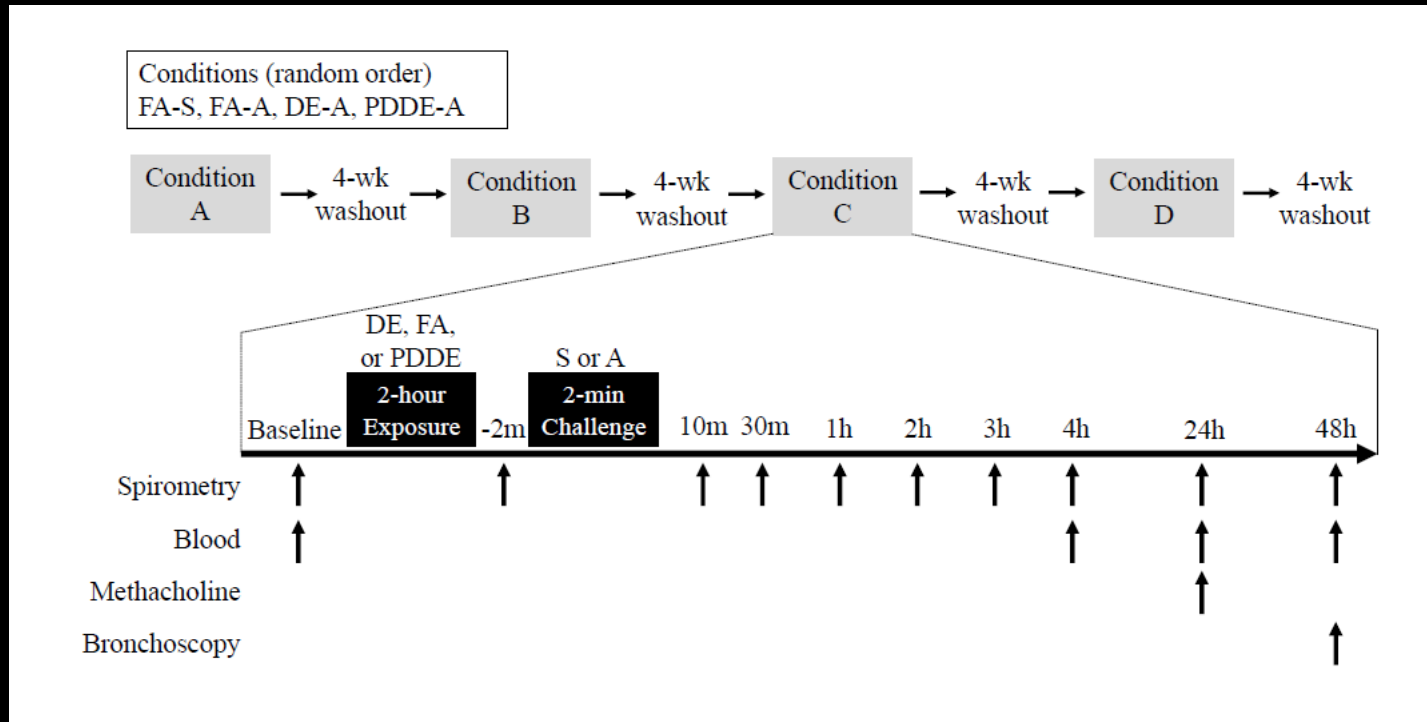
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Adverse effects of pollutants

Exposure of engine exhaust to allergen-sensitized participants



Randomized double blinded crossover study design:

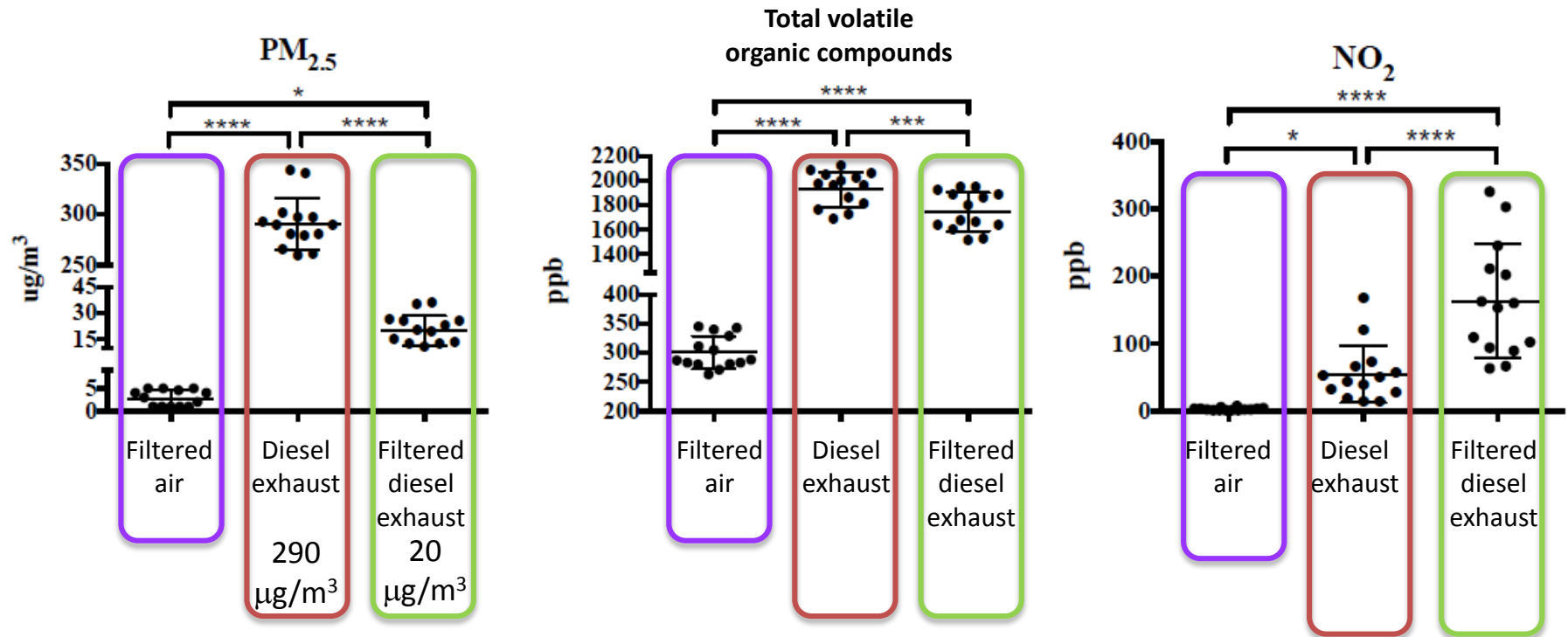
- Filtered air (FA) with or without allergen
- Diesel exhaust (DE) with allergen
- Particle-depleted diesel exhaust (PDDE) enriched with allergen

Wooding et al. Am J Respir Crit Care Med. 2019



Adverse effects of pollutants

Exposure of engine exhaust to allergen-sensitized participants

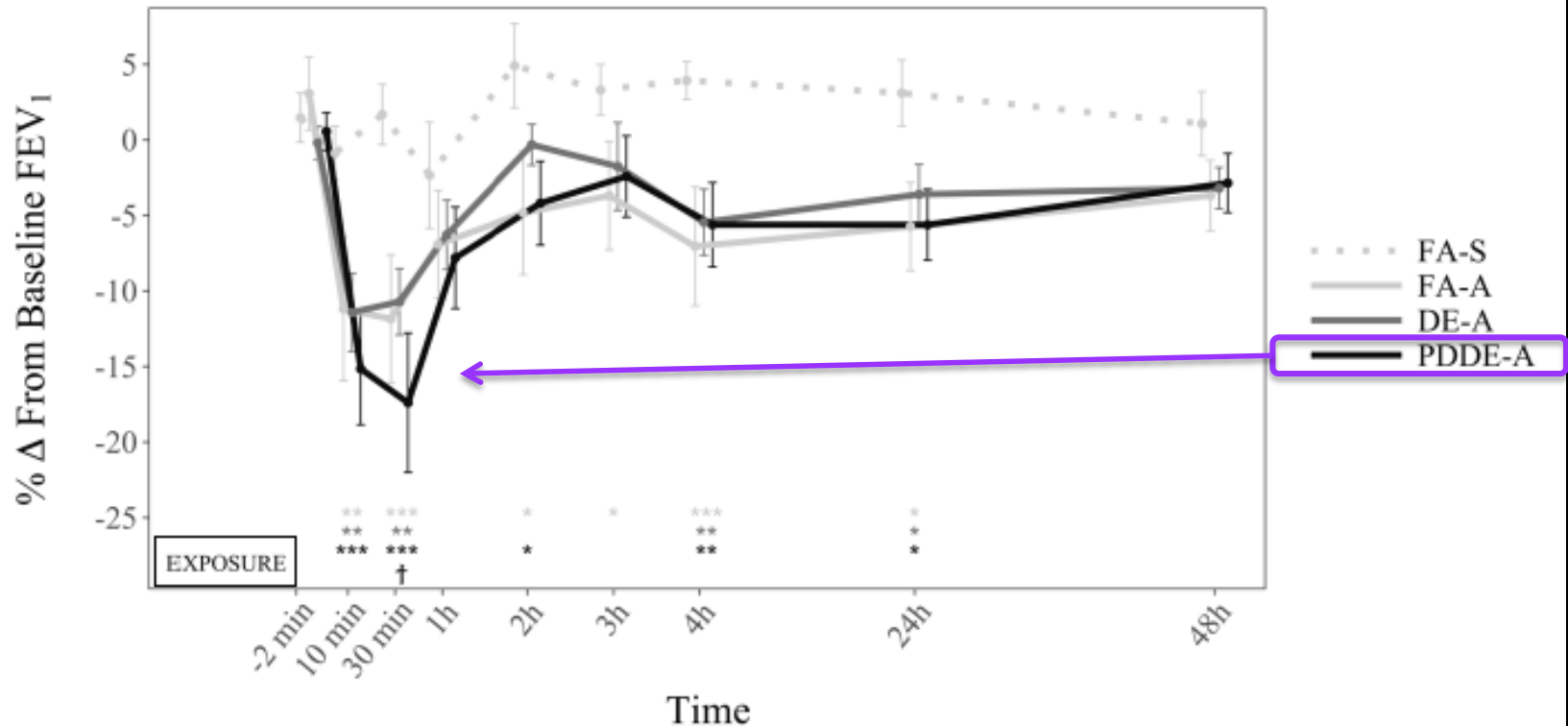


Wooding et al. Am J Respir Crit Care Med. 2019



Adverse effects of pollutants

Effect on forced expiratory volume in 1 second (FEV₁)



Wooding et al. Am J Respir Crit Care Med. 2019



Adverse effects of pollutants

Conclusions

Combustion engine exhaust components result in adverse health / cellular effects

Complete exhaust might lead to a different toxicity than only the single components

Adverse effects persist even after particle depletion suggesting that some diesel particulate-filtering technologies may not protect against the harmful effects of diesel exhaust.

<https://auto.howstuffworks.com/diesel-isnt-always-worse-polluter-than-gasoline.htm>



Acknowledgments

BioNanomaterials group



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Sandro Steiner

