EVALUATION OF NANOPARTICLE EXPOSURE AND ITS RESPIRATORY IMPACT AMONG AIRPORT WORKERS

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Assessment of nanoparticles and metal exposure of airport workers using exhaled breath condensate

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Medical biologists

Researcher - Toxicology
Metrologist in aerosols
The workplace is no exception to this concern.

The airport occupational physicians work on this issue.

Air pollution and ultra fine particles (UFP): negative health effects on humans
- Short term effects: respiratory pathologies like asthma
- Medium term effects: cardiopulmonary morbidity and mortality

Outside pollution in the airport comes from:
- The environmental pollution from an external source and
- The pollution produced in the airports themselves:
  - the exhaust gases of aircraft and diesel engines,
  - the direct fuel emissions (kerosene) during the refueling of aircraft,
  - the particles of dust from brakes, tires and/or bitumen
In airport: **particle number concentration** (PNC) 500 000 particles/cm$^3$  
In urban environment with heavy traffic: 40 000 particles/cm$^3$

- Generation in significant volume by jet engines  
  Emissions composed mainly of nanoparticles between 6 and 40 nm (Moller 2014 – *sys Plos one; Touri, 2013 Eur. Resp. J*)

- In aeronautical field some **metals** are ubiquitous:
  - **Aluminum** Al: airline cabins  
  - **Chromium** Cr: anti-corrosive constitutive of paints, vanishes and mastics  
  - **Cadmium** Cd: composition of engine parts

Global metal exposure in the airport environment? NP exposure?

**Aim of this study**: Evaluate the NP and metal exposure of airport workers using exhaled breath condensate (EBC) as a non invasive biological matrix representative of the respiratory tract
Study approved by - the Ethics Committee of Montpellier University and - the ANSM (French Agency for the Safety of Health Products) (identification number 2011-A00646-35)

Inclusion of 458 workers by their occupational health doctors during a medical consultation

- Written informed consent
- Standardized questionnaire
- Respiratory exploration
- NO and CO analyses
- EBC collection

Two airports:
- Paris (Roissy Charles de Gaulles)
- Marseille (Marignane)

Administrative: 210 workers
Apron: 248 workers
Particle number concentration PNC: - Condensation particle counters
Particle size geometric mean GM: - Fast mobility particle sizers
- Scanning mobility particle sizers

Tarmac: $10^4$-$10^5$ with peak $\approx 10^7$ part/cm$^3$
Offices: $10^3$-$10^4$
Size distribution: *small particles* $< 25$ nm
**RTube™** from Respiratory Research (USA) and following the American Thoracic Society/European Respiratory Society recommendations

Wash 7 times with ultra pure water to minimize the analytical background for particles and elements.

11 RTubes = Blank R tubes

RTubes in individual hermetic bag for workers

Positivity Thresholds
Before
- Washing of their hands
- Rinsing of their mouth three times with tap water

For the collection:
- Wearing a Nose clip
- Tidal breathing during 15 mn

After sampling:
- EBC immediately frozen at – 20 °C

Pre analytical form:
- Weather conditions,
- Time of the beginning of the collection,
- Time of the end of the work shift
- Smoker or not,
- Time of the last meal.
458 CAE of workers in comparison with blank Rtube:

- **Volume**
- **Total protein** - Micro BCA Assay
- **Na**

**EBC particulate content**: dynamic light scattering (DLS) Zetasizer Nano ZS

For a few EBC samples:
**Scanning electron microscopy** coupled to energy-dispersive x ray spectroscopy (SEM-EDS)

**Elemental analysis**: multielemental analysis by inductively coupled mass spectrometry (ICP MS)

**Na, Cd, Al, Cr**
DLS measurements

Scattered intensity: Kcps
Size distribution

The scattered intensity values indicate that a particular content was brought out in EBC in comparison with Blanks. But no difference of scattered intensity was found between administrative and apron workers.

The main peak of the size distribution was centered on 460 nm and appeared for all subjects.

The second peak was characterized by a lower size than the main peak (100 nm), but very few subjects presented this peak.

The size of particles in EBC was higher than the size of particles measured in the air and above the theoretical nano limit of 100 nm.
Dispersed population of particles around 500 nm
Sulphur was found on some particles in EBC as well as elements representative of a biological content such as Calcium and Potassium
**ICP MS**

**Metal content of EBC**

<table>
<thead>
<tr>
<th>Metal</th>
<th>LD µg/l</th>
<th>PT µg/l</th>
<th>Administrative Median µg/l (min-max)</th>
<th>Apron Median µg/l (min-max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>0.09</td>
<td>6.0</td>
<td>3.0 (3.0-131.7)</td>
<td>3.0 (3.0-34.9)</td>
</tr>
<tr>
<td>Cd</td>
<td>0.003</td>
<td>0.06</td>
<td>0.075 (0.075-0.720)</td>
<td>0.075 (0.075-4.52)*</td>
</tr>
<tr>
<td>Cr</td>
<td>0.09</td>
<td>0.3</td>
<td>0.57 (0.15-8.68)</td>
<td>0.52 (0.15-5.12)</td>
</tr>
</tbody>
</table>

- Al and Cd: detected in about **20 % of all subjects**
- Cr: detected in about **80 % of all subjects**.

- No significant influence of gender, age or smoking status.

- No significant difference between admin. and apron workers for [Cr] and [Al]

- Significant higher level of Cd * was found in apron workers / with admin. workers
  **but [Cd] very low near our positivity threshold.**
Forces

- Study using EBC in a large population (> 450 workers).
- Difficult to have such a large study accepted in such a complex security environment.
- One of the first studies to evaluate the nanoparticle exposure and its respiratory impact among airport workers along with a biomonitoring exploration.
- Evaluation of the standardization of the sampling: protein and volume appear essential to validate the sampling.
Weaknesses

- Many technical barriers to overcome:
  - Low volume collected: difficulty to associate markers of effect and markers of exposure,
  - Low levels, need for very sensitive technics
  - Difficulty of characterisation of NP especially carbon NP

- Origin of particles in EBC?
  - Inhalation NP during the work shift, deposit in the airways and finally exhalation during EBC sampling?
  - Inhalation and direct exhalation during the EBC sampling?
  - Endogenous formation during breathing cycles?
Longitudinal study

Development of those parameters **five years later**
Assessment of respiratory function in this population.

**Investigate exposure:**
- 6 different jobs
- Individual exposure: one pump device on one worker of each group

**EBC:** with same devices but
- Filtration of inhaled air,
- Collection during 20 mn

**Urine sampling**

**NP:** DLS, TEM, **single ICPMS and ETV (ElectroThermal Vaporisation)**
**Metals:** Cd, Al, Cr: ICP MS
**Oxydative stress:** 8 isoprostanate.

Widening the national consortium to an **European consortium** which might enlarge the funding search at the European level.
Thank you for your attention!