Effects of Ionisation Air Purifiers on Indoor Air Quality

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SUMMARY

Three different air purifying devices are compared in terms of their influence on indoor air quality. Two systems use ozonisation and ionisation. One system uses ionisation and special filter devices (manufacturer's specifications). In the case of ozone production the perceived intensity and the PD value will increase to inacceptable values. The chemical analyses shows that the increase aldehyde concentration is probably caused by surface reactions between material and ozone.
Purifying devices running with ionisation only have slightly no effect on the perceived air quality. Only one test case, when emissions of human beings are an additionally pollution source in the test room, a small increase in air quality can be recognised.

INTRODUCTION

A common method to achieve good indoor air quality is to reduce concentrations of odorous substances by ventilation. Presently an increasing number of air cleaning devices are offered on the market. The manufactures promise a reduction of odour-active substances in the room air.
Up to now, only very few data is available [1, 2] on the odour removal efficiency. Most of the time the efficiency of these devices refers only to manufacturer's specifications. Therefore systematic tests are made in a new experimental set up.

EXPERIMENTAL SET-UP

With two identical, ventilated test rooms the efficiency of different air cleaning devices are examined. Figure 1 shows the location of the two test rooms (room 1 and room 2) in the air quality lab. The dimensions are 2.5 m x 2.5 m x 2.5 m. Both rooms are supplied with outdoor air by the same supply air duct and two fan coil units.

The rooms are built from the same building materials and have the same furnishing, similar to common office rooms. A controllable air flow of the polluted indoor air of the test rooms is extracted by a potential free tubing of stainless steal. It is presented with diffusers to a panel of subjects to assess the air quality. In addition, the air contaminants are analysed chemically by using GC/MS technology via TENAX probes.

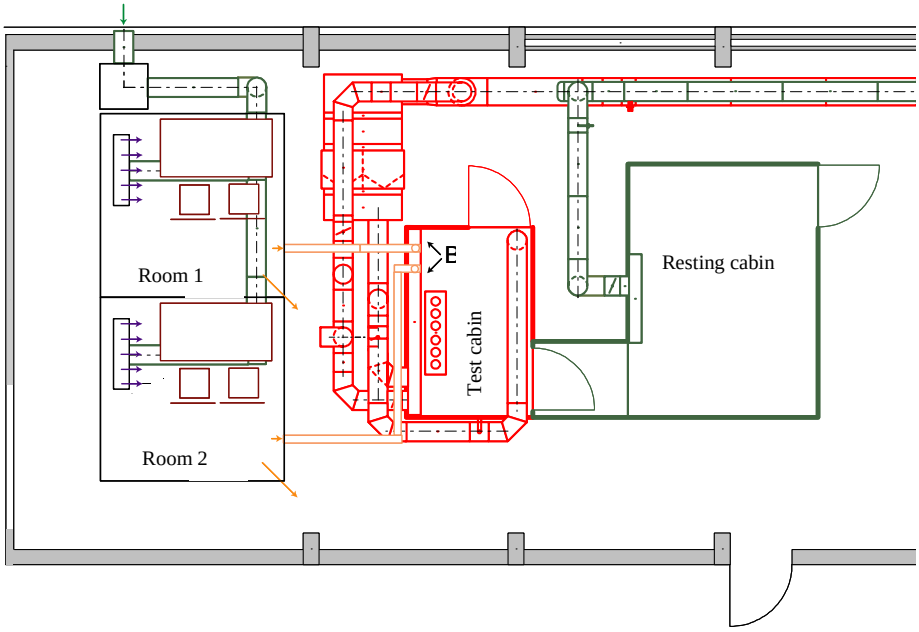

Figure 1: Sketch of Test Setup in the Air Quality Lab with two test rooms and the cabins for the panel [4]

METHOD

The air in the two test rooms is polluted by the equipment (standard building materials like carpet, furniture and wallpapers). In the first step of the experiment the perceived odour intensity, the acceptability and the hedonic impression of both rooms is evaluated.

The perceived intensity is measured with a selected panel of 10 persons [3, 4]. When assessing perceived intensity of unknown samples, panel members can rely on a comparative scale of acetone/air mixtures, the so-called markers, which help to determine the intensity. The perceived intensity Π can only be determined with trained panels using a comparative scale.

Unlike the acceptability method with untrained panels, the intensity of odorous substances in the air is determined by a comparison with different specified intensities of the reference material acetone. The smelling capability varies from human to human. Training and use of comparative sources ensure that the influence of subjective perception of the test result is reduced since all panel members evaluate air quality based on the same scale.

A naive panel of 40 persons is asked about the acceptance of the air quality. Therefore a continuous scale is used for the acceptability. It is converted into values of +10 (clearly acceptable) to –10 (clearly not acceptable). An average value is calculated from all answers to calculate the acceptability [5]. In addition a question to the hedonic impression is answered by both panels.

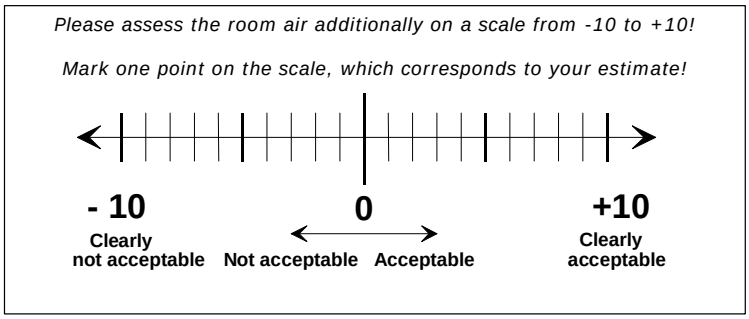

Figure 2: Question to determine acceptability

Three different purifying devices are tested separately. In one of the test rooms the device is installed, the other room is running without any purifying for comparison. For each device a test series over several days is done. In intervals the perceived intensity Π, acceptability and the hedonic impression is assessed for both rooms at the same time in a blind test.

PURIFYING DEVICES

In Table 1 the technical specifications are listed. Type 1 and type 2 have a built in purifying device, which produces ozone and ions. For type 1 there is only the option to run both modes n the same time. Type 2 can produce ozone and ions separately. The stand alone device type 3 has four options for different modes. The manual shows the “turbo” mode as the mode for fast air cleaning. Therefore this mode is tested, additionally all other options are switched on.

Tabele 1: Technical specifications of the tested air purifying devices (manufacturer's specifications)

Type	**1**	**2**	**3**
	Decentralized fan coil	**Decentralized fan coil**	**Stand alone in room**
Purifying Method	Ionization and ozonisation	Ionization and ozonisation	Pre filter Plasma ioniser Bio antibody filter Ionising frame Ionised wire Streamer discharger Opposing pole plates Plated filter (electrostatic) Photo catalyser
Tested working modes	Combination of ionisation and ozonisation runs in out door air modus	Combination of ionisation and ozonisation runs in air recirculation modus	**Auto** (automatically adjusted air volume flow) **Turbo** (fast air cleaning), **Anti Pollen** (removing pollen) **Relax** (negative ions)
	---	ionisation without ozonisation runs in air recirculation modus	---

RESULTS

In the first step a comparison of the two test rooms was done. Figure 3 shows a good analogy in the air quality of both rooms.

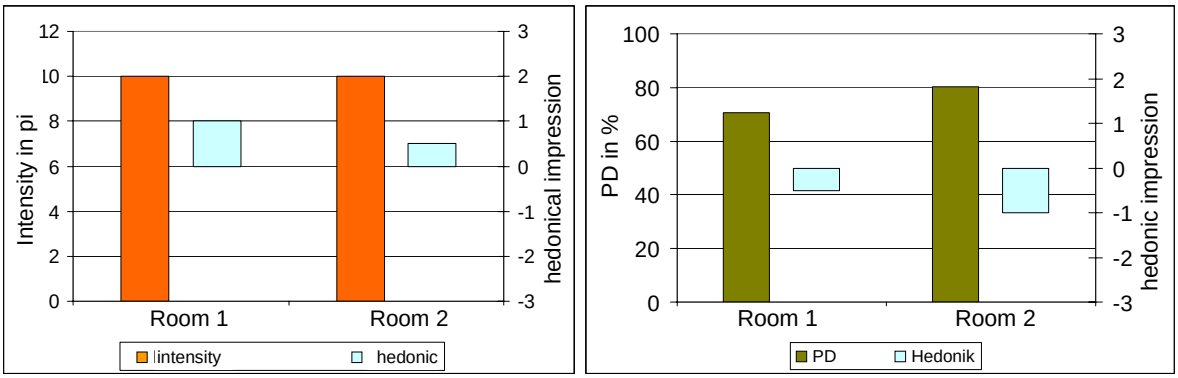

Figure 3: Perceived intensity and hedonic impression, PD and hedonic impression

The perceived intensity is similar for both rooms. The value of 10 pi characterises a strong odour impression. The hedonic impression of the rooms is also quite similar. The acceptability measurements show as well very comparable results for both rooms. During the time the PD-value and the intensity decreases equally in both rooms because of normal emission of the materials and the ventilation.

This similar air quality state in both rooms is the starting point of all investigations of the three different purifying devices.

Device 1

This device runs with a combination of ozone production and ionisation. The ozone concentration in the room is in the range of 50-70 ppb (alternating because of internal control loop).

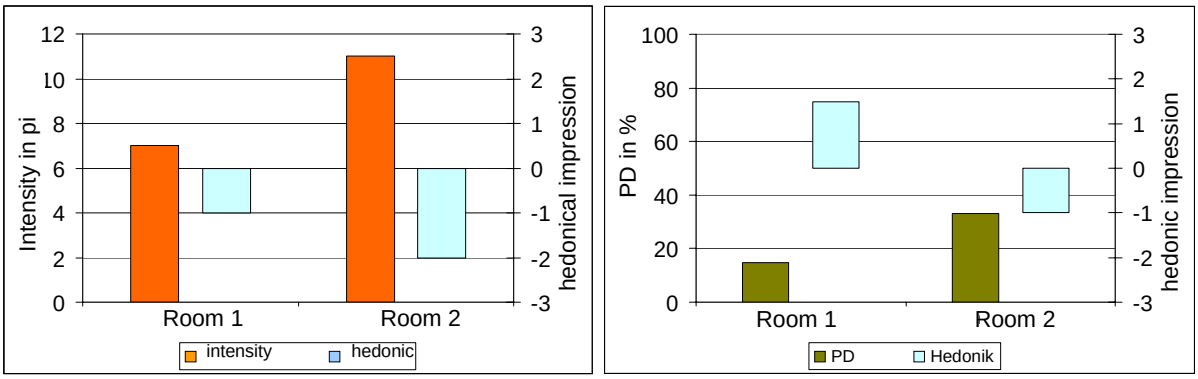

Figure 4: Perceived air quality, hedonic impression and PD for device 1

Figure 4 shows that the purifying device increases the perceived intensity about 4 pi in comparison to the room without purifying device. The hedonic impression becomes negative when the device is switched on. Measurements with the naive panel show similar results. The question of the acceptability gives a PD level of about 15 % for the room without purifying device and about 35 % with purifying device.

Device 2

First device 2 runs in the ionisation mode only with recirculating air. Figure 5 shows that there is slightly no effect on the perceived intensity Π and the acceptance values. Only a

positive tendency in the hedonic impression of the panel that perceives the intensity can be recognised.

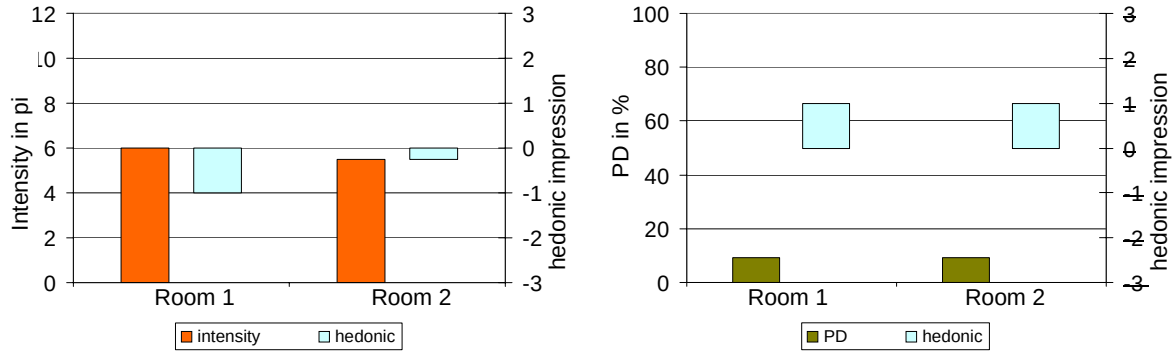

Figure 5: Perceived air quality, hedonic impression and PD for device 2 in ionisation mode (test 1)

Second, device 2 runs in a mode that combines ionisation and ozone production. In Figure 6 the influence of the ozone production (20 ppb) on the perceived intensity is shown. The intensity increases from 6 pi to 9.5 pi.

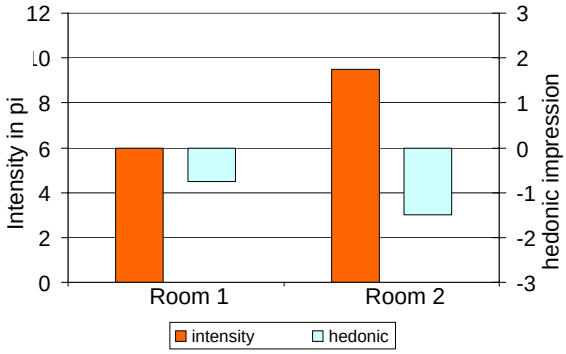

Figure 6: Perceived air quality and hedonic impression for device 2 in ionisation and ozone mode (test 2)

A third test run was made with persons as additional pollution source in the test room. The results are given in Figure 7, where a little increase can be recognised in the hedonic impression. The perceived intensity is nearly the same for both rooms.

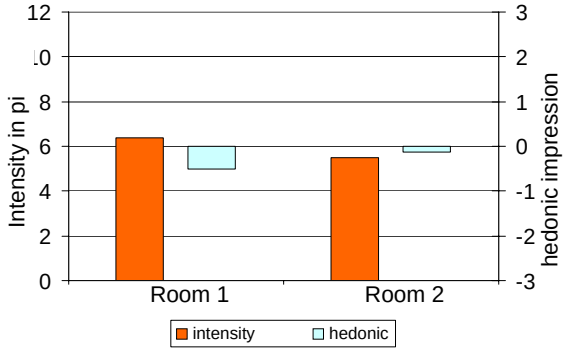

Figure 7: Perceived air quality, hedonic impression for device 2 in ionisation mode, person as pollution source in the test room (test 3)

Device 3

For this stand alone device the internal functions are not documented properly, it runs in the "turbo" mode with all options switched on.

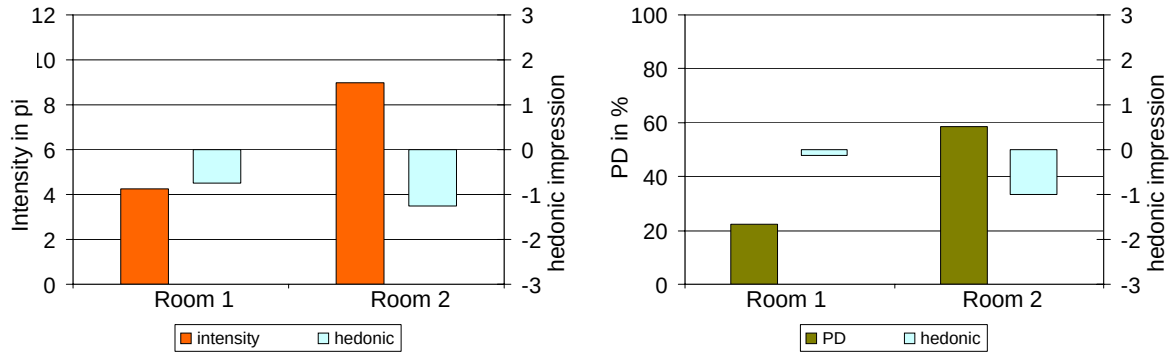

Figure 8: Perceived air quality, hedonic impression and PD for device 3 in automatic mode

Figure 8 shows that perceived intensity and hedonic impression is worse in the case with purifying device also the PD value raises from about 25 % up to nearly 60 %.

Chemical analyses

As an example for all of the chemical measurement the data of device 1 are discussed. The results from chemical analyses using GC/MS technology show the influence of ozone concentration in the room. Figure 9 indicates an increase of the concentration of aldehydes. The dark part of the bar shows the concentration in the test room without air purifier, the whole bar stands for the concentration in the room with running device. One reason of the rising concentrations are chemical reactions of ozone on the surfaces in the room [6]. Products of these reactions are aldehydes. Aldehydes as nonanal and hexanal have a strong odour impression and this might be a reason for the worse perceived air quality. Other concentrations of chemicals are low, but in most cases there is an increasing of concentration according to the ozone concentration. The addition of several chemicals in low concentration can cause odorous irritations.

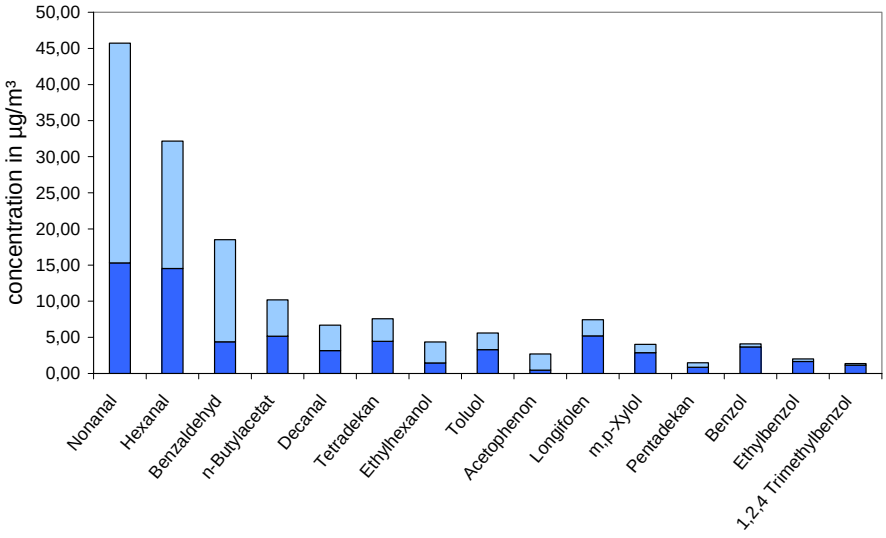

Figure 9: Increasing concentration of aldehydes caused by ozone

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REFERENCES

1. Kolarik J., Wargocki P. 2005.
   Effect of a photocatalytic air purifier on perceived indoor air quality,Proceedings of the 10th International Conference on Indoor Air Quality and Climate – Indoor Air ’05, Beijing, China.
2. Grinshpun S.A., Mainelis G. et al. 2005.
   Evaluation of ionic air purifiers for reducing aerosol exposure in confined indoor spaces, Indoor Air 2005, 15: 235-245.
3. Müller D., Bitter F., Kasche J. and Müller B.. 2005. A two step model for the assessment of the indoor air quality Proceedings of the 10th International Conference on Indoor Air Quality and Climate – Indoor Air ’05, Beijing, China.
4. Bitter, F.; Böttcher, O.; Dahms, A.; Kasche J.; Müller, B; Müller, D. 2006:
   Luftqualitätshandbuch des HRI, *www.tu-berlin.de/fak3/hri/dokumente/lq_handbuch_v08.pdf*
5. Gunnarsen, L; Bluyssen P. 1994
   Sensory measurements using trained and untrained panels proceedings of Healthy Buildings ’94 Budapest, Hungary
6. Weschler, C..J., Hodgson, A.T., Wooley, J.D., (1992). Indoor Chemistry: Ozon, Volatile Organic Compounds and Carpets. Envirn. Sci. Technol., 26: 2371 - 2377.