PM10 HEQ
Approach to a Health-Oriented PM-Characterization

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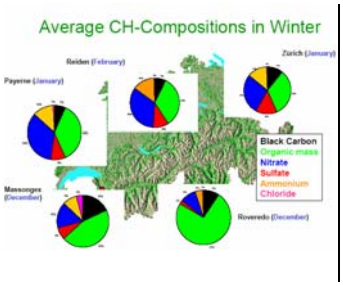
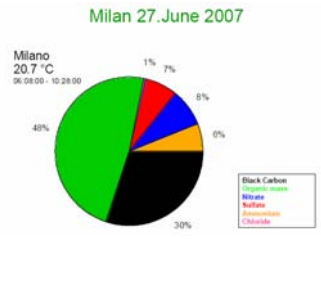
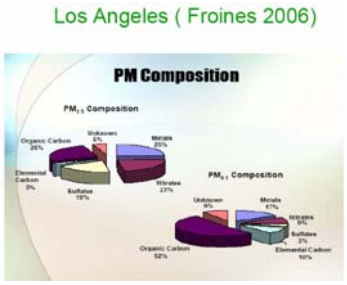
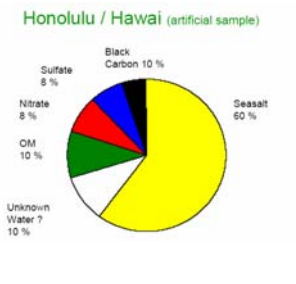
Airborne Particulate Matter is widely accepted to be a very powerful health effecting pollutant but its definition for tailpipe emissions, ambient air pollution and occupational health are different. Different metrics are used and none of them is clearly correlated to health effecting parameters like lung penetration properties, bioavailability, solubility and toxicity. Overall Mass is usually used as a metric and neither chemical composition nor particle size are respected. PM10-samples taken at different times and having the same mass might represent an entirely different toxicity.









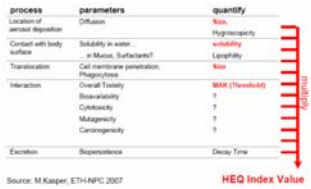
Frustratingly enough, this overall mass parameter used as a uniform metric suffers from the inability to distinguish particles of different toxicity, such as mineral dust, salt from sea spray, secondary atmospheric particles, or combustion soot. Since all captured particles are collected in the same bin, it is very difficult to link air pollution mass data to observed health effects.

Toxicity: The Conventional Engineering Understanding
A substance can be poisoning, if it can enter the system, become distributed (be available on a molecular basis) and exceeds a threshold concentration, defined as substance mass / bodymass. This threshold is high or low depending on bioavailability, residence time and chemical properties, it can be ng/kg (dioxines) up to kg/kg (water) and will be zero in case of carcinogenicity.

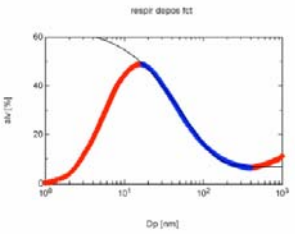
Toxicity of EC-particles: Elemental Carbon is solid, insoluble, not chemically active. The amounts inhaled are within grams per lifetime so it cannot be toxic in the common sense.
However, EC soot particles are submicron size, number concentration is up to 10^5/cc, provide high surface for transport of toxics, penetrate through membranes, are hardly cleared out and since never dissolved and diluted they trigger problems within cells by endless repeated irritation.

Since we have substances of vastly different toxicity in the ambient particulate matter we must separate them and assess their impact on human health by weighting their mass share in the PM-sample – which leads to an **Equivalence Concept** following the well established methods to assess the overall toxicity of a dioxine sample (with 75 isomeres) by TEQ or a PAH sample (acc. to EPA or IARC weighing factors) or using the rules of occupational health to rate mixed pollution. But where take the numbers from ?

Assessment Scheme
Process steps of a toxic agent entering the (human) body



Size Rating
We propose to use normalized lung deposition probability



Solubility –Rating
We propose to use normalized 1/solubility in water

- Diesel soot : 1 (insoluble)
- Metal oxide : 1
- Mineral dust : 1
- Organic matter: 1
- Nitrates: 0.01
- Sulfates: 0.1
- Sea salt: 0.01

Toxicity Rating
We propose to use normalized 1/MAK

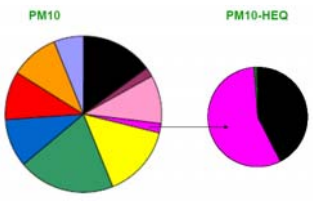
-Diesel soot: 1
-Metal oxide: 0.1 coarse
-Metal oxide: 1 ultrafine
-Nitrates: 0.1
-Sulfates: 0.1
-PAH: 50
-Mineral dust: 0.1
-Sea salt: 0.01 (no MAK)
-Water: 0.01 (no MAK)

In the following we apply this concept to an artificial sample composition and correct the above shown real PM10 samples for the toxicity of their compounds. The resulting **Health Effect Equivalent HEQ** clearly demonstrates which compounds must be taken serious and helps to decide on the important question of reduction measures – a guide for Low Emission Zones.

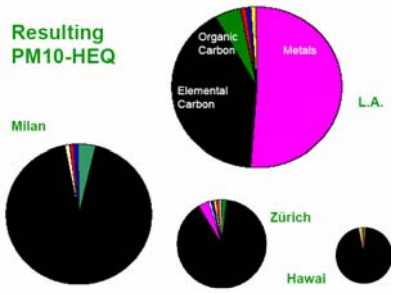
Example
PM10-HEQ Influence Factors *Example*

PM10-Compounds	EC < 500 nm	EC > 500 nm	Metals Minerals > 500 nm	Metals <100 nm	Sea Salt	OM	Benz(a) Pyren	Ammonia	Nitrate	Sulfate	Water
Mass %	15	2	10	2	15	20	0.01	10	10	10	6
Solubility	1	1	1	1	0.001	0.2	1	0.01	0.01	0.1	0.0001
Mobility	1	0.1	0.1	1	1	1	1	1	1	1	1
Toxicity	1	0.1	0.1	10	0.01	0.1	50	0.1	0.1	0.1	0.001
HEQ Index	1	0.01	0.01	10	0.00001	0.02	50	0.001	0.001	0.01	0.000001
PM10-HEQ	15	0.02	0.1	20	0.00015	0.4	0.5	0.01	0.01	0.1	0.000006

Only EC- and metal oxide particles remain important



Resulting PM10-HEQ



And why not use the same approach for Emission Assessment ?

Currently the approach is based on few classes of particle material, and on a limited number of toxicity criteria such as solubility, bio-availability and "toxicity". Further research is planned into refining these parameters; at the same time, the number of particle classes is to remain limited so as to facilitate differentiated measurement of the PM10 constituents with a reasonable extent of equipment. And following this approach it finally should become possible to conclude on improved and unified measurement principles in all application areas and supply data which find scientific support to be correlated to biological effects.