Ultra-fine particles from Air Traffic
A major Public Health Issue for Zaventem

Downwind of runways : previous reports point to a major health issue

- LAX fine particle analysis report
- SCHIPHOL ultra-fine particle (UFP) analysis report
- Jet fuel & Automotive Diesel have similar consumption levels around Brussels
- Clear relationship between UFP level and mortality increase

Analysis campaign near Brussels Airport confirms a severe air pollution issue

- October & November 2015 Tests performed by VITO for Flanders & RBC
- 12- 22 X pollution levels at 2-9 km downwind of the take-off zone
- resulting in 20 extra deaths per year due to cardiovascular diseases

Actions to be taken

- Reduce backwind limit on runway 25R
- Relocate cargo and low-cost flights
- Move the 25L runway further east
- Plan for new airport further away from densely populated areas
LAX Fine Particle Pollution Analysis (75 MPax)

2013 study performed with a mobile pollution monitoring platform
- 5X pollution increase at 10 km downwind of the airport
- LAX air pollution equals 280-790 km of Los Angeles 1 500 km freeway network

http://pubs.acs.org/doi/abs/10.1021/es5001566
2014 study: at 7 km east of runways when the wind is blowing from the airport
- 5 X pollution level for 10-20 nm particles compared to other winds, during the day
- 25 X pollution level for 10-20 nm particles compared to night data

SCHIPHOL Pollution Analysis (58 MPax)

Geographic simulation based on 2012 data
- 10 X pollution level at 10 km downwind vs. other quadrants
  (20,000 vs 2,000 # / cm³)

Brussels: a rare city in Europe where air pollution goes the wrong way.

Kerosene burned daily near Brussels Airport compares to gas from car traffic

**Kerosene consumption for Airbus A321 airplanes at take-off**: 600 Kg = 750 liters
- 100 Kg on the taxiways
- 500-800 Kg for the first 3 mn after brake release

**Kerosene consumption for Boeing 777 airplanes at take-off**: 1,500 Kg = 1,875 liters
- 300 Kg on the taxiways
- 1,200 Kg for the first 3 mn after brake release

**Kerosene consumption for Boeing 747 airplanes at take-off**: 2,600 Kg = 3,250 liters
- 600 Kg on the taxiways
- 2,000 Kg for the first 3 mn after brake release

**Total kerosene consumption within 10 km of the airport**: 296,000 liters / day
- 300 take-off/day, 85 % - 10 % - 5 % split between the three airplane types
- average 980 liters per take-off

**Gasoline/diesel daily consumption by car commuters in Brussels**: 243,000 liters / day
- 180,000 vehicles daily, for an average of 15 km within Brussels limits
- Assumption of 9 liters / 100 km

**Gasoline/diesel daily consumption by Brusselers in Brussels**: 256,000 liters / day
- 190,000 vehicles daily, for an average of three 5 km trips
- Assumption of 9 liters / 100 km

**Diesel daily consumption by heavy trucks on Brussels Ring**: 195,000 liters / day
- 13,000 heavy trucks daily on an average of 50 km of the R0
- Assumption of 30 liters / 100 km
Atmospheric Nanoparticles and Their Impacts on Public Health

Due to intensive research, there is an emerging evidence that exposure to nanoparticles may adversely affect human health (Stölzel et al., 2007).

The nanoparticles enter human body through the skin, lung and gastrointestinal tract (Nel et al., 2006). When they are inhaled, their behavior differs from coarse particles. Their small size allows them to be breathed deeply into the lungs where they are able to penetrate alveolar epithelium and enter the pulmonary interstitium and vascular space to be absorbed directly into the blood stream (Terzano et al., 2010).

They may also translocate within the body to the central nerve system, the brain, into the systemic circulation and to organs like the liver (Helland et al., 2007; Figure 3).

They are more reactive and toxic due to the larger surface areas, leading to detrimental health effects such as oxidation stress, pulmonary inflammation and cardiovascular events (Buseck & Adachi, 2008; Nel et al., 2006).

Systemic Effect of Atmospheric Nanoparticles

![Diagram showing the systemic effects of atmospheric nanoparticles on brain, lung, liver, and blood/circulation.](image)

**FIGURE 3.**
Systemic health effects of atmospheric nanoparticles. Adapted from Terzano et al. (2010).
Higher Mortality Rates due to Ultra Fine Particles are a Reality

Analysis on 5 key European cities, summer months

- Published in June 2016
- A 10,000 particles/cm³ increases hospitalization rate by 4.27%

Long-term exposure to air pollution and incidence of cardiovascular events:

- Analysis of 65,000 postmenopausal women in the US, published in 2007
- Each increase of 10 micrograms per cubic meter is associated with a 76% increase in the risk of death from cardiovascular disease

Californian Teacher's study (130,000 women)

- A 10-μg/m³ increase in PM$_{2.5}$ leads to a 19% increase in the risk of IHD (Ischemic heart disease)

Note:

- In Belgium, 38.6% of deaths are due to cardiovascular diseases.
- Yearly mortality rate for cardio-vascular diseases is 285.5/100,000
- Any increment of cardiovascular diseases has a huge impact.

Source:
Air Pollution: a Sensitive Issue for Inhabitants

Planète Environnement

En fonction des vents, les particules ultratines se déposent sur Bruxelles, le Brabant Flamand ou sur la périphérie nord.

Zaventem, principal vecteur de pollution atmosphérique

"L'impact de l'activité aéronautique sur la qualité de l'air n'est pas étudié en Belgique.

L'Effect de l'activité aéronautique sur la qualité de l'air n'est pas étudié en Belgique.

3 Questions

CORinne CHAUSPIER
Préconise une étude approfondie pour déterminer l'origine de la pollution.

300 000 litres

Dernière mesure vécue par les riverains de Zaventem.

4 Fait saillant

1/ Courrier électronique à tous les riverains du Zaventem.

2/ Faire appel à des experts indépendants pour analyser les données collectées.

3/ Réaliser des mesures supplémentaires sur les zones touchées.

4/ Mise en place d'un système de surveillance continue.

Savoir

Quelle est l'origine de la pollution aéronautique ?

- L'activité aéronautique est principalement due à la combustion de carburants.

- Les avions émettent des particules et des gaz à effet de serre.

3 Facteurs de multiplication

Des concentrations de particules ultratines sont observées sur:

- le piste 25 à Zaventem
- le piste 28 à Zaventem
- le piste 06 à Zaventem

4 Résolution

La mise en place de mesures de réduction de la pollution aéronautique est nécessaire.

La solution repose sur:

- l'utilisation de carburants moins polluants
- l'optimisation des vols pour réduire les émissions

Mesure à prendre:

- Il est nécessaire d'adopter des mesures de réduction de la pollution aéronautique.

- Des études approfondies doivent être réalisées pour évaluer les impacts sur la santé publique.
Air Pollution Tests at Brussels Airport

Brussels Airport Air Pollution Tests: The Settings

Measurements performed between October and November 2015
Wind Distribution during the Tests
A clear focus on deadly 10-20 nm particles: high concentration – high blood deposition

- Average concentrations per 24 hours is not the best indicator due to a strong pollution variability across the time of the day
- Few 10-20 nm particles are generated by automotive traffic

Vito 2105 test results – 2 months average  
2012 Airports Council International report

http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0095456  
Number of aircraft take-offs during a typical day:
Take-off frequency peaks during 4 hours

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>take-off rate</th>
<th>hourly av.</th>
<th>duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:00 AM</td>
<td>7:00 AM</td>
<td>9 - 11 per 20 mn</td>
<td>30 per hour</td>
<td>1 hour</td>
</tr>
<tr>
<td>7:00 AM</td>
<td>9:40 AM</td>
<td>1 - 7 per 20 mn</td>
<td>11 per hour</td>
<td></td>
</tr>
<tr>
<td>9:40 AM</td>
<td>11:40 AM</td>
<td>8 - 16 per 20 mn</td>
<td>35 per hour</td>
<td>2 hours</td>
</tr>
<tr>
<td>11:40 AM</td>
<td>5:20 PM</td>
<td>0 - 8 per 20 mn</td>
<td>17 per hour</td>
<td></td>
</tr>
<tr>
<td>5:20 PM</td>
<td>5:40 PM</td>
<td>9 - 10 per 20 mn</td>
<td>30 per hour</td>
<td>1/3 hour</td>
</tr>
<tr>
<td>5:40 PM</td>
<td>9:00 PM</td>
<td>5 - 8 per 20 mn</td>
<td>20 per hour</td>
<td></td>
</tr>
<tr>
<td>9:00 PM</td>
<td>9:40 PM</td>
<td>11 - 15 per 20 mn</td>
<td>38 per hour</td>
<td>2/3 hour</td>
</tr>
<tr>
<td>9:40 PM</td>
<td>11:00 PM</td>
<td>0 - 6 per 20 mn</td>
<td>3 per hour</td>
<td></td>
</tr>
</tbody>
</table>

15% of the time (4 hours) concentrate 40% of the flight take-offs
Diegem, 1 km downwind of the 25R take-off point:
Pollution averages 95,000 # / cm³, 20X the standard levels

- **Standard pollution:** 5,000 particles /cm³
- Top 15% with wind from N-E
  - 50,000 - 140,000 particles /cm³
- Top 15% with wind from Brussels
  - average 10,000 particles /cm³

Top 15% of the time data (average 4 hours/day)

Kampenhout, 9 km downwind of the take-off point:
Pollution averages 25,000 #/cm³, 12X the standard levels.

Runway 25R Direction

Standard pollution:
2,000 particles/cm³

Top 15% (4 hours per day):
17,000 – 33,000 particles/cm³

Steenokkerzeel, 2 km downwind of the take-off point:
Pollution averages 90,000 # / cm³, 22X the standard levels

Runway 25R Direction

Standard pollution:
4,000 particles /cm³

Top 15% (4 hours per day)
40,000 – 140,000 particles /cm³

Evere, 8 km downwind of the 07R take-off point:
Pollution averages 14,000 #/cm³, 5X* the standard levels

Top 15% (4 hours per day): 8,000 – 20,000 particles/cm³
Standard pollution: 2,500 particles/cm³

* set below the airport plateau and protected by a small forest, the EVERE sensor is less representative
Dangerous concentrations of 10-20 nm particles more than 4 hours per day

2 km downwind of the take-off zone: 90,000-95,000 particles per cm³
(Steenokkerzeel & Diegem) (15% of each day)

9 km downwind of the take-off zone: 25,000 particles per cm³
(Kampenhout) (15% of each day)

These concentration levels are 12 to 22 times higher than normal:
- Kampenhout: 2,000 particles per cm³
- Evere: 2,500 particles per cm³
- Steenokkerzeel: 4,000 particles per cm³
- Diegem: 5,000 particles per cm³

Within 20° of the wind axis pollution levels remain dangerous:
- Kampenhout: Pollution levels remain above 50% of their maximum levels at 20° of the wind axis.
10-20 nm Particles Pollution from the Airport: Days per year with more than 20,000 # / cm³ added
Zaventem Ultra Fine Particles Pollution Kills about 20 Inhabitants per Year

<table>
<thead>
<tr>
<th>In Flanders</th>
<th>frequency per year</th>
<th>concentration increase</th>
<th>population</th>
<th>added cardio deaths / year per 100,000 *</th>
<th>extra deaths per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Steenokkerzeel : 250 days</td>
<td>90,000</td>
<td>11,201</td>
<td>76</td>
<td>8.5</td>
<td></td>
</tr>
<tr>
<td>- Kampenhout : 150 days</td>
<td>30,000</td>
<td>11,090</td>
<td>15</td>
<td>1.7</td>
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</tr>
<tr>
<td>- Diegem : 80 days</td>
<td>90,000</td>
<td>5,000</td>
<td>25</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>- Kortenbergh : 60 days</td>
<td>40,000</td>
<td>18,662</td>
<td>8</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>- Zaventem : 20 days</td>
<td>60,000</td>
<td>29,500</td>
<td>4.0</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>- Kraainem : 20 days</td>
<td>20,000</td>
<td>13,080</td>
<td>1.4</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>- Vilvoorde : 10 days</td>
<td>20,000</td>
<td>38,557</td>
<td>0.7</td>
<td>0.3</td>
<td></td>
</tr>
</tbody>
</table>

| In Brussels |
|-------------|----------------|-------------|----------------|----------------|----------------|
| - Evere : 50 days | 25,000 | 34,727 | 4.2 | 1.4 |
| - Brussels : 25 days | 20,000 | 50,000 | 1.7 | 0.9 |
| - Schaerbeek : 20 days | 35,000 | 116,039 | 2.3 | 2.7 |
| - St Josse : 20 days | 20,000 | 24,078 | 1.4 | 0.3 |

**TOTAL ESTIMATED ADDITIONAL DEATHS PER YEAR** 20.0

* variation of the Brussels standard cardio-vascular death rate for 100,000 inhabitants adjusted for the pollution frequency (80 days = 22% more) and the concentration levels (10,000 = 4.3% more)
Action requested to improve air pollution around Brussels National Airport

Reduces backwind limit for take-offs on runway 25R
- Kerosene consumption and pollution levels are 30% higher with backwind
- Use 07R and 07L for all take-offs with eastern winds
- Use 01 and 07 runways for all landings with eastern winds

Move 25L runway 2 km eastwards
- Bigger impact on noise pollution than on air pollution

Displace cargo & low-cost flights to non-urban runways
- Beauvechain, Zoersel, Liege

Plan for new airport in non-urban environment
- Beauvechain, Chièvres, Eksaarde, or Zoersel