Coherent Metrics for Toxic Air Contaminants are needed to link Vehicle Emissions, Air Quality Criteria and MAK thresholds

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Do you believe in progress over the past 250 years?

1775 Sir Percival Pott detected a correlation between cancer and soot. WHO surprisingly enough confirmed this in 2012
Before the French Revolution 1789 French people used 700 different units for mass, length and volumes and the fact, that king Louis XVI could not guarantee the correct mass of bread started the disaster and he got killed – justice and equality regained!
The "m" and "kg" were created but for Toxic Particles we still use non-coherent PM10, PM2.5, PN23, PN10, EC, BC, LDSA, BS
⊗ Where is the Guillotine? ⊗

Engineers can Improve, but they need to know what

Ambient air in urban environments is overloaded with all kind of particles and other toxic substance: natural and manmade, solid and volatile, soluble and insoluble, some are ultrafine and some – by far not all - are highly toxic. We have to discriminate, detect the sources of the most dangerous ones and eliminate them by setting the correct metrics, monitor correctly and use best available technology for mitigation measures

Engine Emission Definition has made Progress: as soon as health research has concluded that particle size is very important for lung uptake and organ translocation and has pinpointed engine emitted particles to be nano-size, rather insoluble, coated with PAH and metals thus "carcinogenic class 1" we realized that we needed a more sensitive metric for vehicle homologation and control of modern engines and this step is surprisingly enough successfully completed with Euro VI in Europe, not in the US → how to compare engine emission quality between Europe and the US? Further confusion prevails with NOx or NO_2, PAH or THC, metal oxides, secondary toxics and, short living global warming substances.

Public Health however seems to live on a different planet: for ambient air quality we use outdated definitions like PM10 and PM2.5, which are neither taking into account the importance of particle size nor the fact of different toxicity of contained substances nor are they compatible to particle emission of traffic sources. So we are not able to conclude on air quality from emission data and thus cannot support and justify specific mitigation measures. The same with gases where we limit NO_2, which is not even measured at the tailpipe, with hydrocarbons THC and substances classified as carcinogens like Dioxins, Furans, PAH and Nitro PAH.

This anachronistic discrepancies are not only misleading the health effect research but also policy makers and the industry
while epidemiologic studies continue to correlate PM with health endpoints and these studies are regarded to be sacrosanct by existence.

A few examples for PM definitions actually in force

Metric	**Defined by physical criteria** size? shape? phase, surface? morphology?	**Defined by chemical criteria** substance? solubility? reactivity?	**Defined by physiological criteria** residence time? dilution? metabolism?	**Toxicity Equivalent TEQ** inflammatory? mutagenic? carcinogenic?	**Dose/Effect** linear from zero? pro- or degressive? safe threshold? no no-effect level?	**Limit values** Based on what
PM-Tailpipe	Filtration below 325 °K	N/D not defined	N/D	carcinogen WHO 2012	not possible with undefined substance	Euro VI: 10 mg/kWh based on detection limit
PM-CVS	Filtration below 325 °K	N/D	N/D	carcinogen WHO 2012	not possible with undefined substance	Euro 6: 4.5 mg/kWh based on detection limit
PM stationary Switzerland	Hot exhaust "Staub"	N/D	N/D	ND	not possible with undefined substance	LRV 2018: 10 mg/m^3 based on detection limit
PM10	Size < 10 µm	N/D	upper airways deposition		see six cities study but substance undef	CH 20 µg/m^3 EU: 40 µg/m^3
PM2.5	Size < 2.5 µm	N/D	upper airways deposition	N/D	see six cities study but substance undef	WHO: 10 µg/m^3
PN23	size 23-2500 nm	solid < 300°C	lung membrane penetration	N/D	not possible with undefined substance	Euro VI: 6 x 10^{11} P/kWh Euro 6: 6 x 10^{11} P/km
PN10	size 10-2500 nm	solid < 300°C	lung membrane penetration	N/D	not possible with undefined substance	TBD for DI petrol engines by EU
PN ambient	N/D yet but could be	N/D yet but could be	lung membrane penetration	N/D	not possible with undefined substance	N/D
EC	N/D	not evaporate. < 500°C "C" identified	N/D	carcinogen WHO 2012	0.01 µg/m^3 lifelong→ 4 cancer cases per 100'000 exposed	SUVA / CH: 100 µg/m^3 EU proposed: 50 µg/m^3 based on old technology
OC	N/D	evaporated < 500°C ; "C" content ident.	N/D	N/D	not possible with undefined substance	N/D

Undefined metrics and substance mixtures of unknown and ever changing compositions should not be used → PM= salt, sand or soot?
neither should "indicating metrics" be used for phenomena they are not intrinsically connected with → NO_2 indicating ultrafine particles?

Discrepancies between traffic Emissions and Environmental Pollution Criteria

- PM as measured at the vehicle tailpipe acc. to type approval regulations is not at all coherent with PM10 or PM2.5 as measured in ambient air. Some substances might be in both samples but in undefined compositions. Calculate PM10 (or PM2.5) bottom-up from PM type approval data (even during real world driving) is scientifically not permitted. Errors possible up to one order of magnitude.
- For PN as measured at the vehicle tailpipe the same is true
- NOx as measured at the vehicle tailpipe is not defined for the ration of NO/NO_2 and can therefore not be used for ambient near traffic pollution by NO_2. Errors possible up to factor 5
- THC as measured at the vehicle tailpipe is not defined and therefore not applicable to single HC-species judgements

Proposal as a first, immediately possible improvement to get better information on exhaust toxicity and justify mitigation measures

- measure and limit PN solid 10-500 nm in ambient air
- measure and limit EC in ambient air as well as at the tailpipe
- measure and limit NO2 at the tailpipe
- measure and limit the most carcinogenic PAH at the tailpipe