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3061 (English version)

Summary In many offices, schools, dwellings and other non-industrial buildings the air is often perceived as annoying, unpleasant, stale, and stuffy. In many cases it has not been possible to identify the causes of these complaints by chemical analysis of the air. Therefore, two new units, the olf and the decipol, have been introduced to quantify how air is perceived by human beings. Olf is a unit which quantifies the source strength of air pollution; decipol is a unit quantifying perceived air pollution. Humans perceive the air by their olfactory and chemical sense, being sensitive to odorants and irritants in the air.

Olf and decipol: New units for perceived air quality

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1 The olf unit

One olf (from Latin *olfactus* = olfactory sense) is the emission rate of air pollutants (bioeffluents) from a standard person (Figure 1). Any other pollution source is expressed as the number of standard persons (olfs) required to cause the same dissatisfaction as the actual pollution source (Figure 2). The olf is thus a relative unit similar to the clo unit for the insulation value of clothing or the met unit for metabolic rate.

The pollution from a human being was chosen as the reference because it is well known and because considerable knowledge is available as to how bioeffluents are perceived by other human beings. Since Pettenkofer[2] and Yaglou[3] the human being has been considered the main pollution source in offices, assembly halls and other non-industrial buildings. This line of thought is reflected today in ventilation standards all over the world typically stating ventilation requirements as supplied air per occupant.

The most recent knowledge on bioeffluents is given in Figure 3, which shows the definition curve for one olf[1]. The curve shows how air polluted by one standard person (one olf) is perceived at different ventilation rates. The figure identifies the percentage of dissatisfied, i.e. those who perceive the air as unacceptable just after entering the room. The curve is based on bioeffluents from over one thousand subjects judged by 168 men and women[1]. One standard person is an average adult who works in an office or in a similar non-industrial work place, sedentary and in thermal comfort with a hygienic standard equivalent to 0.7 bath day^{-1}. Table 1 states olf values for a few known pollution sources. As the olf concept is so new[1] only a few values exist at present but measurements of olf values for typical building materials and other pollution sources are currently being collected.

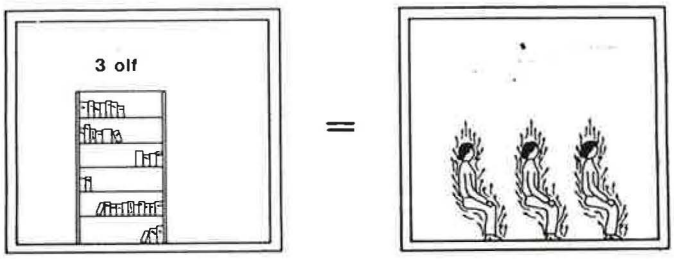

Figure 2 A pollution source has a strength of 3 olf if the pollution from 3 standard persons causes the same dissatisfaction as the source.

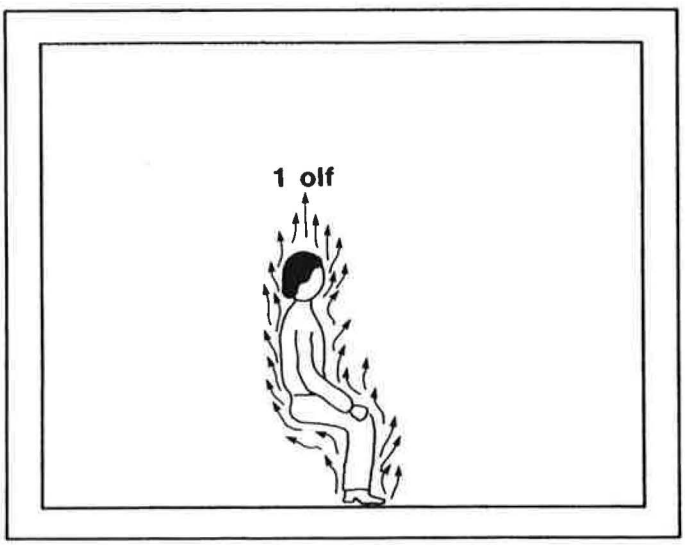

Figure 1 One olf is the air pollution from one standard person, i.e. from an average adult working in an office or a similar non-industrial work place, sedentary and in thermal comfort with a hygienic standard equivalent to 0.7 bath day^{-1}.

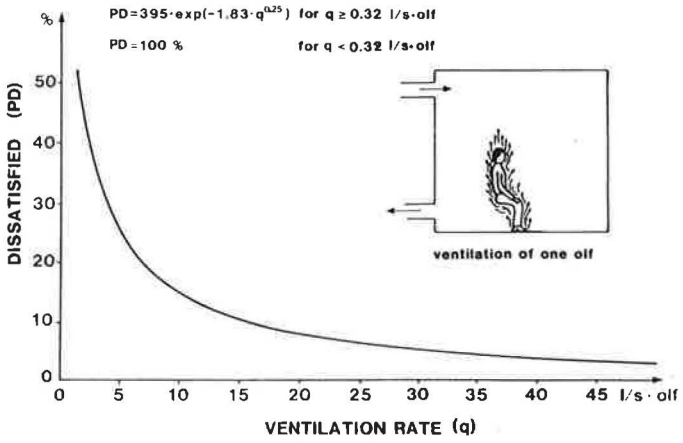

Figure 3 Dissatisfaction caused by one olf at different ventilation rates. The dissatisfied are the persons, who, when entering the space, find the air unacceptable. The curve is based on bioeffluents from more than one thousand persons judged by 168 subjects[1].

Table 1 Olf values for pollution sources

Sedentary person, 1 met	1 olf
Active person, 4 met[4]	5 olf
Active person, 6 met[4]	11 olf
Smoker, when smoking[5]	25 olf
Smoker, average	6 olf
Materials in offices[6]	0–0.5 olf per m^2 floor

2 The decipol unit

The concentration of air pollution depends on the pollution source and the dilution caused by the ventilation. The perceived air pollution is defined as that concentration of human bioeffluents which would cause the same dissatisfaction as the actual air pollution[1]. One decipol (pol from Latin *pollutio* = pollution) is the pollution caused by one standard person (one olf) ventilated by $10\,l\,s^{-1}$ of unpolluted air (Figure 4). That is

$$1\ \text{decipol} = 0.1\ \text{olf}/l\,s^{-1}$$

Figure 5 shows the percentage of dissatisfied as a function of the perceived air pollution in decipol. Figure 5 is derived from the same data as Figure 3.

In many well ventilated buildings with low pollution sources the perceived air pollution is below one decipol or 15% dissatisfied ('healthy' buildings). Spaces with low ventilation and high pollution sources may easily have a perceived air pollution around ten decipol or 60% dissatisfied. Air qualities of 0.1 decipol or 1% dissatisfied are hard to establish in indoor environments. Figure 6 shows the decipol scale and indicates typical levels of perceived air quality.

3 Analogy to light and noise units

The two new units for air quality, olf and decipol, correspond to analogous units for light and noise. As listed in Table 2 olf corresponds to lumen for light. Lumen is the unit for light emitted from a source. Only electromagnetic radiation sensitive to the human eye is considered, i.e. with wavelengths between 380 and 720 nm. Within this range the impact of the different wavelengths is weighted according to the sensitivity of the eye.

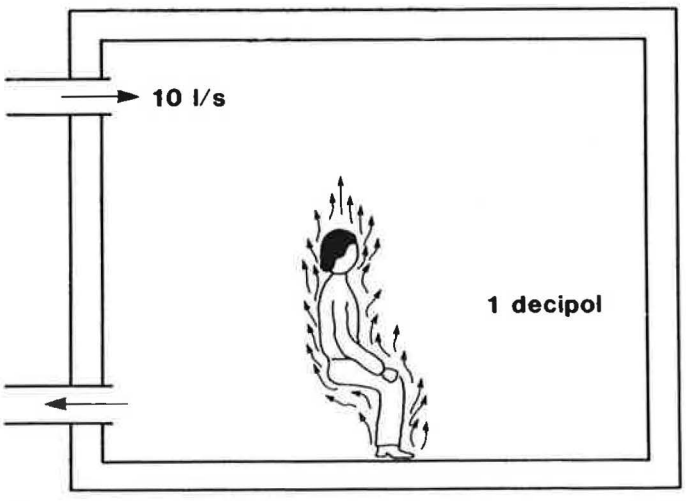

Figure 4 One decipol is the perceived air pollution in a space with a pollution source of one olf ventilated by $10\,l\,s^{-1}$ of unpolluted air. Steady-state conditions and complete mixing are assumed.

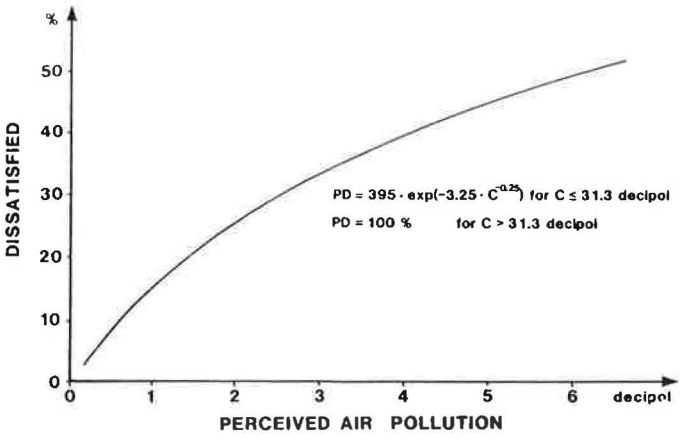

Figure 5 Percentage of dissatisfied as a function of the perceived air pollution in decipol

For noise the source strength is given by the sound power measured in watts. Only power sensitive to the human ear is considered, i.e. with frequencies between 20 and 20 000 Hz.

The olf unit integrates the emitted pollutants according to their impact on the human nose and the perceived annoyance. The decipol expresses the air pollution perceived by the nose as the lux expresses the light perceived by the eye and the decibel (A) expresses the sound perceived by the ear. Both lux and decibel express the perceived level independent of the annoyance. A given dB(A) may for example be caused by traffic or by chamber music. The decipol is different; it was found more useful to define the decipol by the annoyance rather than by the perceived level or intensity. A certain decipol level expresses a constant annoyance, i.e. a constant percentage of dissatisfied, independent of the type of air pollution.

In the beginning, light and noise could only be measured using man as a meter. Later, instruments were developed

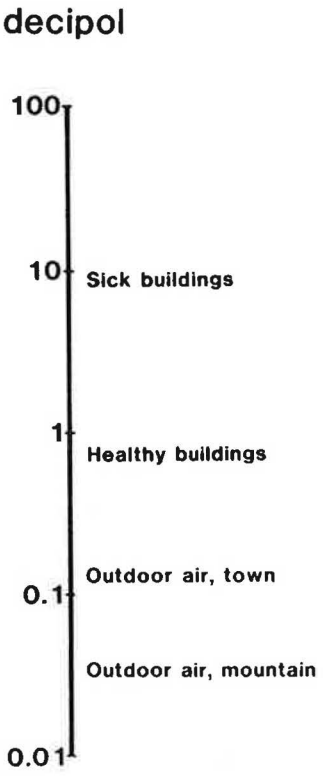

Figure 6 The decipol scale for perceived air pollution with typical examples shown

Table 2 Analogy between the new units for air pollution and units for light and noise

Parameter	Light	Noise	Air pollution
Source strength	lumen	watt	olf
Perceived level	lux	decibel (A)	decipol

with built-in information about the sensitivity of the eye and the ear depending on the wavelength. Similarly, we can at the moment measure olf and decipol only by using man as a meter. This means using a panel of judges. It will, however, be a challenge in the future to develop an instrument which can measure the perceived air pollution—a decipol meter.

4 Health risk

It should be emphasised that the decipol level expresses how the air is perceived by humans, not whether the pollution is a health risk. Any such risk should be considered separately. Still, our senses—with a few exceptions—are also influenced by harmful pollutants. Our senses have an important warning function against dangers in the environment. The perceived air pollution in decipol may therefore in many cases also provide a first estimate of a possible health risk.

5 Measurement of pollution sources

The measurement of the olf value requires a panel of judges and a measurement of the supply of outdoor air to the space. The use of panels of human subjects is common in several other fields where the human senses are superior to chemical analysis, e.g. in the food industry and in food science. The panel should judge the acceptability of the indoor air immediately after entering the room[1,4]. Before each judgement the panel should stay a few minutes in a space with low pollution, if necessary outdoors. If the pollution outdoors is significant the panel may be asked to judge the outdoor air as well. The perceived air pollution in decipol can then be found from Figure 5.

During steady-state conditions the total strength of all pollution sources in a space and the corresponding ventilation system, if any, may then be calculated from

$$C_{\text{outdoor}} + G/Q = C_{\text{indoor}}$$

where C_{outdoor} is the perceived air pollution outdoors (pol), C_{indoor} is the perceived air pollution indoors (pol), G is the strength of all pollution sources in the space and ventilation system (olf), and Q is the rate of supply of outdoor air ($l\,s^{-1}$).

Pollution sources in the space may be separated from sources in the ventilation system by turning off the ventilation system and asking the panel to make a second judgement. Q is then the infiltration of the outdoor air, which should be measured.

A certain pollution source in a room may be measured by introducing the source to the space or removing it and asking the panel to make a judgement during steady-state conditions before and after the change.

The pollution from many building materials, carpets, etc. may most conveniently be quantified as olf per m^2 surface area, whereas furniture or office machines may be quantified as olf per piece.

Systematic measurements of pollution sources could most easily take place in climate chambers where the chambers and the air-conditioning system have a modest and known olf value and where the air supply can easily be changed and measured.

6 Application outdoors

The new units may also be applied to quantify air pollution outdoors. From the thousands of pollutants occurring in small concentrations today, typically only a few are measured, e.g. SO_2, NO_x and particulates. Based on the olf values of outdoor pollution sources (power stations, cars, etc.) the perceived air pollution in a city may be predicted in decipol by the same models calculating the dispersion of SO_2, NO_x etc; olf values for many outdoor pollution sources may be determined as olf per watt produced by combustion of oil, gasoline, kerosine, gas, coal and wood.

7 Conclusions

The two new units, the olf and the decipol, quantify air pollution as perceived by humans indoors and outdoors. Air pollution sources are quantified by the unit olf. One olf is the air pollution from one standard person. Any other pollution source is quantified by the number of standard persons (olfs) required to cause the same dissatisfaction as the actual pollution source; olf is analogous to lumen for light sources and watt for noise sources.

The perceived air pollution is quantified by the unit decipol. One decipol is the pollution caused by one standard person (one olf) ventilated by $10\,l\,s^{-1}$ of unpolluted air (1 decipol = $0.1\,olf/l\,s^{-1}$); decipol is analogous to lux for light and decibel (A) for noise. Applications of the new units are suggested, and a method for measurement of pollution sources and perceived air pollution is presented.

References

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