VENTILATION CONTROL BY PERCEIVED AIR QUALITY – FACTS AND POSSIBILITIES

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ABSTRACT

ASHRAE's definition of acceptable indoor air quality demands air in which there are no known contaminants at harmful concentrations and air with which a substantial majority (usually 80 %) of the people exposed do not express dissatisfaction. Investigations on indoor air pollutants and emission sources are the scientific way to a good indoor air quality tomorrow. To guarantee pleasant and healthy breathing indoors today the control of IAQ is necessary. Demand ventilation control by unspecific sensors is one possible way there. Application of such sensors in connection with field studies of the 'European AUDIT Project to Optimize Indoor Air Quality and Energy Consumption in Office Buildings' showed that signals from tin oxide gas sensor (mixed-gas sensor) correlated well with perceived air quality.

KEYWORDS

Demand ventilation control; perceived air quality; mixed-gas sensor; tin oxide gas sensor, air quality sensor

INTRODUCTION

In 1858 Max von Pettenkofer, a German hygienist, defined the CO_2-value for good indoor air quality. The reason for the use of this metabolic output as an indicator for all the other emissions of human beings - it was easy to measure CO_2. We are still using Pettenkofer's 0.1%value, but emissions have changed during the last decades. Field studies on perceived air quality (PAQ) in several buildings of Copenhagen showed, that less than 1/5 of the sensory pollution load came from occupants and the main emission sources are ventilation systems, building materials and interior (Fanger *et al.*, 1988). To find a new indicator for these non-human emissions Pettenkofer would be faced with a dilemma. Pattern of pollutants varied from room to room, from time to time, depending on temperature, humidity, cleaning procedures, building maintenance, habits, economy, etc.

RESULTS AND DISCUSSION

Part a) Influence of odors on MGS/PAQ comparison

Using single aromatic essences as pollutants no correlation was found between measured (MGS) and perceived air quality (Fig. 1). High olfactory sensitivity to very low concentrations of odorous substances while MGS do not react adequately leads to this discrepancy of subjective and chemical determination of IAQ in this special case.

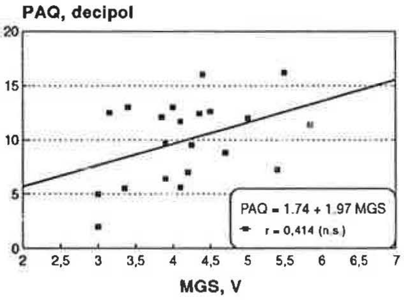

Fig. 1. Correlation of perceived and measured air quality - chamber studies

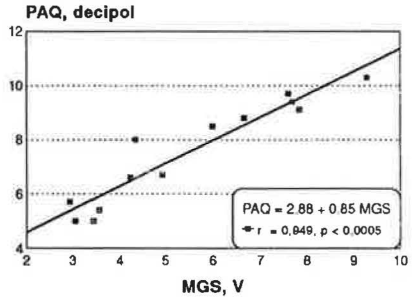

Fig. 2. Correlation of perceived and measured air quality - field study/longitudinal design

The strong influence of odorous substances on MGS/PAQ correlation quality was also shown by pooling of field data of different buildings (Bischof *et al.*, 1993).

Part b) Field study in one office building, longitudinal comparison of MGS and PAQ

Objective and subjective assessment of air quality showed significant correlation in the field (Fig. 2). On the pre-condition that strong odorants are absent and that humidity is nearly constant a given pattern of pollutants (e.g. volatile organic compounds emitted by indoor sources) will vary in total concentration but only to some extent in mixture ratio. So demand ventilation control by MGS makes it possible to compensate for man's olfactory adaptation and thus to enhance air quality.

Part c) Field study in office buildings, cross sectional comparison of MGS and PAQ

Table 1 shows the results of the crosscorrelation analysis of some determined variables which may be used for ventilation control. Significant dependence was shown between MGS and classic IAQ-control parameters as well as TVOC and perceived air quality.

Table 1. Crosscorrelation of air quality relating parameters (+++..$\alpha < 0.001$, ++..$\alpha < 0.05$, n.s. - non significant)

	CO	TVOC	decipol	RF	MGS
CO_2	++	+++	+++	n.s.	+++
CO		+++	+++	n.s.	+++
TVOC			+++	++	+++
decipol				++	++
RH					+++

To decide whether MGS is an useful parameter for demand ventilation control regression analysis is necessary. Fig. 3 and Fig. 4 show the results using data of all of the 6 investigated office buildings. While MGS and TVOC show good correlation, MGS seems to be an insuffi-

Both groups of indoor air pollutants may warn man by sensory terms but a stay of some minutes in the room decreases this physiological function by adaptation. Longtime pollution load without sensory feedback mechanisms, as known for thermal and acoustic parameters, are the consequences.

For a few pollutants the pathophysiological way to a Building-Related Illness is known, while most of the others may lead to effects, usually called Sick Building Syndrome.

So occupants cannot be responsible for good air quality. Primary healthy indoor air has to be guaranteed by prevention: Minimize the emission sources. That seems to be a hard work for scientists and politicians for the next decades.

Simultaneously progress must be made in another way too: As at the time of Pettenkofer sufficient ventilation leads to healthy air, which ASHRAE defines "*air in which there are no known contaminants at harmful concentrations*". To make ventilation sufficient without energy deficit demand control is required. But control of ventilation works only with suitable sensors, CO_2- or humidity-sensors for the Pettenkofercase and 'all-over-integrating' sensors as mixed-gas sensors (MGS) for emissions by materials.

MATERIALS AND METHODS

The investigation was subdivided into three parts:

a) Influence of odors - laboratory comparison of MGS and PAQ
b) Field study in one office building, longitudinal comparison of MGS and PAQ
c) Field study in office buildings, cross sectional comparison of MGS and PAQ

Tin oxide sensors in thin-layer technology were used for all experiments. Sensor output was transformed to a 0...100 %-signal. Perceived air quality was quantified by the method of Fanger (1988) using a trained panel for voting IAQ in decipol.

To correlate MGS and decipol under extreme conditions, 10 odorous substances (Terpineol, Eucalyptol, Diphenylmethan, Camphor, Menthol, Borneol, Fenchol, Thymol, Diphenylether, Menthyl acetate) were used as emission sources. Members of a trained panel (n=7) were exposed to ventilated jars as described by Bluyssen and Fanger (1988). Subjective voting of the perceived air quality and simultaneous MGS and TVOC measurements were carried out under clean room conditions.

Longitudinal field measurements were taken in two rooms of a building with natural ventilation, where one room was mainly polluted by bioeffluents and the second by emission from interior and - for one series - by an artificial source (formaldehyde). The study duration was one week and the panel voted four times each day. MGS-signals were recorded continuously.

Cross sectional comparison of MGS and PAQ was performed in 6 danish office buildings. Measurements of TVOC, CO, CO_2 and MGS and assessments of the perceived air quality were taken in 5 spaces of each of the selected buildings. Concentrations of air pollutants and MGS-data were determined for the time interval of the panel voting.

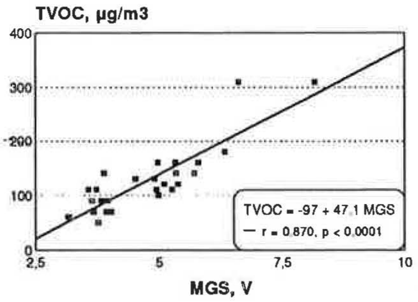

Fig. 3. Correlation of total volatile compounds concentration and mixed gas sensor signal, field study/cross sectional

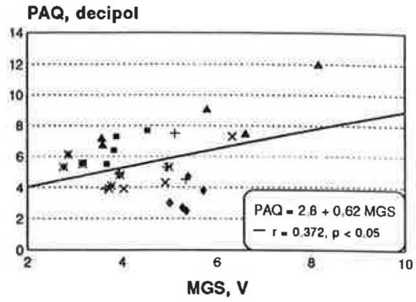

Fig. 4. Correlation of perceived and measured air quality - cross sectional design (different symbols indicate different buildings)

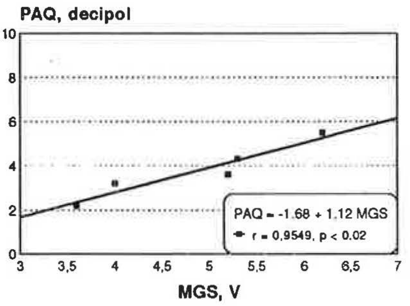

Fig. 5. Correlation of perceived and measured air quality - data from one of 6 buildings

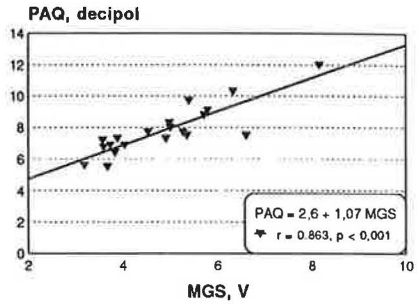

Fig. 6. Retrograde building related correction of sensor callibration - data from 4 buildings

cient parameter for PAQ control. But uncritical combination of measurements in many buildings with differences in the building related microenvironement leads to a high but pseudo variance. Fig. 5, based on data from only one of the 6 buildings, indicates that control of perceived air quality by MG-sensors is applicable.

To demonstrate the possibilities of sensor application, data of 4 buildings were checked by a simple linear correction. By this means building related sensor calibration leads to much better PAQ/MGS-correlation as Fig. 6 shows.

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