Toxicological background for measured substances list

Andrey KOZLOV
Air pollution is a major environmental risk to health. By reducing air pollution levels, countries can reduce the burden of disease from stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma. (WHO)
Toxicity index for i-th substance:

\[ A_i = a_i \cdot \alpha_i \cdot \delta_i \cdot \lambda_i \cdot \beta_i \]

Where:

- \( a_i \) – an indicator of the relative toxicity of the presence of a pollutant in the air inhaled by a person (see next slide);
- \( \alpha_i \) – correction factor, taking into account the probability of accumulation of initial or secondary pollutants in the components of the environment and in food chains, as well as the intake of pollutant into the human body by non-inhalation means (is equal 1…5);
- \( \delta_i \) – correction factor which takes into account the effect on different recipients, in addition to a people (is equal 1…2), if an assessment of the toxic effect only on people is carried out, is taken equal to 1;
- \( \lambda_i \) – correction factor for the probability of secondary transfer of pollutants to the atmosphere after their precipitating on surfaces (introduced for dust and particles) (is equal 1…1.2);
- \( \beta_i \) – correction factor for the probability of formation with the participation of initial pollutants going into the atmosphere, other (secondary) pollutants, more dangerous than the initial pollutants (introduced for light hydrocarbons) (is equal 1…5).
Indicator of the relative toxicity for i-th substance:

\[ a_i = \left( \frac{\text{MAC}_{\text{CO, amb}} \times \text{MAC}_{\text{CO, w.zone}}}{\text{MAC}_{\text{i, amb}} \times \text{MAC}_{\text{i, w.zone}}} \right)^{\frac{1}{2}} = \sqrt{\frac{60}{(\text{MAC}_{\text{i, amb}} \times \text{MAC}_{\text{i, w.zone}})}} \]

Where:
MAC – maximum allowable concentration of pollutant in ambient air (index – amb) or in air of working zone (index – w.zone) for substance i in comparison to carbon monoxide (CO).
**Carbon Monoxide**

**Co**

**Symptoms**
headache, tachypnea, nausea, lassitude (weakness, exhaustion), dizziness, confusion, hallucinations;
cyanosis; depressed S-T segment of electrocardiogram, angina, syncope

**Target Organs**
cardiovascular system, lungs, blood, central nervous system

### Toxicity Index

<table>
<thead>
<tr>
<th>MAC, mg/m³</th>
<th>Russia</th>
<th>WHO</th>
<th>Europe</th>
<th>USA</th>
<th>Korea</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 hours</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 hours</td>
<td>10</td>
<td>11</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 hour</td>
<td></td>
<td></td>
<td>44</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>30 minutes</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workzone</td>
<td>20</td>
<td></td>
<td></td>
<td>40</td>
<td></td>
</tr>
</tbody>
</table>

**In vehicle concentration, mg/m³**

- 25
- 5
- 5

**In vehicle air**
Nitrogen Monoxide

**NO**

**Symptoms**
irritation eyes, wet skin, nose, throat; drowsiness, unconsciousness; methemoglobinemia

**Target Organs**
Eyes, skin, respiratory system, blood, central nervous system

**Toxicity Index**
37.5

<table>
<thead>
<tr>
<th>MAC, ( \mu g/m^3 )</th>
<th>Russia</th>
<th>WHO</th>
<th>Europe</th>
<th>USA</th>
<th>Korea</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 hours</td>
<td></td>
<td>60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 hour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 minutes</td>
<td>400</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workzone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30000</td>
</tr>
</tbody>
</table>

In vehicle concentration, \( \mu g/m^3 \)

- 200
- 1000

In vehicle air
**Nitrogen Dioxide**

**Symptoms**
irritation eyes, nose, throat; cough, mucoid frothy sputum, decreased pulmonary function, chronic bronchitis, dyspnea (breathing difficulty); chest pain; pulmonary edema, cyanosis, tachypnea, tachycardia

**Target Organs**
Eyes, respiratory system, cardiovascular system

**Toxicity Index**
41.1

<table>
<thead>
<tr>
<th>MAC, μg/m³</th>
<th>Russia</th>
<th>WHO</th>
<th>Europe</th>
<th>USA</th>
<th>Korea</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td>20</td>
<td>40</td>
<td>40</td>
<td>109</td>
<td>62</td>
</tr>
<tr>
<td>24 hours</td>
<td>20</td>
<td>40</td>
<td>40</td>
<td>109</td>
<td>123</td>
</tr>
<tr>
<td>8 hours</td>
<td>20</td>
<td>40</td>
<td>40</td>
<td>123</td>
<td></td>
</tr>
<tr>
<td>1 hour</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>205</td>
<td>205</td>
</tr>
<tr>
<td>30 minutes</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>205</td>
<td>205</td>
</tr>
<tr>
<td>Work zone</td>
<td>2000</td>
<td>1800</td>
<td>1800</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**In vehicle air**

In vehicle concentration, μg/m³

- Green arrow: 8 μg/m³
- Red arrow: 250 μg/m³
Formaldehyde

**HCHO**

**Symptoms**
- irritation eyes, nose, throat, respiratory system;
- lacrimation (discharge of tears);
- cough; wheezing; [potential occupational carcinogen]

**Target Organs**
- Eyes, respiratory system

---

**Toxicity Index**
- 131.5

---

<table>
<thead>
<tr>
<th>MAC, $\mu g/m^3$</th>
<th>Russia</th>
<th>WHO</th>
<th>Europe</th>
<th>USA</th>
<th>Korea</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 hours</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 hour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 minutes</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workzone</td>
<td>500</td>
<td></td>
<td></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

---

In vehicle concentration, $\mu g/m^3$
- In vehicle air
  - 92

In vehicle air
- 16
Particulate matter less than 2.5 μm

**PM$_{2.5}$**

**Symptoms**
Nonfatal heart attacks, irregular heartbeat, aggravated asthma, decreased lung function, increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing, premature death in people with heart or lung disease

**Target Organs**
Respiratory system, cardiovascular system

**Toxicity Index**
124.2

<table>
<thead>
<tr>
<th>MAC, μg/m$^3$</th>
<th>Russia</th>
<th>WHO</th>
<th>Europe</th>
<th>USA</th>
<th>Korea</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td>10</td>
<td>25</td>
<td>12</td>
<td>25</td>
<td>110</td>
</tr>
<tr>
<td>24 hours</td>
<td>35</td>
<td>25</td>
<td>35</td>
<td>50</td>
<td>110</td>
</tr>
<tr>
<td>8 hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 hour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 minutes</td>
<td>160</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workzone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In vehicle concentration, μg/m$^3$
Particulate matter less than 10 μm

**PM$_{10}$**

**Symptoms**
Nonfatal heart attacks, irregular heartbeat, aggravated asthma, decreased lung function, increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing, premature death in people with heart or lung disease

**Target Organs**
Respiratory system, cardiovascular system

**Toxicity Index**
69.3

<table>
<thead>
<tr>
<th>MAC, μg/m$^3$</th>
<th>Russia</th>
<th>WHO</th>
<th>Europe</th>
<th>USA</th>
<th>Korea</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td></td>
<td>20</td>
<td>40</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>24 hours</td>
<td>60</td>
<td>50</td>
<td>50</td>
<td>150</td>
<td>100</td>
</tr>
<tr>
<td>8 hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 hour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 minutes</td>
<td>300</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workzone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In vehicle concentration, μg/m$^3$

- **In vehicle air**
  - 140
  - 10
### Ozone

**Symptoms**
- irritation eyes, mucous membrane; pulmonary edema; chronic respiratory disease

**Target Organs**
- Eyes, respiratory system

<table>
<thead>
<tr>
<th>MAC, µg/m³</th>
<th>Russia</th>
<th>WHO</th>
<th>Europe</th>
<th>USA</th>
<th>Korea</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 hours</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 hours</td>
<td></td>
<td>100</td>
<td>120</td>
<td>141</td>
<td>121</td>
</tr>
<tr>
<td>1 hour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 minutes</td>
<td>160</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workzone</td>
<td></td>
<td>200</td>
<td>202</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Toxicity Index**
- 212.1

**In vehicle concentration, µg/m³**
- In vehicle air: 60 µg/m³
- 30 minutes: 28 µg/m³
  - Workzone: 200 µg/m³
  - USA: 202 µg/m³
Average daily travel time (hours) by day of the week in Europe

European Commission, Joint Research Centre, Institute for Energy and Transport, 2012
doi:10.2790/7028
Aspirated air volume per year:
1 hour * 700 l/hour * 365 days = 255,5 m³/year
or 2 hour * 700 l/hour * 365 days = 511,0 m³/year

Doze of aspirated toxicant (NO) per year:
minimal: 255,5 m³/year * 0,2 mg/m³ = 0,051 g/year
maximal: 511,0 m³/year * 1,0 mg/m³ = 0,511 g/year

Relative toxic effect of NO:
minimal: 0,051 g/year * 37,5 = 1,92 rel.g/year
maximal: 0,511 g/year * 37,5 = 19,2 rel.g/year
Relative toxic effect of main pollutants

- NO: 20
- NO2: 5
- CO: 15
- CH2O: 5
- PM2.5: 7
- PM10: 5
- O3: 7
Relative toxic effect of hydrocarbons

- Benzene
- Ethylbenzene
- 1,2,4-Trimethylbenzene
- Acetaldehyde
- Phenol
- Toluene
Conclusions

1. The assessment of relative toxic effect of main pollutants in vehicle interior air showed that most aggressive components are NO and CO, but formaldehyde and particles have also strong negative potential effect on human health.

2. Relative toxic effect of other hydrocarbons is small in comparison to effect of main pollutants.

3. It is advisable to include to scope of VIAQ IWG particulate matters with dimensions less then 2.5 and 10 μm.

4. It is important to collect and analyze the information about fine particles in vehicle interior, because they have very strong negative effect on human health.
Thank you for your attention!