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Kakovosten zrak v pisarnah povečuje produktivnost

Good Air Quality in Offices Improves Productivity

P. Ole Fanger

Tri nedavne neodvisne študije so pokazale, da ima kakovost zraka v pisarnah pomemben in pozitiven vpliv na produktivnost zaposlenih. Kombinacije analiz rezultatov raziskav kažejo pomembno povezavo med produktivnostjo in kakovostjo zraka. Z izboljšanjem kakovosti zraka v pisarni se zvečuje produktivnost. Ena od možnosti zagotavljanja kakovostnega zraka za dihanje ljudi, brez pretirane ventilacije in porabe energije, je zagotavljanje ″osebnega zraka″ vsakemu posamezniku. O tej temi piše ta prispevek.

(Ključne besede: zrak v prostorih, vplivi na produktivnost, ventilacija, kakovost zraka)

Three recent independent studies have documented that the quality of indoor air has a significant and positive influence on the productivity of office workers. A combined analysis of the results of the three studies shows a significant relationship between productivity and perceived indoor air quality. The impact on productivity justifies a much higher indoor air quality than the minimum levels prescribed in present standards and guidelines. One way of providing air of high quality for people to breathe, without involving excessive ventilation rates and energy use, is to provide "personalized air" to each individual.The application of this concept is discussed in this paper.

(Keywords: indoor air quality, productivity, ventilation, personalized air)

0 UVOD

Yagou je leta 1936 predstavil novo filozofijo prezračevanja z namenom zagotoviti notranjo kakovost zraka ljudem. Ta filozofija je podlaga za prezračevalne standarde neindustrijskih poslopij. Na tej podlagi so bili nedavno sprejeti tudi standardi in priporočila, to so ASHRAE Standard 62 [1] in CR 1752 [2]. Kakovost notranjega zraka ima zelo velik vpliv na ljudi. Tri nedavne študije so pokazale, da ima kakovost zraka v pisarnah pomemben vpliv na produktivnost in simptome nezdravih prostorov (SNP - SBS). Te študije so prikazane v prvem odstavku tega članka.

Dobro kakovost zraka v prostoru lahko dosežemo z zmanjševanjem virov onesnaženja, povečanjem stopnje prezračevanja ali s čiščenjem zraka. Pomembna je vrednost zraka, ki ga uslužbenci dihajo. Ena izmed možnosti je dovod zelo dobrega zraka v območje dihanja vsakega posameznika. Drugi odstavek tega članka govori o ″osebnem zraku″.

0 INTRODUCTION

In 1936, Yagou introduced a new philosophy for ventilation, the aim being to provide an indoor air quality that is perceived as acceptable by people. This philosophy has subsequently dominated the thinking in ventilation standards for nonindustrial buildings. It is still the idea behind recent standards and guidelines such as the ASHRAE Standard 62 [1] and the recent CR 1752 [2]. But indoor air quality has an impact on humans beyond perception. Three recent studies have now documented that indoor air quality has a significant impact on productivity in offices and on sick building syndrome (SBS) symptoms. These studies are reviewed in the first section of this paper.

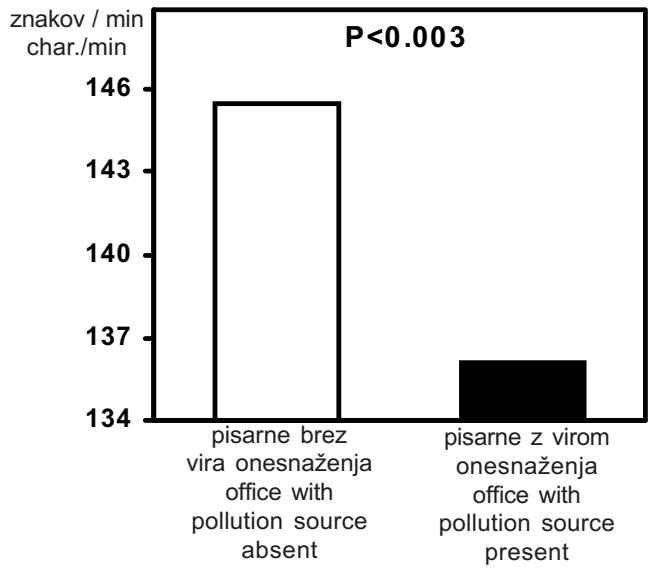
High air quality in a space can be achieved by decreasing the pollution sources, by increasing the ventilation rate, or by cleaning the air. But what really counts is the quality of the air that the occupants breathe. One option is to supply air of high quality direct to the breathing zone of each individual. The establishment of such "personalized air" is discussed in the second section of this paper.

1 PRODUKTIVNOST IN NOTRANJA KAKOVOST ZRAKA

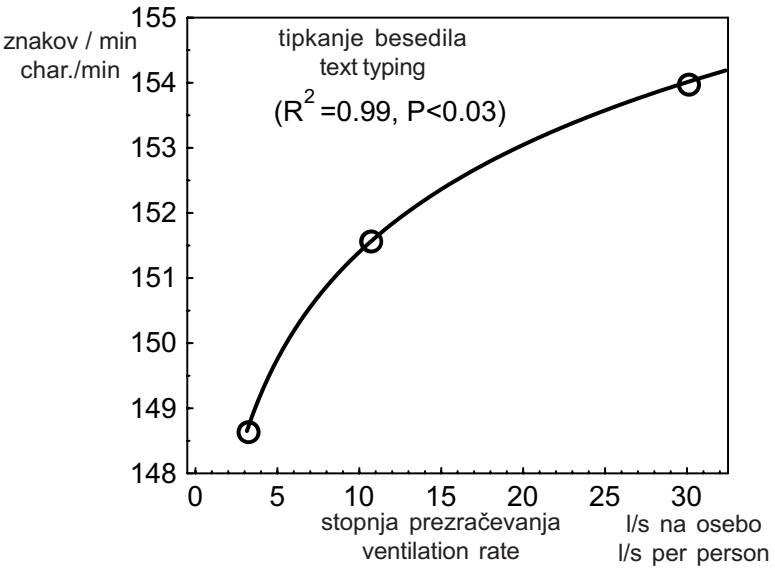
Tri nedavne neodvisne študije kažejo, da ima kakovost notranjega zraka pomemben in pozitiven vpliv na produktivnost zaposlenih. V dobro nadzorovani pisarni, ki je bila namenjena za preskus, so uporabili dve različni kakovosti zraka (boljše in slabše kakovosti), za kar zaposleni niso vedeli [6]. Po evropskih priporočilih za oblikovanje notranjega okolja [2] sta dva primera ustrezala bolni in zdravi stavbi. Iste osebe - zaposleni so delali 4 do 1/2 ure pri obeh kakovostih zraka, pri tem so stopnja prezračevanja in vsi drugi dejavniki okolja ostali nespremenjeni. Ugotovljeno je bilo, da je produktivnost teh oseb večja za 6,5% (P<0,003) pri dobri kakovosti zraka (sl. 1) in da so naredili manj napak in doživeli manj simptomov nezdravih prostorov. Raziskava je bila opravljena na Danskem, kasneje je bila ponovljena na Švedskem, pri kateri so dobili podobne rezultate [5]. Tretja študija je bila opravljena na Danskem z enakimi viri onesnaženja pri treh različnih stopnjah prezračevanja: 3, 10 in 30 l/s na osebo. Produktivnost se je zvečala s stopnjami prezračevanja (sl. 2). Te tri študije so analizirale odvisnost produktivnosti od kakovosti zraka, zajemale so sedem različnih eksperimentalnih dejavnikov in 90 oseb in bile analizirane kot celota [8]. Rezultati so prikazani na sliki 3 in kažejo močan vpliv kakovosti zraka na produktivnost v pisarnah. Izboljšanje kakovosti zraka za 1 decipol pomeni povečanje produktivnosti za 0,5%. Rezultati študij kažejo, da večja kakovost zraka pomembno vpliva na povečanje produktivnosti.

1 PRODUCTIVITY AND INDOOR AIR QUALITY

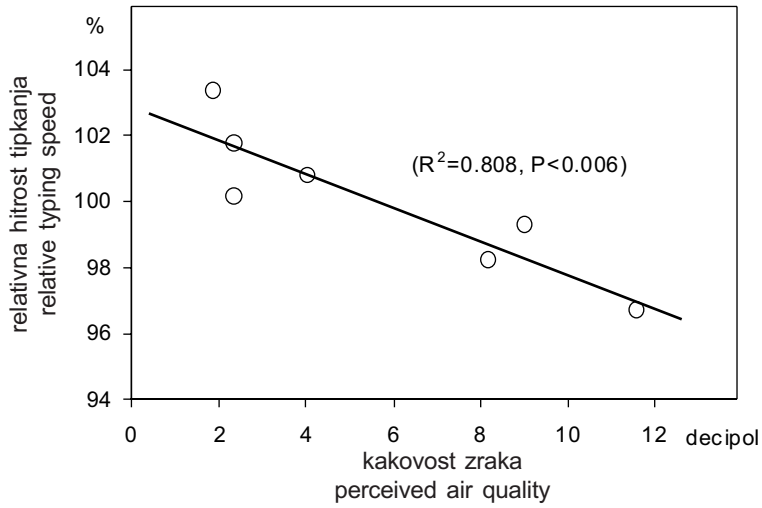
Three recent independent studies document that the quality of indoor air has a significant and positive influence on the productivity of office workers. In one study, a well-controlled normal office (field lab) was used in which two different air qualities were established by including or excluding an extra pollution source, invisible to the occupants [6]. The two cases corresponded to a low-polluting and a non-low-polluting building as specified in the new European guidelines for the design of indoor environments [2].The same subjects worked for 4-1/2 hours on simulated office work in each of the two air qualities. The ventilation rate and all other environmental factors were the same under the two conditions. The productivity of the subjects was found to be 6.5% higher (P<0.003) in good air quality (Fig. 1) and they also made fewer errors and experienced fewer SBS symptoms. This study performed in Denmark was later repeated in Sweden with similar results [5]. A third study was performed in the Danish field lab with the same pollution sources present at three different ventilation rates: 3, 10 and 30 l/s×person. The productivity increased significantly with increased ventilation (Fig. 2). The three studies involving seven experimental conditions and 90 subjects have been analysed as a whole, relating productivity to perceived air quality [8]. The results are presented in Figure 3 and show a significant influence of perceived air quality on productivity in offices. An improvement of perceived air quality by 1 decipol increased productivity by 0.5%. The results of three blind studies document that improved air quality increases productivity significantly.



Sl. 1. *Vpliv notranjega onesnaženega zraka na produktivnost pri pisanju na osebni računalnik [6]*
Fig. 1. *Impact of indoor air pollution on productivity, i.e. number of characters typed on a PC [6]*



Sl. 2. *Vpliv stopnje prezarčevanja na produktivnost [7]*
Fig. 2. *Impact of ventilation rate on productivity [7]*



Sl. 3. *Razmerje med kakovostjo zraka in produktivnostjo [8]*
Fig. 3. *Relation between perceived air quality and productivity [8]*

2 OSEBNI ZRAK

Dotok svežega zraka z uporabo ventilatorjev znaša 10 l/s na osebo. Od te količine zraka se ga vdiha le 0,1 l/s na osebo oziroma 1%. Preostala količina je neuporabljena. Kako velika izguba! Pa še tisti 1% zraka, ki ga zaposleni vdihavajo, ni čist. Onesnažen je z emisijami gradbenih materialov in včasih tudi s tobačnim dimom.

Kombinirano prezračevanje naj bi zagotovilo povsem enako kakovost zraka po celotnem prostoru. To pomeni, da imajo zaposleni ne glede na to, kje so (sedijo za mizo, stojijo na mizi ali ležijo na tleh), enako kakovost zraka za dihanje.

Nadomestitev prezračevalnega sistema s kombiniranim sistemom prezarčevanja izboljšuje

2 PERSONALIZED AIR

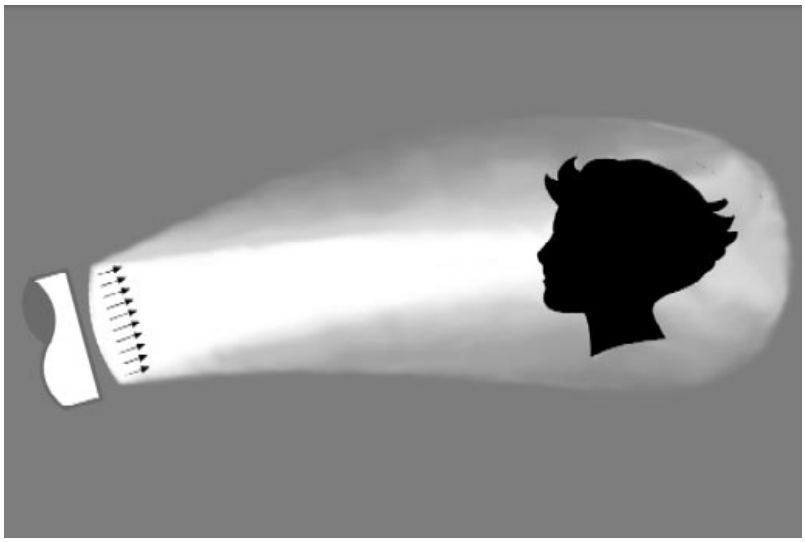
In many ventilated rooms the outdoor air supplied is of the order of magnitude of 10 l/s·person. Of this air, only 0.1 l/s·person, or 1%, is inhaled. The rest, i.e. 99% of the supplied air, is not used. What a huge waste! And the 1% of the ventilated air being inhaled by human occupants is not even clean. It is polluted in the space by bioeffluents, emissions from building materials and sometimes even by environmental tobacco smoke before it is inhaled.

The idea of mixing ventilation is to provide the same quality of air in the entire volume of the space. This means that occupants will find the same quality of air for breathing whether they are sitting at their desk, standing on the desk or lying on the floor.

Displacement ventilation systems do ac-

kakovost zraka v dihalni coni, vendar le v majhni meri. Predvidevam, da bodo v prihodnosti uporabljeni sistemi, ki dovajajo razmeroma majhno količino čistega zraka v dihalno območje vsakega posameznika. Tako bi vsakemu zaposlenemu zagotovili dotok svežega zraka. Imeli bi pomisleke pri pitju vode, onesnažene z iztrebki. Še vedno dihamo notranji zrak, ki ga je malo prej izdihala druga oseba, in je onesnažen. Zakaj ne bi zadostovale majhne količine zelo dobrega zraka za vsakega posameznika kakor pa veliko drugorazrednega zraka v prostoru? Takšen ″osebni zrak″ (PA) bi moral biti zagotovljen tako, da bi oseba vdihavala tok svežega zraka, ki ni pomešan z onesnaženim zrakom prostora (sl. 4). V pisarnah lahko na primer postavimo ta dotok poleg računalnika na mizi. Pomembno je, da se zrak dovaja ″nežno″, tako da ima majhno hitrost in turbulenco, ki ne povzroča prepiha [3]. Z osebnim zrakom je mogoče zagotoviti zrak optimalne kakovosti. Zaposleni občutijo svež in prijeten zrak, kar ima pozitiven učinek na človeško produktivnost (sl. 3).

knowledge the air quality in the breathing zone but the ventilation effectiveness is usually only moderately better than with mixing ventilation. What I foresee in the future are systems that supply rather small quantities of clean air close to the breathing zone of each individual. The idea would be to serve to each occupant clean air that is unpolluted by the pollution sources in the space. We would hesitate to drink water from a swimming pool polluted by human bioeffluents. Still we accept consuming indoor air that has previously been in the lungs of other persons and is polluted by human bioeffluents and other contaminants generated in the space. Why not serve small quantities of high-quality air direct to each individual rather than serving plenty of mediocre air throughout the space? Such "personalized air" (PA) should be provided so that the person inhales clean air from the core of the jet where the air is unmixed with polluted room air (Fig. 4). In an office the PA may, for instance, come from an outlet next to the PC on the desk. It is essential that the air is served "gently", i.e. has a low velocity and turbulence which do not cause a draught [3]. By means of personalized air it is possible to provide breathing air of optimal quality. The air will be perceived as fresh and pleasant with a positive effect on human productivity as indicated in Fig. 3.



Sl. 4. *Načelo svežega zraka (SZ - PA): dovod majhne količine čistega zraka neposredno in blago v dihalno območje [4]*
Fig. 4. *The principle of personalized air (PA): small amounts of clean air supplied directly and gently to a person's breathing zone [4]*

V prihodnosti je izziv inženiringa za razvoj klimatizacijskih in čistilnih sistemov tak, da bo zrak optimalno kakovosten in bodo razvijali primerne metode za prenos tega zraka v dihalno območje vsakega posameznika.

The challenge for HVAC engineering in the future will be to develop conditioning and cleaning processes so that air is perceived optimally and to develop appropriate methods for transporting this air to the breathing zone of each individual without mixing with room air.

3 SKLEP

– Tri različne študije so pokazale pozitiven učinek notranje kakovosti zraka na produktivnost v pisarnah

3 CONCLUSIONS

– Three different studies have documented a positive effect of perceived indoor air quality on productivity in offices.

– Dovod osebnega zraka v dihalno območje vsakega posameznika je obetajoč osnutek, ki zagotavlja zelo dober zrak za dihanje, kar je pomembno za človeško zaznavanje in produktivnost. Priporočeno je nadaljnje delo pri teh študijah in razvijanje te zamisli.

– Personalized air supplied to the breathing zone of each individual is a promising concept, allowing a quality of the air for breathing that is optimal for human perception and productivity. Further work on studying and developing this concept is recommended.

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