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# KAKOVOST ZRAKA V NOTRANJJIH PROSTORIH

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RECENZIRANIH  
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Ljubljana, 2017

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Zbornik recenziranih znanstvenih povzetkov je nastal v sklopu projekta Interreg »Transnational Adaption Actions for Integrated Indoor Air Quality Management (InAirQ)«.

## KAKOVOST ZRAKA V NOTRANJIH PROSTORIH / INDOOR AIR QUALITY

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# Interreg

CENTRAL EUROPE



European Union  
European Regional  
Development Fund

InAirQ

## PROGRAM KONFERENCE

Pozdravna nagovora	
9.00-9.15	<i>Predstavnik Ministrstva za zdravje</i>
	<b>Peter Otorepec</b> <i>Predstojnik Centra za zdravstveno ekologijo, Nacionalni inštitut za javno zdravje, vodja projekta InAirQ v Sloveniji</i>

Strokovni del	
9.15-9.30	<b>Kakovost zunanje zraka v Sloveniji</b> <i>Janja Turšič</i>
9.30-9.45	<b>Vpliv onesnaženosti zraka na bolezni dihal pri otrocih</b> <i>Marina Praprotnik</i>
9.45-10.00	<b>Metodološki pristopi in izzivi na področju ocenjevanja vplivov kakovosti zraka na zdravje v notranjih prostorih</b> <i>Andreja Kukec</i>
10.00-10.15	<b>Izboljšanje kakovosti notranjega zraka v izobraževalnih ustanovah z izborom gradbenih proizvodov</b> <i>Mateja Dovjak</i>
10.15-10.30	<b>Odmor</b>
10.30-10.45	<b>Meritve ogljikovega dioksida (CO<sub>2</sub>) v vzgojno-izobraževalnih ustanovah v Sloveniji: pregled stanja</b> <i>An Galičič</i>
10.45-11.00	<b>Arhitekturni pristopi pri zagotavljanju kakovosti zraka v notranjem prostoru: prikaz primera</b> <i>Anja Jutraž</i>
11.00-11.15	<b>Kako naj v šoli zaznamo slab zrak?</b> <i>Sonja Šorli</i>
11.15-11.40	<b>Razprava</b>

## CONFERENCE PROGRAM

Welcome address	
9.00-9.15	<i>Representative of the Ministry of Health</i>
	<b>Peter Otorepec</b> <i>Head of Centre for Environmental Health, National Institute of Public Health, head of Slovenian InAirQ project team</i>

Expert part	
9.15-9.30	<b>Outdoor air quality in Slovenia</b> <i>Janja Turšič</i>
9.30-9.45	<b>The effect of air pollution on respiratory diseases in children</b> <i>Marina Praprotnik</i>
9.45-10.00	<b>Methodological approach and challenges in the field of air quality assessment</b> <i>Andreja Kukec</i>
10.00-10.15	<b>Improving indoor air quality in educational institutions with the selection of construction products</b> <i>Mateja Dovjak</i>
10.15-10.30	<b>Break</b>
10.30-10.45	<b>Measurements of carbon dioxide (CO<sub>2</sub>) in educational facilities for children in Slovenia: State of art</b> <i>An Galičič</i>
10.45-11.00	<b>Architectural approach to providing indoor air quality: the case study</b> <i>Anja Jutraž</i>
11.00-11.15	<b>How to detect poor air quality in schools?</b> <i>Sonja Šorli</i>
11.15-11.40	<b>Discussion</b>

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## UVODNIK

Andreja Kuček

V pričujočem zborniku recenziranih povzetkov želimo zaposlenim v vzgojno-izobraževalnih ustanovah, zdravstvenim in okoljskim strokovnjakom ter splošni javnosti iz različnih vidikov osvetliti pomen zagotavljanja ustrezne kakovosti notranjega zraka.

V zunanjem in notranjem zraku je prisotna mešanica različnih onesnaževal, ki lahko škodljivo učinkujejo na zdravje. Znano je, da zdrava odrasla oseba, odvisno od konstitucije in telesne aktivnosti, dnevno vdihne od 10 do 20 m<sup>3</sup> zraka. Na podlagi teh podatkov z javnozdravstvenega vidika uvrščamo kakovost zraka med pomembno determinanto zdravja. V epidemioloških raziskavah so v notranjem zraku kot najpomembnejša onesnaževala, ki škodljivo vplivajo na zdravje, opredelili benzen, ogljikov monoksid, formaldehid, naftalen, ogljikov dioksid, policiklične aromatske ogljikovodike, radon, trikloretilen in tetrakloretilen. Pri proučevanju vpliva onesnaženosti zraka na zdravje, otroke zaradi njihovih vedenjskih in patofizioloških značilnosti, uvrščamo med ranljivo populacijsko skupino.

Na področju proučevanja vpliva onesnaženosti zunanjega zraka na zdravje so bile v svetu in pri nas izvedene številne epidemiološke raziskave in mednarodni projekti. Po drugi strani pa se znanost in stroka zavedata, da ljudje vedno več časa preživimo v zaprtih prostorih, kjer so tudi prisotne številne zdravju škodljive snovi. Področje izpostavljenosti onesnaževalom v notranjem zraku je zaenkrat slabo raziskano. Iz metodološkega vidika se pri oblikovanju z dokazi podprtih javnozdravstvenih aktivnosti pri tem nakazujejo številni izzivi. Le-ti so povezani z možnostjo pridobitve podatkov o vrsti in koncentraciji onesnaževal v zraku in o drugih dejavnikih tveganja na podlagi katerih bo možno opredeliti zdravstvene učinke. Za pripravo tovrstne ocene je potrebno aktivno sodelovanje vseh partnerjev, od sodelujočih opazovancev in organizacij/inštitucij, strokovnjakov s področja zdravja in okolja do podpore oblasti na lokalni, regionalni in nacionalni ravni.

V evropskem prostoru so bili do sedaj izvedeni trije večji projekti (SINPHONIE, TAB in HEIMTSA), katerih namen je bil oceniti vpliv kakovosti notranjega zraka na zdravje otrok v vzgojno-izobraževalnih ustanovah. Rezultati teh raziskav so bili pridobljeni z namenom priprave priporočil in zakonskih podlag za izboljšanje kakovosti zraka v zaprtih prostorih. Na območju Slovenije sta bili do sedaj izvedeni dve raziskavi meritev ogljikovega dioksida v zaprtih prostorih vrtcev.

Možnost pridobitve podatkov o kakovosti zraka v šolskih okoljih, opredelitev potencialnih učinkov na zdravje pri otrocih ter o drugih pomembnih dejavnikih tveganja povezanih s stavbo, družbenim in fizičnim okoljem ter družinsko anamnezo, predstavlja sodelovanje Slovenije v evropskem Interreg projektu InAirQ (angl. Transnational Adaption Actions for Integrated Indoor Air Quality Management).

## FOREWORD

Andreja Kuček

With this peer-reviewed book of abstracts, we would like present to the employees in educational institutions, health and environmental professionals and to the public the importance of the indoor air quality from different points of view.

In outdoor and indoor air, a mixture of different pollutants is present, which may have adverse effects on health. It is known that healthy adult, depending on the body constitution and physical activity, inhales from 10 up to 20 m<sup>3</sup> of air per day. Based on these data, public health recognizes air pollution as an important determinant of health. In the epidemiological studies benzene, carbon monoxide, formaldehyde, naphthalene, carbon dioxide, polycyclic aromatic hydrocarbons, radon, trichloroethylene and tetrachloroethylene are defined as the most important indoor air pollutants with adverse health effect. Children are the vulnerable population group due to their behavioural and pathophysiological characteristics in relation to the effects of air pollution on health.

In the field of studying the impact of outdoor air pollutants on health there have been carried out several national and worldwide epidemiological studies and international projects. On the other hand, the scientists and experts are realizing that people spend more time indoors where are present numerous harmful substances. Field of the exposure to the indoor air pollutants is poorly studied. From the methodological point of view based on the evidence-based public health activities at this suggest several challenges. Challenges are associated with the possibility to obtain data about the type and concentration of pollutants in the air and other risk factors biased on of which we will be able to define health effects. For preparation of these kind of assessments is required active participation of all partners, survey participants and participating organizations / institutions, health and environmental experts, as well as support of local, regional and national authorities is needed.

In Europe, so far, have been carried out three major projects (SINPHONIE, TAB and HEIMTSA), whose purpose was to assess the impact of the indoor air quality on the health of children in educational institutions. Research results have been obtained with the purpose of setting up the recommendations and legal bases for improving air quality in indoor environment. In Slovenia, have been, so far carried out two surveys on measuring the carbon dioxide concentration in kindergarten indoor environment. The possibility to obtain the information about air quality in the school environment, about the definition of the potential effects on health of children and other important risk factors associated with building, social and physical environment and family history, represents Slovenia's participation in the European Interreg project InAirQ (Transnational Adaption Actions for Integrated Indoor Air Quality Management).

## KAKOVOST ZUNANJEGA ZRAKA V SLOVENIJI

Janja Turšič, Rahela Žabkar

**Uvod:** Na kakovost zraka v notranjih prostorih poleg dejavnikov, ki se nanašajo na aktivnosti v notranjih prostorih in prezračevanje, vpliva tudi kakovost zunanjskega zraka. Nivoji nekaterih onesnaževal se precej dobro odražajo v notranjih prostorih (npr. delci  $PM_{2,5}$ ), pri drugih (npr. ozon  $O_3$ ) pa povezava ni tako izrazita.

**Namen in metode:** Pregled in predstavitev ugotovitev Agencije RS za okolje (ARSO) o kakovosti zunanjskega zraka v Sloveniji.

**Rezultati in razprava:** Onesnaženost zunanjskega zraka je v Sloveniji pereča problematika, saj se soočamo s čezmernimi ravni delcev  $PM_{10}$  in ozona. Povišane ravni delcev so posledica lokalnih izpustov in meteoroloških pogojev, problematika ozona pa ima izrazit regionalni značaj z vplivom čezmejnega transporta.

Z vidika zagotavljanja skladnosti je v primeru delcev  $PM_{10}$  najbolj problematično število preseganj dnevne mejne vrednosti. Do visokih ravni delcev prihaja praviloma v hladni polovici leta. Takrat se visokim izpustom zaradi uporabe lesne biomase v zastarelih kurilnih napravah pridružijo še neugodne meteorološke razmere z izrazitimi temperaturnimi inverzijami v nižinah celinske Slovenije. Dopustno število preseganj je preseženo na večini merilnih mest v celinski Sloveniji. V zadnjem obdobju sta najbolj problematični merilni mesti v Zagorju ob Savi in Celju. Nižje ravni delcev beležimo na Primorskem. V celinski Sloveniji je izjema Velenje, kjer so praktično vsi prebivalci priključeni na daljinski sistem ogrevanja. Število dni s preseženo dnevno mejno vrednostjo v posameznem koledarskem letu pa je zelo odvisno od meteoroloških pogojev v posamezni zimi. Onesnaženost z ozonom je najbolj problematična na Primorskem in v krajih z višjo nadmorsko višino, kjer poleti občasno prihaja tudi do preseganj opozorilne urne vrednosti. Dopustno število prekoračitev ciljne maksimalne 8-urne koncentracije je preseženo praktično na vseh merilnih mestih. Izjema so le lokacije pod neposrednim vplivom prometa. Tudi v primeru ozona so razlike med posameznimi leti odvisne predvsem od meteoroloških pogojev.

Ostala onesnaževala v zunanjem zraku z vidika doseganja standardov niso problematična. Na nekaterih merilnih mestih se pojavljajo nekoliko povišani nivoji delcev  $PM_{2,5}$ ,  $NO_2$  in benzo(a)pirena, vendar pa ravni niso višje od predpisanih standardov.

**Sklep:** Pri vplivih zunanjskega zraka na kakovost zraka v prostorih šolskih objektov v Sloveniji pričakujemo predvsem vpliv zaradi prisotnosti delcev pozimi in ozona poleti.

**Gljučne besede:** kakovost zraka, delci, ozon, Agencija RS za okolje

## OUTDOOR AIR QUALITY IN SLOVENIA

Janja Turšič, Rahela Žabkar

**Introduction:** Besides activities inside buildings and air conditioning, indoor air quality is also influenced by outdoor air. Levels of some pollutants in indoor air (e.g. PM<sub>2.5</sub> particles) reflect ambient levels, while for others (e.g. O<sub>3</sub>) the association is not significant.

**Aim and methods:** Review and presentation of Slovenian Environment Agency's findings of outdoor air quality in Slovenia.

**Results and discussion:**

Outdoor air pollution in Slovenia is an important issue because of exceeded levels of PM<sub>10</sub> particle and ozone. Reasons for elevated levels of particles are local emissions and unfavourable meteorological conditions. Pollution with ozone is regional and connected to trans-boundary pollution.

Compliance with air quality standards is not attained for PM<sub>10</sub> daily limit value. High levels of particles are associated with the cold part of the year due to the widespread use of wood for domestic heating and unfavourable meteorological conditions in basins and valleys of continental part of Slovenia. The allowed number of daily exceedances is exceeded at the most urban monitoring sites.

The most problematic locations are Zagorje ob Savi and Celje. Lower levels of particles are measured in Primorska region and in some towns in continental part with effective district heating. The number of days with exceeded daily limit value in particular year is significantly influenced by meteorological conditions in winter time.

The highest ozone levels are measured in Primorska region and at the high altitude monitoring sites, where occasionally in summer information value is exceeded. The maximum daily eight-hour mean value is exceeded at almost every measuring sites. The variation of ozone levels between different years depends mainly on meteorological conditions in summer.

Levels of other pollutants are below air quality standards. At some measuring sites slightly increased concentrations of PM<sub>2.5</sub>, NO<sub>2</sub> and benzo(a)pyrene are measured, but air quality standards are not exceeded.

**Conclusion:** Outdoor air pollution effects quality of indoor air in school environment with the presence of particles in the winter and ozone in the summer.

**Key words:** air quality, particles, ozone, Slovenian Environment Agency

## VPLIV ONESNAŽENOSTI ZRAKA NA BOLEZNI DIHAL PRI OTROCIH

Marina Praprotnik

**Uvod:** Svetovna zdravstvena organizacija je leta 2016 objavila, da umre za posledicami onesnažega zraka po vsem svetu 3 milijone ljudi letno, od tega skoraj 90% v državah jugovzhodne Azije. Otroci so za vplive onesnaževal iz zraka še posebej občutljivi. Njihov imunski odziv je še nezrel, pogosteje kot odrasli dihajo skozi usta, kar zmanjša čiščenje zraka v nosni votlini. Poleg tega dihajo hitreje in njihov dihalni volumen je v primerjavi s površino telesa večji kot pri odraslih.

**Namen in metode:** Pregled in predstavitev ugotovitev novejše znanstvene literature glede povezanosti med onesnaženostjo zraka in izbranimi zdravstvenimi izidi.

**Rezultati in razprava:** Onesnaževala v zraku ( $\text{NO}_2$ ,  $\text{SO}_2$ , trdi delci) lahko poškodujejo lokalno obrambo v pljučih, kot so sluz in migetalčne celice ter alveolarni makrofagi v spodnjih dihalnih poteh. Prav tako vplivajo na alveolokapilarno membrano, preko katere v pljučih poteka izmenjava plinov. Lokalno vnetje povzroča zadebelitev te membrane. Do leta 1990 so se raziskave o vplivu onesnaženega zraka na zdravje osredotočale na proučevanja vpliva na dihala, saj onesnažen zrak vstopa v telo skozi pljuča. Pozneje je postalo jasno, da vnetni mediatorji, ki se sproščajo v dihalih, po krvi potujejo tudi v druge organe, zlasti srce, in povzročajo vnetje tudi tam.

Vplivi na različne organske sisteme so akutni in kronični. Najpogostejši akutni oz. takojšnji učinki so povečana umrljivost zaradi srčno-žilnih in dihalnih zapletov, povečano število sprejemov v bolnišnico zaradi srčnih obolenj in obolenj dihal, povečana poraba zdravil za srce in dihala ter povečana odsotnost iz dela in šole. Najpogostejši kronični vplivi onesnaženosti zraka na zdravje ljudi pa so povečano tveganje za pojav astme in kronične obstruktivne pljučne bolezni (KOPB), nižja pljučna funkcija in povečano tveganje za pojav pljučnega raka. V okolju z visoko stopnjo onesnaženosti zraka z delci je bila ugotovljena večja pogostost nizke porodne teže pri otrocih ter prezgodnjih porodov.

Številne raziskave objavljene konec osemdesetih let so pokazale, da imajo otroci, ki živijo v okolju z visoko stopnjo onesnaženosti z  $\text{SO}_2$  in  $\text{NO}_2$ , pogosteje kašelj in bronhitis kot njihovi sovrstniki iz čistejših okolij.

Skoraj polovica otrok, ki živi v neposredni bližini prometno zelo obremenjenih avtocest, ima nižjo pljučno funkcijo in povečano vnetje v dihalnih poteh. Njihovi starši pa so poročali o povečani pogostosti kroničnega kašlja, piskanja v prsih in pogostejših obiskih v dežurni ambulanti kot pri otrocih, ki ne živijo ob avtocesti.

**Sklep:** Onesnaževalci zraka imajo neugoden učinek na različne organske sisteme. Skrb za čist zrak mora biti pomembna naloga za zdravnike in druge zdravstvene delavce. Zmanjšanje emisij je najbolj učinkovita strategija in kot vsi osveščeni ljudje morajo tudi zdravniki aktivno sodelovati pri nastajanju zakonodaje, ki je okolju prijazna in trajnostno usmerjena.

**Ključne besede:** onesnažen zrak, delci, bolezni srca in ožilja ter dihal

# THE EFFECT OF AIR POLLUTION ON RESPIRATORY DISEASES IN CHILDREN

Marina Praprotnik

World Health Organisation has in 2016 published that yearly 3 million deaths in the whole world can be attributed to air pollution, of this number nearly 90 % from the countries in Southeast Asia. Children's vulnerability to air pollution is especially high because their immune system is not completely developed, they more often than adults use mouth breathing, which reduces the filtering provided by the nasal cavity. Also they breathe faster and their respiratory volume is higher compared to adults.

**Aim and methods:** Review and presentation of findings from relevant scientific literature associating air pollution and selected health outcome.

**Results and discussion:** Pollutants (NO<sub>2</sub>, SO<sub>2</sub>, particulate matters) compromise the respiratory systems's own defences like mucus layer, ciliated cells and alveolar macrophages in lower airways. They affect the alveolocapillary membrane which is important in gas exchange. Local inflammation results in the thickening of the air-blood barrier. Until the 1990s, studies focused mainly on respiratory health, as the airways are the primary gateway for pollution to the human body. Later it become clear that pollution also affects the cardiovascular system through inflammatory mediators which drive systemic responses to local pulmonary events. The effects on different organ systems are different and may be acute and chronic. The most common acute effects are mortality from acute cardiorespiratory disease, more respiratory and cardiovascular hospital admissions, emergency room visits for respiratory and cardiac problems, work and school absenteeism. Chronic effects are: increase in asthma and COPD incidence, lower lung function and higher incidence of lung cancer. In the environment with high level of air pollution with particulate matter more preterm deliveries and low birth weight in children are presented.

Several studies published in the 1980s showed that children in communities exposed to higher levels of SO<sub>2</sub> and NO<sub>2</sub> suffered more from cough and acute bronchitis compared with children in less polluted regions.

Nearly half of children living near a highway with heavy traffic have lower lung function and increase in airway inflammation. Their parents reported more chronic cough, wheezing and common use of emergency services compared to children living in a region with better air quality.

**Conclusion:** Outdoor air pollutants may affect several organ systems. Sustained improvement of air quality through the reduction of emissions is the most important strategy. The role of health professionals is the same as that of any informed citizen: to call for and support air quality regulations.

**Key words:** air pollution, particulate matter, cardiovascular and respiratory diseases

# METODOLOŠKI PRISTOPI IN IZZIVI NA PODROČJU OCENJEVANJA VPLIVOV KAKOVOSTI ZRAKA NA ZDRAVJE V NOTRANJIH PROTORIH

Andreja Kuček, Lijana Zaletel-Kragelj

**Uvod:** V preteklosti so bili izvedene številne epidemiološke raziskave na področju ocenjevanja vplivov škodljivih onesnaževal v zunanjem zraku na zdravje, bistveno manj je raziskano področje kakovosti zraka v notranjem okolju. V procesu z dokazi podprtih javnozdravstvenih aktivnosti na področju kakovosti zraka se znanost in stroka srečujeta s številnimi metodološkimi izzivi.

**Namen:** Predstaviti metodologijo ocenjevanja vpliva onesnaženosti zunanjega in notranjega zraka na zdravje otrok v Zasavju.

**Metode:** V letu 2008 je bila izvedena presečna pregledna raziskava o pogostosti bolezni dihal med osnovnošolskimi otroci od prvega do petega razreda. Podatke o pogostosti bolezni dihal pri otrocih ter ostalih potencialnih dejavnikih tveganja, ki vplivajo na opazovani izid smo pridobili z vprašalnikom, ki so ga izpolnjevali starši ter iz zdravstvenih kartonov. Oceno izpostavljenosti onesnaženemu zraku smo pripravili na podlagi ocene staršev, nevladne organizacije in podatkov iz Državne mreže kakovosti zunanjega zraka. V letih 2011 in 2012 smo na dveh osnovnih šolah v Zasavju, v okviru projekta povezovanja zdravstvenih in okoljskih podatkov, izvedli meritve črnega ogljika.

**Rezultati in razprava:** Glavni metodološki izzivi pri presečni raziskavi so se pokazali v fazi načrtovanja raziskave (ustrezen izbor opazovane populacije, opredelitev vzorca, opredelitev opazovanega zdravstvenega izida in potencialnih dejavnikov tveganja, ocena izpostavljenosti, priprava vprašalnika in v fazi izvedbe raziskave (izpolnjevanje vprašalnika, analiza podatkov). Meritve črnega ogljika so pokazale, da so učenci osnovnih šol v Trbovljah in Zagorju ob Savi izpostavljeni najvišjim koncentracijam črnega ogljika v zunanjem zraku med potjo v šolo, čez dan pa koncentracije padejo.

**Sklep:** Glavne metodološke izzive pri povezovanju zdravstvenih podatkov z okoljskimi predstavlja izdelava ocene tveganja, ki temelji na kakovostnih podatkih o izpostavljenosti, opazovanih zdravstvenih izidih ter potencialnih motečih dejavnikih tveganja.

**Ključne besede:** kakovost zraka, zdravje otrok, metodološki pristopi



## METODOLOGICAL APPROACH AND CHALLENGES IN THE FIELD OF AIR QUALITY ASSESSMENT

Andreja Kuček, Lijana Zaletel-Kragelj

**Introduction:** In the past a number of epidemiological studies have been carried out in the field of the assessment of harmful pollutants in outdoor air pollution, but much less the field of indoor air quality has been studied. In the process of evidence based public health activity on the field of air quality, science and profession are facing with several methodological challenges.

**Aim:** To present the methodology for assessment of the impact of outdoor and indoor air pollution on the children's health in Zasavje.

**Methods:** In year 2008 cross-sectional study on the prevalence of respiratory diseases among primary school children from first to fifth grade was conducted. Data on the prevalence of respiratory diseases in children and other potential risk factors which have effect on observed health outcomes were obtained with a questionnaire, which was completed by parents and with some help of medical records. Estimate of exposure assessment of air pollution was prepared based on parents' assessment, non-governmental organization and from the data of The national network for monitoring air quality. In the years 2011 and 2012 in two primary schools in Zasavje black carbon was measured, as a part of the project assessing the relation between health and environmental data.

**Results and discussion:** The main methodological challenges in cross-sectional study showed in the stage of research planning (appropriate selection of the study population, the definition of sample, definition of the observed health outcomes and potential risk factors, exposure assessment, preparation of the questionnaire) and in the conducting stage of the research (completion of the questionnaires, data analysis). Measurements of black carbon showed that children in Trbovlje and Zagorje ob Savi are exposed to the highest concentrations of black carbon in outdoor air on the way to school, however during the day, concentrations decrease.

**Conclusion:** The main methodological challenges in the field of associating health and environmental data present an estimate of health impact assessment, which is based on the quality of exposure data, the quality of health outcomes and the potential risk factors data.

**Key words:** air quality, children's health, methodological approach

# IZBOLJŠANJE KAKOVOSTI NOTRANJEGA ZRAKA V IZOBRAŽEVALNIH USTANOVAH Z IZBOROM GRADBENIH PROIZVODOV

Mateja Dovjak

**Uvod:** Po navedbah raziskav uvrščamo gradbene proizvode in z njimi povezane emisije med kemične dejavnike tveganja za pojav sindroma bolnih stavb. V skladu z Uredbo (EU) 305/2011 morajo biti gradbeni proizvodi zdravju in okolju neškodljivi tekom celotnega življenjskega cikla stavbe.

**Namen:** Namen prispevka je prikazati vpliv izbranih gradbenih proizvodov na kakovost zraka v stavbah z javnozdravstvenega in gradbeno tehničnega vidika ter določiti ukrepe.

**Metode:** Opravili smo sistematični pregled literature na področju gradbenih proizvodov iz lesa in polivinil klorida. Preučili smo možen vpliv na zdravje. Izpostavili smo problematiko rabe osvežilcev zraka. Na osnovi ugotovitev smo določili ukrepe z javnozdravstvenega in gradbeno tehničnega vidika.

**Rezultati in razprava:** Formaldehid vsebujejo polikondenzacijska lepila, ki se uporabljajo v proizvodnji gradbenih proizvodov in elementov pohištva iz lesa. Pregled študij je pokazal, da koncentracije formaldehida v notranjem zraku pogosto presežejo zunanje vrednosti. Koncentracija formaldehida v stavbah je odvisna od starosti vira, vrste materialov, načina ogrevanja in prezračevanja, mikroklimatskih razmer in prisotnosti sekundarnih virov. Zaradi njegove široke uporabe ter ob nezadostnem prezračevanju lahko koncentracije dosežejo vrednosti, ki pri uporabnikih povzročajo nezadovoljstvo in imajo negativen vpliv na zdravje. Gradbeni proizvodi iz polivinil klorida so problematični zaradi ftalatnih estrov. Raziskave so dokazale, da so ftalati endokrini motilci, izpostavljenost ftalatom lahko vodi do pojava rakavih obolenj, astme, alergij in ima vpliv na dihala. Za izboljšanje kakovosti notranjega zraka pogosto ukrepamo neustrezno, sem sodi tudi raba osvežilcev zraka. Če prostorov ne prezračujemo dovolj, sredstva za odišavljanje zraka le odpravijo ali prekrijejo neprijeten vonj, kakovost zraka pa ostane bolj ali manj nespremenjena ali se celo poslabša. Osvežilci zraka imajo lahko negativen učinek na zdravje uporabnikov, kar se najpogosteje odraža z draženjem dihalnih poti, kot poslabšanje astme, kot slabost, z glavobolom in s številnimi drugimi simptomi.

**Sklep:** Za izboljšanje kakovosti notranjega zraka so potrebni celoviti ukrepi. Ključno je sodelovanje različnih strok in sektorjev.

**Ključne besede:** gradbeni proizvodi, kakovost zraka, stavbe

## IMPROVING INDOOR AIR QUALITY IN EDUCATIONAL INSTITUTIONS WITH THE SELECTION OF CONSTRUCTION PRODUCTS

Mateja Dovjak

**Introduction:** Emissions from construction products have been identified as chemical risk factor for sick building syndrome. Regulation (EU) 305/2011 states that construction products must be harmless to health and the environment throughout the entire life cycle of the building.

**Aim:** The purpose of this paper is to examine the selected construction products in relation to air quality issues from public health and building point of view as well as to define measures.

**Methods:** Systematical literature review was performed in order to examine the constructional products made of wood and polyvinyl chloride in relation to air quality issues and possible adverse health effects. Additionally, the problems related to air aromatization products were highlighted. Based on our findings, we determined the main measures from public health and building point of view.

**Results and discussion:** Formaldehyde is a key component of several polymers used in constructional products. Studies show that indoor concentrations often exceed those outdoors. Emissions of formaldehyde in buildings are closely related to the age of the indoor source, the type of the material, efficiency of HVAC systems, microclimate conditions and the presence of secondary sources of air pollution. Measured concentrations in the analysed studies often exceed the exposure limits and may cause adverse health effects. Construction products of polyvinyl chloride are problematic because of phthalate esters. Studies show that phthalates are endocrine disruptors, and exposure to phthalates can lead to the occurrence of cancer, asthma, allergies and the respiratory impact. To improve the indoor air quality incorrect actions are often performed, which may also include the use of air fresheners. If rooms are not ventilated enough, aromatization of the air only masks the unpleasant odour, but the air quality remains more or less unchanged or even worse than it was. Air fresheners may have adverse health effects, such as respiratory irritation, asthma, nausea, headaches and many other symptoms.

**Conclusion:** To improve indoor air quality, holistic measures should be implemented. Cooperation among professions and sectors is crucial.

**Key words:** constructional products, air quality, buildings

## MERITVE OGLJIKOVEGA DIOKSIDA (CO<sub>2</sub>) V VZGOJNO-IZOBRAŽEVALNIH USTANOVAH V SLOVENIJI: PREGLED STANJA

An Galičič, Natalija Kranjec

**Uvod:** Kakovost zraka v notranjih prostorih se v Sloveniji spremlja zgolj občasno s posameznimi raziskavami.

**Namen:** Zbrati in predstaviti vse raziskave, ki so ocenjevale kakovost zraka v prostorih vzgojno-izobraževalnih ustanov v Sloveniji in rezultate primerjati z rezultati evropskih raziskav.

**Metode:** Pregled literature v bibliografski bazi COBISS in Google Učenjak je bil pripravljen sistematično.

**Rezultati in razprava:** V Sloveniji sta bili s področja kakovosti notranjega zraka v vzgojno-izobraževalnih ustanovah izvedeni dve raziskavi. V obeh so izvajali meritve vrednosti ogljikovega dioksida (CO<sub>2</sub>) v vrtcih. CO<sub>2</sub> se uporablja kot indikator kakovosti notranjega zraka predvsem za prostore, v katerih predstavljajo glavni vir emisij ljudje, hkrati pa je tudi pokazatelj ustreznosti prezračevanja. CO<sub>2</sub> sam po sebi ni škodljiv, povišane vrednosti pa povzročajo glavobol in utrujenost. Rezultati meritev v slovenskih vrtcih so pokazali, da so vrednosti CO<sub>2</sub> presegale priporočeno vrednost CO<sub>2</sub>, 1000 ppm, po standardu ANSI/ASHRAE. V enem primeru klasično grajenega vrtca so vrednosti CO<sub>2</sub> presegale tudi dopustno vrednost iz Pravilnika o prezračevanju in klimatizaciji stavb (Ur. l. RS, št. 42/02, 105/02). Primerljive vrednosti so bile izmerjene tudi v evropskem projektu SINPHONIE, v katerega je bilo vključenih 300 osnovnih šol iz različnih držav Evrope. Vrednosti CO<sub>2</sub> pod priporočeno vrednostjo so bile pri tem izmerjene v poljskih vrtcih pozimi v jutranjem času, v francoskih varstvenih centrih otrok tako poleti kot pozimi in v latvijskih otroških varstvenih centrih otrok tako v starih kot v prenovljenih stavbah. Rezultati meritev so pokazali pomembne razlike v vrednostih CO<sub>2</sub> med portugalskimi otroškimi varstvenimi centri otrok glede na ustreznost prezračevanja in poljskimi igralnicami v vrtcih glede na jutranje in popoldanske vrednosti.

**Sklep:** Kakovost zraka v prostorih vzgojno-izobraževalnih ustanovah v Sloveniji je treba opredeliti tudi z vrednostmi zdravju dokazano škodljivih onesnaževal.

**Ključne besede:** kakovost notranjega zraka, vzgojno-izobraževalne ustanove, CO<sub>2</sub>, Slovenija

## MEASUREMENTS OF CARBON DIOXIDE (CO<sub>2</sub>) IN EDUCATIONAL FACILITIES FOR CHILDREN IN SLOVENIA: STATE OF ART

An Galičič, Natalija Kranjec

**Introduction:** Indoor air quality measurements in Slovenia are implemented periodically, with studies.

**Aim:** To assemble and present all the studies assessing indoor air quality in the educational facilities for children implemented in Slovenia and to compare the results with the results of European studies.

**Methods:** Literature review in the bibliographical database COBISS and Google Scholar was prepared systematically.

**Results and discussion:** In Slovenia two studies have examined indoor air quality in educational facilities. In both studies measurements of carbon dioxide (CO<sub>2</sub>) have been implemented. Commonly, CO<sub>2</sub> is used as indicator of indoor air quality in buildings where people present the main pollution source, at the same time it indicates adequate ventilation. CO<sub>2</sub> itself is not considered harmful, heightened levels of CO<sub>2</sub> can cause headaches and fatigue. The results of measurements in Slovenian kindergartens show that levels of CO<sub>2</sub> are exceeding the recommended value of 1000 ppm, prescribed in the standard ANSI/ASHRAE. In one example of classically built kindergarten the levels of CO<sub>2</sub> were also exceeding admissible level of CO<sub>2</sub> pollution subscribed in the Rules on the ventilation and air-conditioning of buildings. Comparable values of CO<sub>2</sub> pollution were also measured in European project SINPHONIE, in which 300 elementary schools from different European countries were included. Levels of CO<sub>2</sub> pollution under the recommended value were measured in Polish kindergartens in the winter in the morning, in the French child day care centers in winter and in the summer and in Latvian child day care centers in old and in renovated buildings. Important differences in CO<sub>2</sub> levels were shown in Portugal child day care centers depending on the adequacy of ventilation and Polish kindergartens between morning and afternoon values.

**Conclusion:** Indoor air quality measurements in educational facilities in Slovenia need to identify health hazardous air pollutants.

**Key words:** indoor air quality, educational facilities, CO<sub>2</sub>, Slovenia

## ARHITEKTURNI PRISTOPI PRI ZAGOTAVLJANJU KAKOVOSTI ZRAKA V NOTRANJEM PROSTORU: PRIKAZ PRIMERA

Anja Jutraž

**Uvod:** Pri načrtovanju stavb velikokrat pozabljamo na kakovostno zasnovo notranjega okolja z vidika vplivov na zdravje uporabnikov. Premalokrat se načrtovalci, investitorji in uporabniki zavedajo, da tehnična zasnova stavbe (npr. izbira materialov, načini prezračevanja) lahko predstavljajo pomemben dejavnik tveganja za zdravje

**Namen:** Na primeru PKP (Po kreativni poti do praktičnega znanja) projekta "Super mikroklima v bivanjskem prostoru" prikazati ustrezen pristop pri zagotavljanju kvalitetnega notranjega okolja.

**Metode:** Cilj kvalitativne in kvantitativne presečne raziskave je bilo ugotoviti, koliko se ljudje zavedajo vpliva mikroklimе v prostoru, kjer delajo in bivajo, na njihovo počutje in zdravje in koliko so pripravljeni narediti za izboljšanje le-te. Ugotavljali smo povezavo med arhitekturno zasnovo stavbe ter zdravjem njenih uporabnikov (preučevanje različnih vidikov bivanjske mikroklimе, ki vpliva na zdravje človeka: izbira lokacije, materialov, načinov gradnje, kakovosti zraka in osvetlitve, toplotno in zvočno ugodje, razporeditev prostorov itd.). V obdobju od februarja do junija 2015 smo se v okviru projekta »Super mikroklima v bivanjskem prostoru« srečali s predstavniki podjetja Damahaus Prestige d.o.o., obiskali njihova gradbišča, izvedli pol-strukturirane intervjuje in anketo med prebivalci lesenih in zidanih hiš ter načrtovalci / projektanti.

**Rezultati in razprava:** Izvedli smo 333 anket med opazovano populacijo (javnost in stroka) in 7 pol-strukturiranih intervjujev. Opazovancem je v njihovem bivalnem prostoru najpomembnejša vizualna povezanost z okolico, sledita zvočno in toplotno ugodje, nato ustrezna osvetlitev prostorov, najmanj pomembna pa jim je kakovost zraka. Več kot 80% opazovancev meni, da mikroklima (temperatura, vlaga, osvetlitev, kvaliteta zraka, izbira materialov ipd.) v njihovem bivalnem okolju pomembno vpliva na zdravje.

**Sklep:** Poznavanje povezave med arhitekturnimi elementi in njihovim vplivu na zdravje obstaja, vendar je premalo implementirano v prakso (npr. ekonomski vidik je javnosti še vedno pomembnejši kot zdravje).

**Ključne besede:** arhitekturni pristop, mikroklima, kakovost notranjega zraka, zdravje

## ARCHITECTURAL APPROACH TO PROVIDING INDOOR AIR QUALITY: THE CASE STUDY

Anja Jutraž

**Introduction:** The design of buildings often lack the reflection on the design of quality indoor environment in terms of impact on the users' health. Planners, investors and users are rarely aware that the technical conditions of the building (materials, ventilation etc.) may represent an important risk factors for health.

**Aim:** To show the appropriate approach by providing a quality indoor environment on the PKP (Po kreativni poti do praktičnega znanja) project "Super microclimate in living environment".

**Methods:** The objective of the qualitative and quantitative cross-sectional research was to determine how many people are aware of the impact of the microclimate in the living and working environment on their mood and health, and how much they are willing to do to improve it. We investigated the link between the architectural design of the building and the health of its users (the study of various microclimate elements that affects human health: choice of location, materials, type of construction, air quality, quality of lighting, temperature and noise comfort, distribution of the space, etc.). In the PKP project "Supermicroclimate in living environment", which was done between February and June 2015, we meet with representatives of company Damahaus Prestige Ltd., visited construction sites, conducted semi-structured interviews and questionnaires among residents of wooden and brick houses and planners / designers.

**Results and discussion:** Respondents found in their living room the most important visual link with the surroundings, followed by acoustic and thermal comfort, adequate ambient lighting, the least important to them was the quality of the air. More than 80% of respondents believe that the microclimate (temperature, humidity, lighting, air quality, choice of materials, etc.) in their living environment has a significant impact on health.

**Conclusion:** Association between architectural elements and their impact on health exists but is insufficiently implemented in practice (eg. the economic aspect of the public is still more important than health).

**Key words:** architectural approach, microclima, indoor air quality, health

## KAKO NAJ V ŠOLI ZAZNAMO SLAB ZRAK?

Sonja Šorli

**Uvod:** Tako kot odrasli v zaprtih prostorih doma ali na delovnem mestu, tudi učenci preživijo precejšen del dneva v šolskih prostorih. Dokazano je, da človek v eni sami uri vdihne več kot pol kubičnega metra zraka, polnega bakterij in virusov, pršic, vlage in drugih dejavnikov, ki jih v prostoru ne vidimo, vplivajo pa na naše zdravje in počutje. Zato je v notranjem okolju potrebno zagotoviti ustrezno kakovost zraka. V šolskem okolju lahko ustrezno kakovost notranjega zraka dosežemo s prezračevanjem, z odpiranjem oken v učilnicah. Težavo pri tem predstavlja dejstvo, da je tak način zračenja neenakomeren, nastaja lahko prepih, ta način je tudi energijsko potraten.

**Namen:** Na primeru predstaviti, kako v šoli zaznavamo slab zrak ter s katerimi aktivnostmi lahko izboljšamo stanje.

**Metode:** Prikazali smo lastne izkušnje na področju zaznavanja slabega zraka v učilnicah ter aktivnosti, ki jih izvajamo za izboljšanje stanja v šoli.

**Rezultati in razprava:** Prostornina naših učilnic je od 20 – 25 m<sup>3</sup>, število učencev v posamezni učilnici pa se giblje od 18 – 25. Učitelji po vsaki učni uri v času odmora prezračijo učilnico. Učenci na razredni stopnji ostanejo v isti učilnici, na predmetni stopnji se zamenjajo, odidejo v drugo učilnico. Med zračenjem v odmoru se celoten zrak v prostoru ne zamenja, več možnosti za to je v tistih učilnicah, kjer izvajajo zračenje že med uro. Slabo kakovost zraka zaznamo z vstopom v prostor. Ne le slab vonj, tudi preveč suh zrak povzroča zdravstvene težave pri učencih. Ustrezna vlažnost zraka pripomore k izboljšanju odpornosti, manj pogosti obolevnosti dihal in k dobremu počutju. Zagotoviti pa je treba ustrezno vlažnost v prostoru, saj lahko previsoka vlažnost pospeši razmnoževanje pršic, plesni, glivic in bakterij.

**Sklep:** Na temperaturo, vlago in kakovost zraka v prostorih vplivajo različni dejavniki, ki so povezani tudi z gradnjo in uporabo različnih gradbenih materialov, npr. vrsta vgrajenih oken in vrat, lega stavbe, način ogrevanja, prisotnost drugih virov onesnaževanja. Kako torej v štirideset let stari stavbi brez mehanskega prezračevanja zagotoviti, da bo v vsaki učilnici od 7. ure zjutraj do poznega popoldneva kakovost zraka ustrezna?

**Ključne besede:** kakovost zraka, šole, ukrepi



## HOW TO DETECT POOR AIR QUALITY IN SCHOOLS?

Sonja Šorli

**Introduction:** As adults spend time in closed places at home and at work, school children spend the biggest part of the day inside the school environment. It has been proven that humans in a single hour breathe in more than a half of cubic meter of air, full of bacteria, viruses, mites, humidity and other factors unseen to human eye, but which affect our health and well-being. That is why provision of adequate indoor air quality is important. In school environment adequate indoor air quality can be provided with natural ventilation in classrooms. The difficulty presents that this type of ventilation is not constant, causes air drafts and is also energetically wasteful.

**Aim:** On the example present how in school poor air quality should be detected and with which activities this situation could be improved.

**Methods:** We are presenting our own experiences in the field of detecting poor air quality in classrooms and activities which we are implementing in order to improve air quality in the school.

**Results and discussion:** The volume of our classrooms is between 20 – 25 m<sup>3</sup>, the number of pupils is between 18 – 25. Teachers after each lesson ventilate the classroom. Younger pupils stay in the same classroom, older pupils exchange classrooms. While ventilating whole air is not exchanged, the chance for the whole exchange could be more possible if the ventilation would also be implemented between lesson. Poor air quality can be detected while entering the classroom. Not only bad smell but also dry air causes health issues in pupils. Adequate humidity improves immunity, reduces morbidity for respiratory diseases and well-being. Provision of adequate humidity is also important to prevent reproduction of mites, mold, fungi and bacteria.

**Conclusion:** Temperature, humidity and air quality in indoor air are affected by different factors associated also with the construction and the use of different construction materials, e.g. the type of installed windows and doors, situating of building, type of heating, the presence of other pollution sources. So how can we provide adequate indoor air quality for each classroom from 7 am to late afternoon in 40 year old building without mechanical ventilation?

**Key words:** air quality, schools, measures

## Kratka predstavite Interreg projekta InAirQ

Predstavniki Nacionalnega inštituta za javno zdravje (NIJZ) smo od julija 2016 vključeni v mednarodni projekt »Transnational Adaption Actions for Integrated Indoor Air Quality Management (InAirQ)«. Projekt financira program Interreg, Central Europe.

Svetovna zdravstvena organizacija in Direktorat za zdravje Evropske komisije poudarjata, da predstavlja izpostavljenost onesnaženemu zraku - zunanjemu in v notranjih prostorih - enega največjih okoljskih javnozdravstvenih problemov z resnimi zdravstvenimi posledicami. Do sedaj je bila v EU večina raziskav in ukrepov v zvezi z onesnaženim zrakom usmerjena v izboljšanje kakovosti in zmanjšanje izpustov posameznih onesnaževal. Zaradi načina življenja, da večino časa preživimo v notranjih prostorih, je potrebno pozornost usmeriti tudi v kakovost notranjega zraka. Onesnaževalom v notranjem zraku smo lahko izpostavljeni v različnih notranjih okoljih, tudi šolah. Glede na literaturo so za učinke onesnaženega zraka najbolj občutljivi otroci v starosti od 6 do 14 let, šolarji, ki predstavljajo dobro desetino prebivalstva.

V projektu InAirQ želimo opredeliti zdravstvene učinke onesnaženosti notranjega zraka na ranljivo populacijsko skupino in sprejeti ukrepe za izboljšanje zdravja v šolskih okoljih v srednji Evropi. V projektu InAirQ bomo razvili Virtualno odložišče podatkov o zdravju v podporo odločevalcem pri zagotavljanju kakovosti notranjega zraka in njegovih spremembah.

Na podlagi ocene in izboljšav kakovosti notranjega zraka bo izdelan, preizkušen in implementiran Nacionalni akcijski načrt z namenom dviga standardov zdravja. Za čim boljšo implementacijo nacionalnega akcijskega načrta v šolah bodo organizirana izobraževanja za ravnatelje ter vse lokalne in regionalne deležnike, ki so povezani s šolo. Mednarodni forum kakovosti okolja pa bo zagotavljal spremljanje rezultatov projekta in nadaljevanje sodelovanja s potencialnimi zainteresiranimi deležniki.

Strokovno visoko usposobljeni sodelujoči na nacionalnih zdravstvenih inštitutih bomo zagotovili izhodišča za oceno kakovosti notranjega zraka in njegovih vplivov na zdravje na mednarodnem nivoju. Pri izdelavi, preizkušanju in implementaciji akcijskega načrta bodo vključene lokalni in regionalni deležniki, mreža šol in pilotne šole. Poleg tega bodo organizirana tudi skupna izobraževanja vseh deležnikov, kjer se bodo izmenjavala znanja in izkušnje.

Vodilni partner projekta je Nacionalni center za javno zdravje iz Budimpešte (angl. National Public Health Center Budapest). Poleg Madžarske in Slovenije v projektu sodelujejo še inštitucije iz Italije, Poljske in Češke. Iz vsake države sta v projekt vključeni zdravstvena ustanova in osnovna šola, v kateri se bo izvedel aplikativni del projekta. Slovenijo zastopa Osnovna šola Karla Destovnika-Kajuha iz Ljubljane.

## Short presentation of the Interreg project InAirQ

National Institute of Public Health of Slovenia (NIJZ) was from July 2016 included in the international project Transnational Adaption Actions for Integrated Indoor Air Quality Management (InAirQ). Project InAirQ is financially supported by Interreg, Central Europe.

The World Health Organisation (WHO) and the European Commission's DG Health have warned that air pollution – indoor and outdoor – is a major environmental health concern, which can lead to serious health effects. Much progress has been made in the EU to improve outdoor air quality and reduce the emission of pollutants. However, indoor air quality also requires attention because it is where we spend most of our time. Indoor exposure to air pollutants may occur in any indoor environment; among them, schools. The most vulnerable to the adverse effects of air pollution are pupils aged 6-14, which represent 11% of the total Programme area's population.

InAirQ aims to describe the health impacts of indoor air quality on the vulnerable population and to take action to improve the healthy environment in schools in central Europe. The project will develop a virtual health repository to help decision makers monitor the indoor air quality and its changes.

National Action Plans will be elaborated, tested and implemented, striving to raise standards of human health through improvements in the indoor environment. Capacity-building courses will be organised, tailored to the school managers and local / regional school operating bodies for the best implementation of the action plans, while the transnational Environment Quality Forum will provide the follow up of the project results and sustain the co-operation to the potential stakeholders.

Knowledge-providing partners – national / regional health authorities and institutions - will provide the baselines of indoor air quality and its health impacts at transnational scale. Local and regional authorities, network of schools and the pilot schools will contribute to elaborating, testing and implementing the action plans. They will also conduct capacity-building activities.

The leader partner in project is National Public Health Centre from Budapest. The other partners are from Italy, Poland and Czech Republic. From each country are in project included one health institution and one primary school. Primary school Karla Destovnika-Kajuha from Ljubljana represented Slovenian school in InAirQ.

