Course “Indoor Air Quality and Ventilation”

Spring 2020

Monday, 16h15 – 19h00; Room: GC B3 30

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Office and hours: Mondays 14h45 to 16h00, office GC A1 344 (by appointment only)

Date	Topics covered	Suggested readings *	Tasks due
17 Feb 2020	Introduction to topic/field: - Course introduction - Indoor and outdoor air quality - Overview of indoor aerosols & gases - Why do we care about IAQ?	(1-5)	
24 Feb 2020	Material-balance models for buildings: - Steady state and dynamic Air exchange rate in buildings **Blog post overview****	(6,7) Spengler Ch. 58	
02 Mar 2020	Gaseous pollutants: - Overview of gaseous pollutants - Properties of gases - Sources and emission models - Chemical reactions overview **Course project overview*****	(8-10) Spengler Ch. 29, 31, 32, 40	
09 Mar 2020	Indoor aerosols: - Particulate matter overview - Particle sources - Particle size distribution and lung deposition - Particle dynamics - Deposition and resuspension	(11,12) Seinfeld Ch. 8	Blog post topic selection
16 Mar 2020	Guest lecture – Dr. Shen Yang, EPFL IAQ and ventilation assessment methods: - Gaseous pollutants measurement techniques - Aerosol measurement techniques - Review of the scales with respect to IAQ - Design stage tools - Tools for post occupancy evaluation Course project: Briefing on instruments use		Take over instruments and keys
23 Mar 2020	Special topics in IAQ: - IAQ in developing countries - Indoor microbiology Course project consultations	(13-19)	Return the instruments and keys
30 Mar 2020	Written mid-term exam based on theory 1		

06 Apr 2020	Exposure: - Human exposure patterns - Exposure definitions and factors influencing exposure - Direct and indirect assessment of IAQ and exposure - Integral mass balance for exposure - Intake fraction Course Project consultations	(20-23)	
13 Apr 2020	No courses (happy Easter holidays!)		
20 Apr 2020	Ventilation: - IAQ control overview - Ventilation requirements - Air exchange rates and room air distribution - Ventilation strategies	Awbi + Etheridge Spengler Ch. 2	
27 Apr 2020	Infiltration and air leakage Filtration & air cleaning: - Air filtration – Particles Course Project consultations	(24-27) Hinds Ch. 9	Blog post
04 May 2020	***Project work and consultations (no lecture)***		
11 May 2020	Filtration & air cleaning: - Removal of gases and vapors - Disinfecting air Overview of buildings and green building guidelines - LEED - WELL Course review	(28-30)	
18 May 2020	Written mid-term exam based on theory 2		
25 May 2020	Course project presentations in class		Final report

***Suggested Reading Material (not compulsory)**

(1) Jones AP. Indoor air quality and health. Atmospheric Environment (1999), 33: 4535-4564
(2) Mitchell CS, Zhang J, Sigsgaard T, Jantunen M, Lioy PJ, Samson R, Karol MH. Current state of the science: health effects and indoor environmental quality Environmental Health Perspectives (2007), 115: 958-964.
(3) Sundell J. On the history of indoor air quality and health. Indoor Air (2004), 14: 51–58.
(4) Klepeis NE, Nelson WC, Ott WR, Robinson JP, Tsang AM, Switzer P, Behar JV, Hern SC, Engelmann WH. The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants. J. Exp. Anal. Environ. Epidemiol., 11 (2001), 231-252.
(5) Ott WR, Roberts JW. Everyday exposure to toxic pollutants. Sci Am (1998), 278(2):86-91.
(6) Jamieson S. A partial review of mass balance models. Department of Epidemiology and Biostatistics Imperial College London. [Link]
(7) Murray DM, Burmaster DE. Residential air exchange rates in the United States: empirical and estimated parametric distributions by season and climatic region Risk Analysis, 15 (1995), 459-465.

(8) Weschler CJ. Changes in indoor pollutants since the 1950s. Atmospheric Environment 2009, 43 (1), 153–169.
(9) Guo Z. Review of indoor emission source models. Part 1. Overview. Environ. Pollut. 2002, 120 (3), 533–549.
(10) Weschler CJ. Ozone in indoor environments: concentration and chemistry. Indoor Air 2000, 10 (4), 269–288.
(11) Nazaroff WW. Indoor particle dynamics. Indoor Air 2004, 14 (s7), 175–183.
(12) Chen C, Zhao B. Review of relationship between indoor and outdoor particles: I/O ratio, infiltration factor and penetration factor. Atmos. Environ. 2011, 45 (2), 275–288.
(13) Bruce N, Perez-Padilla R, Albalak R. Indoor air pollution in developing countries: a major environmental and public health challenge. Bull World Health Organ 2000, 78 (9), 1078–1092.
(14) Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJ. Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. The Lancet 2006, 367 (9524), 1747–1757.
(15) Lim SS, Vos T, Flaxman AD, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. The Lancet 2012, 380 (9859), 2224–2260.
(16) Fuel for life: household energy and health. World Health Organization 2006
(17) Stephens B. What Have We Learned about the Microbiomes of Indoor Environments? mSystems 2016, 1 (4), e00083-16.
(18) Nazaroff WW. Indoor bioaerosol dynamics. Indoor Air 2004, 14 (s7), 175–183.
(19) Qian J, Hospodsky D, Yamamoto, N, Nazaroff WW, Peccia J. Size-resolved emission rates of airborne bacteria and fungi in an occupied classroom. Indoor Air 2012, 22 (4), 339–351.
(20) Morawska L, Afshari A, Bae GN, et al. Indoor aerosols: from personal exposure to risk assessment. Indoor Air 2013; 23: 462–487.
(21) Özkaynak H, Xue J, Spengler J, et al. Personal exposure to airborne particles and metals: results from the Particle TEAM study in Riverside, California. J Expo Anal Environ Epidemiol. 1996; 6: 57–78.
(22) Wierzbicka A, Bohgard M, Pagels JH. Quantification of differences between occupancy and total monitoring periods for better assessment of exposure to particles in indoor environments. Atmospheric Environment 106 (2015) 419-428.
(23) Bennett DH, McKone TE, Evans JS, Nazaroff WW, Margni MD, Jolliet O, Smith KR. Defining intake fraction. Environmental Science & Technology 2002; 36: 206A-211A.
(24) Chen C, Zhao B. Review of relationship between indoor and outdoor particles: I/O ratio, infiltration factor and penetration factor. Atmospheric Environment 2011; 45: 275-288.
(25) Liu D-L, Nazaroff WW. Modeling pollutant penetration across building envelopes. Atmospheric Environment 2001; 35: 4451–4462.
(26) Liu D-L, Nazaroff WW. Particle penetration through building cracks. Aerosol Science & Technology, 37:7, 565-573.
(27) US EPA. Evaluation of in-room particulate matter air filtration devices; EPA/600/R-08/012; United States Environmental Protection Agency, 2008.
(28) Zhang Y, Mo J, Li Y, Sundell J, Wargocki P, et al. Can commonly-used fan-driven air cleaning technologies improve indoor air quality? A literature review. Atmospheric Environment 45 (2011) 4329-4343.
(29) Persily AK, Emmerich SJ. Indoor air quality in sustainable, energy efficient buildings. HVAC&R Research, 2012, 18(1–2):4–20.
(30) Licina D, Bhangar S, Pyke S. Occupant health & well-being in green buildings: Trends and future directions, ASHRAE Journal, April 2019.

****Blog Post**

Each student will be required to write one blog post throughout the duration of the course on topics related to indoor air quality (IAQ), indoor exposures, indoor environmental health, building ventilation and any other topics closely related to the course. The aim of this assignment is to deepen your familiarity on contemporary IAQ issues and trends, as well as to encourage you to think about IAQ issues in a broader scientific and societal context, introduce you to the writings of leading experts in the field, and give you practice of concise writing of short, interesting and visually stimulating columns.

You will be able to access the course blog with tequila (EPFL login), which is available at the following URL: https://hobelblog.epfl.ch/. You will be expected to login and publish you post on the date that it is due (refer to the course schedule for due dates). You will be able to choose from the following list of topics:

- Air Humidity and Indoor Air Quality
- Biomass Cookstoves: Indoor Air Quality in a Global Context
- Microbiology of the Built Environment
- Impact of Indoor Air Quality on Human Productivity
- Environmental Tobacco Smoke
- Are Candles Toxic to Indoor Air Quality?
- Flame retardants: Good or Bad Guys?
- Phthalates: Good or Bad Guys?
- Airborne Infectious Disease Transmission in Hospitals
- Indoor Nanoparticles: Sources & Exposure
- Humans as Sources of Particlate and Gasesous Pollutants Indoors
- Novel Ventilation Strategies for Commercial Buildings
- Emerging HVAC Filtration and Air Cleaning Technologies
- IoT Sensing of Indoor Air Quality – Is This a Future?

Alternatively, you may propose your own topic (with permission from the lecturer). Examples of other possible blog posts include highlights of IAQ topics in the popular media, reviews of recently published peer-reviewed research articles, overviews of new or old IAQ standards, and many others.

The length of the blog post should be around 1’000 words (excluding the references, tables and figures) in order to fully explain your ideas on a subject, typically with one or two helpful figures and/or tables. The blog post will be worth 15 points, with 50% of your grade coming from completeness and accuracy of your post and the other 50% coming from your writing technique and grammar.

You must submit your own writing for this blog post. You are encouraged to discuss and even work with other students on blog post (unless explicitly told otherwise), but material that is submitted must be your own work.

*****Course Project**

You will work in teams to perform field investigation of indoor air quality at the GC building at EPFL campus (or other spaces with permission from the lecturer). The aim of this project is to introduce you to the IAQ topic and writings of leading experts in the field, to learn how to perform IAQ assessment through handling instrumentation, conducting measurements and performing survey questionnaires, to conduct data analysis and calculations related collected data, and to acquire the practice of writing, presenting and discussing the results with the peers.

The class will be divided into 3-6 groups (depending of the final number of students that sign up for the course). Each student will have his/her own individual set of responsibilities within the group project based on which grading will be done. The project will include several deliverables, including conducting a comprehensive review of existing literature on the topic of IAQ in buildings (exact type of building/space will be assigned/agreed in the class); utilizing state-of-the-art scientific instruments to measure particle and gas-phase air pollutants in buildings (detailed instructions will be given during the class); collect, extract, analyze and interpret data; prepare a final written report of the findings (something like a conference paper or journal article), and give an oral presentation to your classmates during the last week of the semester. For the purpose of oral presentation, each member of your team should present part of the work done using computer slides. You may use the blackboard to illustrate key points. You are expected to integrate course material to complete the course project and to demonstrate a firm understanding of project materials as reflected in the final written report and oral presentation.

The project report must be submitted in printed version on the date that it is due (refer to the course schedule for due dates). In addition, students must submit the report in the form of an electronic PDF (filename: Project Report_2020_GroupNickName.pdf).

The length of the report should be not more than 10’000 words (not less than 5’000 words) including tables and figures, but excluding the list of references. The structure of the report should be the same or similar to a journal publication style, including the following subsections: Abstract; Introduction; Methodology; Results and Discussion; Conclusions; References (see a template uploaded in Moodle). For the purpose of data analysis, you will be encouraged to use Microsoft Excel, MATLAB or other software for data processing and plotting. The course project will be worth 45 points, with 30 points of your grade coming from the written project report and the other 15 points coming from the oral presentation. Both report and presentation will be graded based on the quality, completeness, accuracy, writing and presentation style.