Baden-Württemberg
LANDESGESUNDHEITSAMT BADEN-WÜRTTEMBERG
IM REGIERUNGSPRÄSIDIUM STUTTGART

Newsletter

WHO Collaborating Centre for Housing and Health
Baden-Württemberg State Health Office

Landes Gesundheits Amt Baden-Württemberg

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Editorial

Modern construction and indoor air quality - a challenging partnership

Historically, housing has offered mankind shelter from bad weather conditions and the dangers of the outdoors. Throughout time, man has evolved from living primarily outdoors to spending more and more time inside buildings. For the populations of industrial nations this is more than 90% of their day time. Of course, the amount of time spent within different kinds of buildings depends on a person's daily routine and personal habits. This means that people are exposed during the day to varying indoor conditions [1, 2]. This applies in particular for temperature, humidity and air exchange rate depending on whether it is a private residential building, a place of work, or a publically accessible building.

Faced with the increasing amount of time people spend indoors, the influence of indoor conditions on human health has become increasingly important for scientific research. In the mid 19th century (1858), the German chemist and hygienist Max von Pettenkofer defined the concentration of carbon dioxide (CO_2) in indoor air as an indicator of poor indoor air quality [3]. In stating this, he emphasized that these factors themselves do not have a negative effect on human health, but that they would weaken the body's resistance to infections [4]. The very first hygiene requirement for indoor air is associated with his name – i. e. the indoor air CO_2 concentration should not be allowed to exceed 1000 ppm (0.1 Vol.-%, the so-called "Pettenkofer figure"). As a result, carbon dioxide remained the only guideline parameter for evaluating indoor climate hygiene conditions for a long time. The Pettenkofer figure has, in principle, maintained its validity until today [5].

The mode of construction of formerly built buildings differs significantly from modern dwellings. Cracks and openings in walls and unsealed windows and doors in older buildings allow a natural exchange of air, providing good air quality. Issues concerning correct ventilation did not arise until houses became more airtight, which was primarily pursued in order to save energy. In Germany, key points for this development were the energy crisis of 1973 and the laws implemented through the German Ordinance on Energy Saving in 2002 (*Energieeinsparverordnung - EnEV*) [6, 7].

The lower energy requirements of energy-optimized buildings are primarily achieved through effective insulation of the building's outer shell and by installing sealed doors and windows. Thus, correct ventilation behavior and the need to achieve a sufficient air exchange rate became of key importance [7, 8]. The EnEV does indeed contain recommendations on a minimum air exchange rate, but practical experience shows that these are not formulated clearly enough and that there is an obvious lack of detailed specified requirements and regulations [9].

Changed physical requirements for the building construction open up new challenges in terms of indoor air quality. The increasing airtightness of building envelopes leads to increased CO_2 concentrations and humidity indoors. This facilitates microbial growth on surfaces and an increase of air contaminants and noticeable odors. A main basic requirement in construction and carrying out conversion work is therefore to clearly define a ventilation concept in line with the foreseen use of the building. If this is not feasible, new developments such as air purification devices, filter systems and/or functional surfaces designed to counteract air contaminants may be possible solutions. However, it should still be the aim to meet indoor air hygiene requirements.

The two following articles in this newsletter provide an overview of the effects of energy-saving measures and modern architecture on indoor air quality and present additional technical means for its improvement.

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The influence of energy-saving measures and modern building construction on indoor air quality

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Modern inhabitants of an industrial nation spend most of their time indoors. Complex daily routines mean changing indoor locations throughout the day and different time/activity patterns depending on age and gender [1]. Therefore, indoor air quality in occupied rooms of private and public buildings is becoming increasingly important, as it influences people's well-being and health.

Types and requirements of buildings as well as their usage forms have always changed considerably as decades have passed. In recent times, the introduction of the German Ordinance on Energy Saving (*Energieeinsparverordnung - EnEV*) [2] has been a significant intervention in building physics and building's technical features. The EnEV sets boundary conditions specifying a building's primary energy requirement. These include both the building shell's heat insulation properties and the efficiency of the operating energy requirement. The key demand is to build dwellings in such a way that energy loss under conditions of heating and cooling is avoided where possible. Current technologies foresee the reduction of the energy loss mainly by sealing the building's outer shell. The implementation of the EnEV thus led to an increased development of efficient heating systems that reduce the fossil fuel requirement, a stronger consideration of renewable energies, an improvement of heat insulation materials and the development of new construction concepts.

Many existing buildings have recently undergone energy-saving measures to reduce their energy consumption. State subsidy programmes have been put in place to promote such activities. These measures have primarily focused upon greater insulation of the buildings' shell (outer walls, roof and cellar) and modernization of windows and doors. Energy-saving renovation work on existing buildings and such concepts in new buildings implement optimizations in the buildings' structure to allow them to meet the EnEV standards or better (low-energy houses). Continued improvement of heat insulation can even reduce thermal energy requirements so far that the demand can be covered by passive sources alone (e.g. sunlight, heat emitted by users of the building or by electrical devices), in some cases allowing to forego traditional heating systems (passive houses). New developments are even pushing the boundaries, for example by using solar panels to collect and generate even more energy than the building itself requires (plus-energy house). It must be considered, however, that this only applies to the overall balance. It is still the case that such buildings require an energy supply from time to time. However, all variations of energy-saving renovation work have in common that the measures implemented to reduce energy consumption result in a severe reduction of the natural air exchange. If the ventilation concept is not adapted to the new situation, this will have a negative effect on indoor air quality. Conflicting interests are the result [3].

According to a statement given by the Indoor Air Hygiene Commission at the German Federal Environmental Agency in 2006 [4], energy-saving construction methods and good indoor air quality should not be conflicting aims. This particularly applies when the minimum air exchange rate is met (fully opening all the windows several times a day, controlled ventilation systems) and low-emission construction products and furnishings are used. Practical experience from recent years show, however, that these conflicting interests between energy-saving on one side and good indoor air quality on the other continue to exist [3].

The additional insulation often seals the building's outer shell so completely that the natural exchange of air between the interior and exterior is practically non-existent. The building's heat and humidity balance can thus no longer be regulated or influenced in a typical manner. Without additional ventilation measures, incorrect or unadapted ventilation behavior (particularly in private households) leads to very low natural air exchange rates ($< 0.1\ h^{-1}$) [5] and, as a result, to rising indoor concentrations of, for example, carbon dioxide (CO_2). There can also be excessively high humidity levels. Especially during the times when the heating system is in operation, humidity levels above the dew-point temperature can occur (if the rooms are insufficiently ventilated). Without considering and ensuring a sufficient hygienic minimum air exchange, energy-optimized buildings present a risk of microbial growth on surfaces cooler than the indoor air, for example condensation on walls. The formation of microbial deposits depends on the material's capacity to absorb water and behavior in absorbing and releasing water and on the air flow patterns in the room. Mould can release secondary metabolic products into indoor air. These so-called mycotoxins primarily enter the gas phase particle-bound and can cause health issues, beginning with allergic reactions and moving on to direct fungal infections or acute toxic effects [6]. The microbial load in indoor areas is therefore moving more strongly into the focus of public attention and research, even though it must be said that bacterial and microbial growth does not lead to health issues in every case.

A growth of mould can also cause unpleasant odours in the building. These can also be caused by organic primary and secondary products emitted from the variety of different building and furnishing products in the rooms [7, 8]. These compounds often have low odour thresholds meaning that a noticeable odour is not always an indication of a health risk in the room through air contamination. However, a strong reduction of the natural air exchange through energy-saving measures can lead to a long-lasting, more intensive perception of odours. The perceived odour of indoor air quality has therefore been of increasing interest in recent years [9, 10].

Emissions from building materials and furnishings are the most significant source of organic compounds (VVOCs/VOCs/SVOCs) in indoor air. Faced with a considerable reduction of natural air exchange, clearly measurable indoor air concentrations can arise from even low-emission sources if there is insufficient additional ventilation. Guideline values for indoor air may well be exceeded. Construction materials used for the energy-saving measures can themselves be a source of emissions, such as inner and outer insulation materials. Certain studies have shown that emissions from these products can cause massive indoor air quality problems [11, 12]. The widespread use of flammable insulation materials on outer facades bring up, beyond indoor air quality issues, the additional questions of fire safety and the end-of-life disposal of these materials.

While the emission behavior of building products is regulated and liable to registration in certain areas (AgBB scheme) [13, 14], not nearly all products used in the interior are subject to such tests. There also exist only guideline values, but no binding legal requirements for evaluating indoor air quality as such. The regulation difficulties are due to the situation that indoor air quality is influenced by a wide range of peripheral parameters which interact with each other (e.g. emission sources, climatic conditions, ventilation, user behavior) [15].

Paragraph 6 of the EnEV mentions the necessity to ensure the minimum air exchange required for health and heating [2]. However it is not specifically mentioned how this can be achieved, maintained and monitored. Therefore, this aspect receives little consideration, as numerous “damage cases” show. Faced with the lack of specific figures, this parameter is not clearly defined and can be interpreted too broadly. By installing mechanical ventilation systems, these problems could generally be eliminated, although new hygiene problems (fungal contamination) can then arise from the equipment if it is of poor quality or poorly maintained. In addition, there is so far no set of regulations for operating such mechanical ventilation systems in private residential buildings.

Another attractive way to solve problems is the use of construction materials with catalytically active surfaces and/or the use of air cleaners, but currently there is a lack of mandatory regulations for testing and using these, too.

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Additional technical means for achieving good indoor air quality in energy-optimized buildings

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1. Introduction

Recent years have seen a strengthening trend towards increasing insulation of buildings in order to reduce energy costs [1, 2]. A consequence of this is that the natural air exchange in energy-optimized buildings is becoming ever-lower. Without suitable countermeasures, this can have negative effects on the well-being or even on the health of the occupants [3, 4]. **Fig. 1** shows examples of technical measures which can be implemented to still achieve good indoor air quality:

- Installation of a ventilation system
- Forced ventilation, e.g. around windows
- Using air cleaners in the rooms
- Integration of functional anti-contaminant surfaces

All of these measures can be useful on their own or in combination and are even necessary in some cases. They can, however, also be counterproductive if they are applied wrongly or not properly used. The most important aspects are examined more closely in the following.

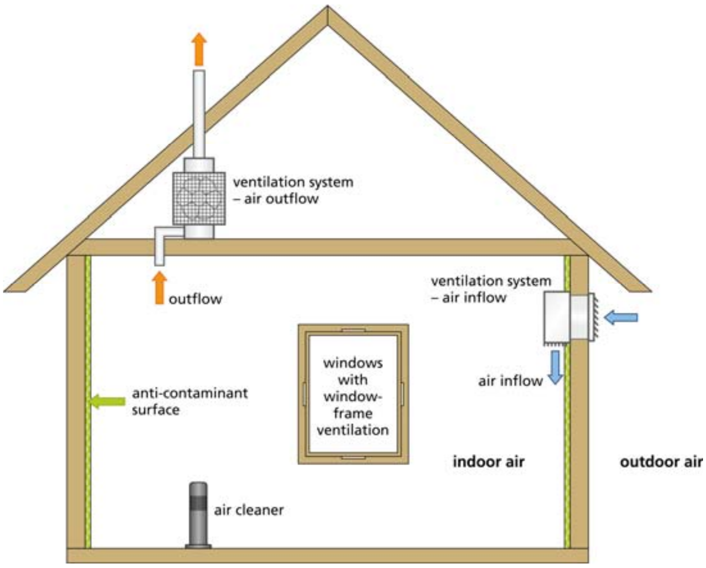

Fig. 1: Means of improving the indoor air quality (Source: Fraunhofer Institute for Wood Research, Wilhelm Klauditz Institute WKI, Braunschweig)

2. Ventilation systems

The installation of ventilation systems is the most comprehensive and flexible solution towards ensuring sufficient air exchange and therefore the supply of fresh air necessary for proper hygiene. This does not only apply to reducing the chemicals emitted from building materials and consumer products present in the building and to reducing the CO_2 levels in the room – it also regulates the humidity level and the temperature. Ventilation systems fundamentally work by exchanging indoor and outdoor air with the aim of an air exchange of about 30 m³/h per person or an average air exchange of 0.3 h^{-1} [5]. The loss of warmth is minimized by using highly efficient heat exchangers. The installed filters remove undesired substances and particles from the outdoor air.

When operating a ventilation system, attention should be paid on ensuring the hygienically necessary minimum air exchange, optimal adjustment and regular maintenance of the system. If the filter capacity is exhausted, the filter will gradually lose its effect and substances from outside can pass into indoor air unhindered [4]. Also, filters based on activated carbon are especially prone to forming irritants and other hazardous substances when reacting with ozone from the outdoor air. These substances can then enter the building's interior [6]. Poor humidity management can lead to mould or germs building up inside the system or to the formation of odorous substances [7]. When conducting renovation work of older buildings, it is often difficult or even impossible to install a ventilation system within a realistic budget.

A correctly installed ventilation system with regular professional maintenance is, however, in many cases a good solution for combining energy-saving measures with healthy living and well-being in terms of indoor air quality [8].

3. Natural ventilation via windows

A simpler way of achieving a hygienic level of air exchange is manual or integrated ventilation via the windows. This can be achieved by regularly opening the windows or by integrating outdoor air inlets in the windows themselves. Both options have the disadvantage that heat is lost (or cold air comes in) due to the air exchange and thereby the effect of the insulation will partly get lost. With manual ventilation, some residents may become over-keen and cause more warmth to be lost than necessary or a longer absence may lead to too little ventilation, with the corresponding consequences for the indoor air quality and humidity levels [5]. Another disadvantage is the lack of filtering. This leads to substances in the outdoor air being able to enter the building in higher quantities. This problem is a considerable factor in urban areas [9]. However, even rural areas can experience these problems, e.g. odours. In the future, sensor-controlled windows could be an intelligent solution. Security issues and the cost factor would of course be questions which would need to be answered before implementation.

4. Air cleaners

One means for counteracting at least elevated concentrations of air contaminants is to set up air cleaners. These have different ways of working such as photocatalysis, electrostatic filters, plasma, UV, ionization or by using various adsorption filter techniques [10]. While the first-mentioned systems remove air contaminants and thus have longer maintenance intervals, adsorber materials have to be replaced regularly. Most devices affect neither the CO_2-level nor the humidity level, which might necessitate supplementary measures. Air cleaners also consume a certain amount of energy, as do ventilation systems. In addition, the operation of such devices can, in itself, cause an emission of air contaminants or airborne pollutants if they are not fully mineralized to carbon dioxide (CO_2), water or other mineral oxidation products. Such reaction products, also known as secondary emissions, could be more relevant in respect to odour and toxicity than the initial compounds themselves [11, 12]. For example, aldehydes can be formed by such reaction mechanisms and thus also formaldehyde [13]. Such emissions are counteracted in some devices by means of an additional filter.

Functional verifications based on specific investigations offer a degree of certainty. **Fig. 1** shows an example in which the functionality of two such devices in reducing toluene (a substance often carried in from the outside air) is compared. It can be seen that the less effective device (cleaner 2) reduces toluene to a significant extent to formaldehyde. Formaldehyde is additionally emitted from the device itself when in operation.

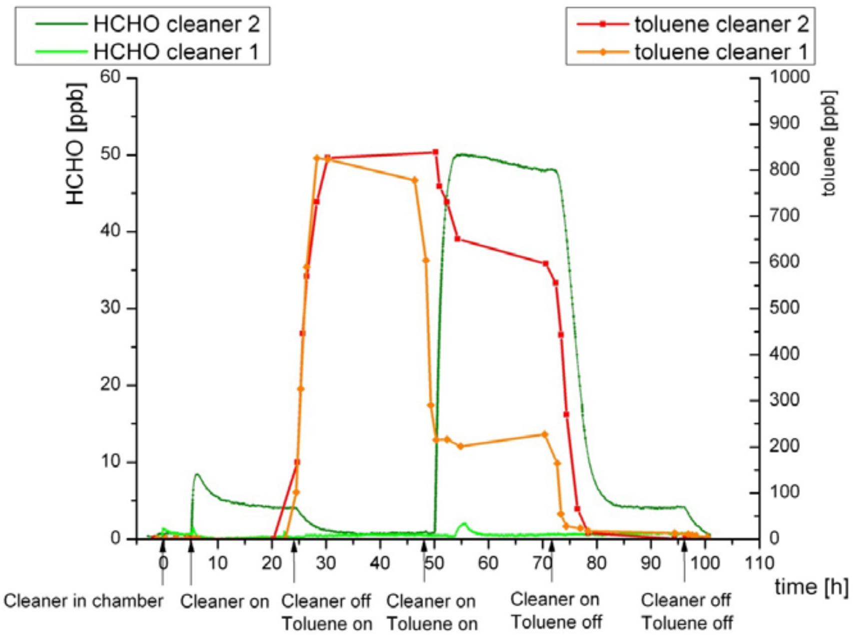

Fig. 1: Reduction of toluene levels with two different air cleaners (Source: Fraunhofer Institute for Wood Research, Wilhelm Klauditz Institute WKI, Braunschweig)

Properly developed air cleaners can be used to reduce the concentrations of air contaminants or odours, but they really only serve as a supplementary measure. However, generally recognized test procedures which allow a statement to be made on the efficiency and indoor compatibility of such devices in practice are only now being developed [14].

5. Functional surfaces

The reduction of undesired air contaminants or odorous substances can be also achieved via so-called functionalized surfaces. Such surfaces are equipped with a catalyst which directly or indirectly oxidizes adsorbed molecules. In an ideal case, the substances are mineralized this way. However, various conditions must be fulfilled before this can happen and these conditions are not always present in real indoor environments. Photocatalysts, for example, require sufficient light with enough intensity of the required wavelength. This is not always available. Also, the reaction requires a sufficiently long adsorption time of the target substances to be reduced on the surface. To achieve this, the surface carrying the catalyst must be appropriately designed, which in many situations is not or is insufficiently the case. All this can lead to incomplete reduction reactions resulting in substances which "poison" the catalyst, smell unpleasant or can even be hazardous to human health. With some products, even a self-decomposition has been observed which can, for example, lead to formaldehyde formation [15-17]. The conclusion is therefore that when using functionalized construction products, a professional selection of products and their suitability in proper application is to be ensured.

6. Summary

Modern construction compliant to the EnEV often results in buildings which, while energy-optimized, have not been sufficiently examined during its planning and construction in terms of the minimum air exchange necessary for hygiene. The building's air exchange rate can be sustainably improved using additional mechanical ventilation systems. Undesirable concentrations or air contaminants in indoor air can be reduced by using air cleaners and functional construction products, but such measures harbour the above-mentioned risks which then can have negative effects on indoor air quality due to the production of undesired by-products and substantial deactivation of the catalysts used. These aspects should be thoroughly and professionally considered during the planning and execution of such measures.

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Publications and Resources

Health ratings for urban environments provided by new software

New software has been developed to rate the health risks of different activities in the urban environment, for example, cycling or driving in different areas of a city. 'CENSE' is based on a variety of different pollutants and environmental health hazards encountered in urban environments and may provide a useful tool for urban planning and improving residents' quality of life, its developers say.
http://ec.europa.eu/environment/integration/research/newsalert/pdf/365na5.pdf

European test standard on VOC emission

Volatile organic compounds (VOC) that pass off, for example, oriented strand boards (OSB) into indoor air, may cause health problems such as mucous membrane irritations. A new test standard for building products shall ensure that VOC emissions can be uniformly measured and declared throughout Europe. This new standard shall be implemented within the European Economic Aerea over the year. Consumers will so obtain reliable information on building products. The German Umweltbundesamt (UBA) was involved in the development of the new test standard and applies the new test method to the award criteria for the eco-label "Blue Angel".
http://www.umweltbundesamt.de/themen/neue-bauprodukte-pruefnorm-fuer-einheitliche

Odours in the home

Odours are information of chemical nature: fragrances and scents are recognized by receptor cells in the nose. This information is directly transmitted through nerve fibres from the nose to the brain. Here, the information is analyzed and interpreted. If odours are associated with strong emotions such as the typical smell at the dentist or the favourite perfume of the partner, they are especially well remembered. However, since fragrances may also cause headache or can even trigger allergic reactions, they should be omitted or used only sparingly in the home.
http://www.umweltbundesamt.de/sites/default/files/medien/479/publikationen/ratgeber_informationen_ueber_den_umgang_mit_duftstoffen.pdf

Literature

In this section we will provide a collection of recent housing and health publications from a variety of backgrounds. Literature published in German or French, respectively, is indicated with the German flag or the French flag.
If you have suggestions for interesting journals that we should screen for the literature collection, please let us know!

Table of Topics

Allergies and Respiratory Diseases

Residential proximity to major highways - United States, 2010.
Boehmer TK, Foster SL, Henry JR, Woghiren-Akinnifesi EL, Yip FY; Centers for Disease Control and Prevention (CDC).
MMWR Surveill Summ. 2013 Nov 22;62 Suppl 3:46-50. *Free Article.*

The impact of environmental factors on quality of life and symptoms of children with allergic rhinitis.
Castro TM, Marinho DR, Cavalcante CC.
Braz J Otorhinolaryngol. 2013 Sep-Oct;79(5):569-74. *Free Article.*

Association of tobacco smoke exposure and atopic sensitization.
Ciaccio CE, DiDonna AC, Kennedy K, Barnes CS, Portnoy JM, Rosenwasser LJ.
Ann Allergy Asthma Immunol. 2013 Nov;111(5):387-90. *Free Article.*

Controversial role of pets in the development of atopy in children.
Fretzayas A, Kotzia D, Moustaki M.
World J Pediatr. 2013 May;9(2):112-9. *Review.*

Impact of parental smoking on childhood asthma.
Gonzalez-Barcala FJ, Pertega S, Sampedro M, Lastres JS, Gonzalez MA, Bamonde L, Garnelo L, Castro TP, Valdés-Cuadrado L, Carreira JM, Moure JD, Silvarrey AL.
J Pediatr (Rio J). 2013 May-Jun;89(3):294-9. *Free Article.*

The synergistic effect of heredity and exposure to second-hand smoke on adult-onset asthma.
Lajunen TK, Jaakkola JJ, Jaakkola MS.
Am J Respir Crit Care Med. 2013 Oct 1;188(7):776-82.

Environmental control for asthma: recent evidence.
Matsui EC.
Curr Opin Allergy Clin Immunol. 2013 Aug;13(4):417-25. *Review.*

Indoor pollutant exposures modify the effect of airborne endotoxin on asthma in urban children.
Matsui EC, Hansel NN, Aloe C, Schiltz AM, Peng RD, Rabinovitch N, Ong MJ, Williams DL, Breysse PN, Diette GB, Liu AH.
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Environmental assessment and exposure control of dust mites: a practice parameter.
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Events Announcement

VDI Forum Indoor Pollutants
VDI - Wissensforum - Schadstoffe in Innenräumen - Ursachen - Messstrategie - Bewertung
March 25-26, 2014
Munich, Germany
Further Informationen: VDI Wissensforum: Schadstoffe in Innenräumen

WHO | World Health Day 2014 : vector-borne diseases
April 7, 2014
Worldwide
Further Information: WHO | World Health Day - 7 April 2014

25th APPA Annual Meeting
25. Jahrestagung der Arbeitsgemeinschaft Pädiatrische Pneumologie und Allergologie
May 23-25, 2014
Leipzig, Germany
Further Information: APPA-2014

Indoor Air 2014 - ISIAQ International Society of Indoor Air Quality and Climate
July 7-14, 2014
Hong Kong, People's Republik of China
Further Information: Indoor Air 2014 — ISIAQ

7th GHUP Annual Meeting
7. GHUP Jahrestagung 2014
July 26-27, 2014
Cologne, Germany
Further Information: GHUP - Jahrestagung

26th Conference of the International Society for Environmental Epidemiology ISEE
August 24-28, 2014
Seatle / Washington, USA
Further Information: ISEE - International Society for Environmental Epidemiology

9th Conference of the German Society for Epidemiology (DGEpi) e.V.
September 17-20, 2014
Ulm, Germany
Further Information: German Society for Epidemiology - DGEpi

9th German Conference on Allergies
9. Deutscher Allergiekongress
October 2-4, 2014
Wiesbaden, Germany
Further Information: Allergiekongress

Microbiology and Infection 2014
4th Joint Conference of the German Society for Hygiene and Microbiology (DGHM) and the Association for General and Applied Microbiology (VAAM)
October 5-8, 2014
Dresden, Germany
Further Information: dghm-vaam-kongress.de

24th Conference of the International Society of Exposure Science ISES
October 12-16, 2014
Cincinnati / Ohio, USA
Further Information: International Society of Exposure Science (ISES)

Message Board

In this section we will inform you about activities and projects related to housing and health that are being carried out by WHO or the WHO CC. This may relate to ongoing activities and projects, as well as invitations to participate in data collections or case study projects.

WHO work on indoor and built environments

Urban and housing-related inequalities in Malta

The report presents the first national assessment of the magnitude and distribution of environmental health inequalities in the Maltese Islands. The assessment report is based on a set of 14 core inequality indicators related to housing, injuries and the environment developed by the WHO Regional Office for Europe. National data has provided a good snapshot of the current distribution of environmental risk factors, indicating that environmental health inequalities are a reality in Malta.
This report is the first national follow-up report to the European assessment of environmental health inequalities published in 2012.

For the Malta report: see http://www.euro.who.int/__data/assets/pdf_file/0016/243160/Environmental-Health-Inequalities-in-Malta.pdf
For the European report: see
http://www.euro.who.int/__data/assets/pdf_file/0010/157969/e96194.pdf

Disparities in access to water and sanitation

In the WHO European Region, access to water and sanitation in urban as well as rural areas varies widely between countries, provinces and even people in the same communities, regardless of countries' level of development. A major difficulty in addressing these inequities is the lack of both a detailed picture of the level of access for all population groups and a clear understanding of the main factors in the origin of the inequities. This is especially relevant at times of financial crisis.
For the first time, inequities in access to water and sanitation can now be measured with a new analytical tool prepared by UNECE and the WHO Regional Office for Europe: the Equitable Access Score-card. The Score-card provides a checklist to enable a country, region or city to gather, organize and evaluate information, enabling users to undertake a comprehensive overview of existing policy measures on fair access to water and sanitation.

For the full report, please see:
http://www.unece.org/index.php?id=34032

Under preparation: WHO Guidelines on environmental noise

The WHO Regional Office for Europe is currently developing the WHO Environmental Noise Guidelines for the European Region. These will provide suitable scientific evidence and recommendations for protecting human health from environmental noise exposure originating from various sources and community settings. The need for health-based guidelines originates in part from the European Union, which requires EU Member States to establish action plans to control and reduce the harmful effects of noise exposure. In addition, the noise guidelines will include additional noise sources not addressed in the previous Guidelines for Community Noise (1999), such as personal electronic devices, toys, and wind turbines. The process for guideline development has been initiated in 2013 and the publication is expected to be finalized in 2015.

For further information and access to the current Community Noise Guidelines, please see
http://www.euro.who.int/en/health-topics/environment-and-health/noise/activities/update-of-who-guidelines-for-community-noise-for-the-european-region

Countries urged to reduce health risks from asbestos, second-hand smoke and toxic chemicals by 2015

With the approach of the 2015 deadline for achieving 3 of the 5 commitments made at the 2010 Fifth Ministerial Conference on Environment and Health, 30 countries at the third meeting of the Environment and Health Task Force agreed to boost action to free Europe from asbestos-related diseases and exposure to second-hand tobacco smoke and toxic chemicals.

For further information on the European Environment and Health Process, see http://www.euro.who.int/en/health-topics/environment-and-health/sections/news/2013/12/countries-urged-to-lower-health-risks-from-asbestos,-second-hand-smoke-and-toxic-chemicals-by-2015

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