ODOR PERCEPTION THRESHOLDS VERSUS DANGER LEVELS
OF AIRBORNE GASES AND PARTICULATE MATTER

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Humans are programmed or trained to believe that their senses will protect them from potentially dangerous things. In particular, we tend to believe that "if I can't smell it, it's not bad for me." In fact, this is not true and can lead to erroneous perceptions of air pollution levels in our environment.

A number of substances are commonly emitted by combustion sources, particularly aircraft. Concentrations of aircraft emissions at airports results in substantial levels of pollutants that are carried to neighboring communities, where residents tend to draw conclusions based on their senses of sight and smell. There is often no technical corroboration of these tentative sense-based conclusions if there are no pollutant level monitors, such as employed by the EPA, located in the area. The objective of this report is to quantitatively demonstrate that our noses are insensitive to air pollutant levels that are dangerous to our health and well-being.

We do this by comparing the odor threshold concentrations (the level at which they can be smelled) to the danger level of several substances. Pollution "danger" can be generally defined as 'acute" or "chronic" exposure level related, where acute means a short-term high level while chronic relates to a longer term average exposure that is typically lower than the acute level. In this context, the danger level for the considered substances varies from 1, 8 or 24 hours (acute) to 1-70 years of lifetime average exposure (chronic). [70 years is normally associated with carcinogens (cancer causing).]

On a technical note, both odor thresholds and danger level concentrations for any given substance might be found in the literature or guidelines/regulations (USEPA and the Hazardous Chemical Database, http://ull.chemistry.uakron.edu/erd/index.html used here) in terms of parts-per-million by volume (PPMv) or micrograms per cubic meter of air (µg/m3). The conversion factors between these two are given in Appendix 1.

The actual levels are not so important here, as the focus is on the substance concentration ratio of (Odor Threshold)/(Danger Level) or O/D. That is, if the O/D ratio is exactly 1.0, then we luckily will smell the danger just as it is becoming dangerous. If the O/D ratio is substantially less than 1.0, then we will sense impending danger well before the substance concentrations reach potentially dangerous levels. On the other hand, if the O/D ratio is substantially greater than 1.0, our noses will not inform us of the danger until we are already in the dangerous condition; the greater the ratio the poorer job our sense of smell protects us.

An MSNBC report quote is a relevant stage-setter for the data: "In our town, you can smell jet fuel in the air," said Wietecka (sic), who years ago helped customers and moved jetways as an intern for TWA. "We wake up to the smell of benzene and formaldehyde-based chemicals." [Ref. Appendix 2]

Let's look at those two substances first. From Appendix 1, it is seen that the O/D ratio for benzene is 38,281 while that for formaldehyde is 11,400! This tells us that the fact that the residents seem to be detecting these odors often (as compared to, say, a few hours in a year) means that the situation is rather chronic and that the EPA danger levels for both of these carcinogenic substances is exceeded by factors greater than 10,000:1!

Another appropriate example is carbon monoxide. Most educated adults know that this is a dangerous substance that causes many deaths each year, primarily due to defective heating systems. Quite relevantly in this case, the O/D ratio is infinitely large because CO is a totally odorless substance i.e. don't count on your nose as a detector. CO poisoning can be either acute (death potential) or chronic (neurological problems, etc.), both resulting from elimination of the oxygen-carrying capability of our blood. Table 1 summarizes this information for additional substances. Note that in all cases the O/D ratio <u>greater than</u> 10 to1!

Table 1

SUBSTANCE	ODOR THRESHOLD	DANGER THRESHOLD	O/D RATIO
Carbon Monoxide	<None>	10,000	Infinite
Ozone	<3888	0.08	48,600
Benzene	4900	0.128	38,281
Formaldehyde	912	0.08	11,400
Acetaldehyde	375	0.5	750
Nitrogen Dioxide	2000	100	20
1,3-Butadiene	4000	0.1	18.5
Sulphur Dioxide	1220	80	15.25

<u>Conclusions</u>

Our nose is a poor detector for ALL of these dangerous pollution substances and should not be counted on as a guide to whether conditions are safe. [In the case of carbon monoxide, the nose is not a detector at all.] Serious chronic (longer term) health problems such as cancer, respiratory illness and heart disease can result if high but non-detectable chemical concentrations persist and corrective steps are not taken.

Conversely, if the odors of any of these substances ARE being detected, it's a sure sign that the levels are probably high enough to cause acute (immediate) health problems e.g. asthmatic or cardiac attacks for at least some of the population and that corrective measures need to be taken immediately.

Officially calibrated pollution monitors should be installed in any suspect area to confirm the exact substance (what we think we smell might actually be something else) and the short/long term concentration levels.

<u>Appendix 1</u>

Derived conversion factor: 1 PPMv = 40.49*formula mass ($\mu g/m^3$)

*CO: 1PPMv=40.49*28.01=1134 $\mu g/m^3$

Odor Threshold: <None> $\mu g/m^3$ Danger level: 10,000 $\mu g/m^3$ O/D Ratio: **Infinite**

[Danger: 8-hour average]

*Ozone (O3): 1PPMv=40.49*48=1944 $\mu g/m^3$

Odor Threshold: <2ppm=3888 $\mu g/m^3$ Danger level: 0.08 $\mu g/m^3$ O/D Ratio: **48,600**

[Danger: 8-hour average]

*Benzene: 1PPMv=40.49*78.11=3163 $\mu g/m^3$

Odor Threshold: 1.55ppm=4900 $\mu g/m^3$ Danger level: 0.128 $\mu g/m^3$ O/D Ratio: **38,281**

[Danger: Carcinogenic, 1E-6 in 70 years average]

*Formaldehyde 1PPMv=40.49*30.03=1216 $\mu g/m^3$

Odor Threshold: 0.75ppm=912 $\mu g/m^3$ Danger level: 0.08 $\mu g/m^3$ O/D Ratio: **11,400**

[Danger: Carcinogenic, 1E-6 in 70 years average.]

*Acetaldehyde 1PPMv=40.49*44.05=1784 $\mu g/m^3$

Odor Threshold: 0.21ppm=375 $\mu g/m^3$ Danger level: 0.5 $\mu g/m^3$ O/D Ratio: **750**

[Danger: Carcinogenic, 1E-6 in 70 years average.]

*NO2: 1PPMv=40.49*46.01=1863 $\mu g/m^3$

Odor Threshold: 1.074ppm=2000 $\mu g/m^3$ Danger level: 100 $\mu g/m^3$ O/D Ratio: **20**

[Danger: annual arithmetic mean]

*1,3-Butadiene: 1PPMv=40.49*54.09=2168 $\mu g/m^3$

Odor Threshold: 1.85ppm=4000 $\mu g/m^3$ Danger level: 0.1 $\mu g/m^3$ O/D Ratio: **18.5**

[Danger: Carcinogenic, 1E-6 in 70 years average.]

*SO2: 1PPMv=40.49*64.1=2595 $\mu g/m^3$

Odor Threshold: 0.47ppm=1220 $\mu g/m^3$ Danger level: 80 $\mu g/m^3$ O/D Ratio: **15.25**

[Danger: annual arithmetic mean]

Gas physics reference (here for conversion factors).
http://www.civil.mtu.edu/~reh/courses/ce251/251_notes_dir/node4.html#SECTION00041300000000000000

Appendix 2

MSNBC report July 2000.

“They weren’t smokers, and there was no apparent other cause for their illnesses — except that Park Ridge lies just three miles from O’Hare Airport, one of the busiest air travel hubs on Earth.

Their puzzling condition set Wietecka on a crusade against what he calls the “nasty soup” of chemicals that drifts out from O’Hare — nitrogen oxides, sulfur oxides and hydrocarbons from jets, along with carbon monoxide from ground vehicles.

Wietecka’s crusade is a somewhat lonely task: U.S. authorities do not have hard standards for the amount of pollution jets are allowed to spew into the air. And there’s no ongoing enforcement system for the standards that do exist. However, the issue is on the agenda as the United Nations’ talks on global pollution resume this week in Bonn.

In the meantime, to many residents in quiet Park Ridge, pop. 37,000 and the hometown of Hillary Clinton and Harrison Ford, their bustling neighbor to the west is a major nuisance. “In our town, you can smell jet fuel in the air,” said Wietecka, who years ago helped customers and moved jetways as an intern for TWA. “We wake up to the smell of benzene and formaldehyde-based chemicals.””