Rapport de veille n° 41

Aéraulique et COVID-19

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Google Scholar et WoS

Peters, T. M., Rabidoux, D., Stanier, C. O., Anthony, T. R.
Assessment of University Classroom Ventilation during the COVID-19 Pandemic.
Journal of Occupational and Environmental Hygiene, (2022), pp. 1-10

Ventilation plays an important role in mitigating the risk of airborne virus transmission in university classrooms. During the early phase of the COVID-19 pandemic, methods to assess classrooms for ventilation adequacy were needed. The aim of this paper was to compare the adequacy of classroom ventilation determined through an easily-accessible, simple, quantitative measure of air changes per hour (ACH) to that determined through qualitative "expert judgement" and recommendations from the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the American Conference of Governmental Industrial Hygienists (ACGIH). Two experts, ventilation engineers from facilities maintenance, qualitatively ranked buildings with classrooms on campus with regard to having "acceptable classroom ventilation". Twelve lecture classrooms were selected for further testing, including a mix of perceived adequate/inadequate ventilation. Total air changes per hour (ACH) was measured to quantitatively assess ventilation through the decay of carbon dioxide in the front and rear of these classrooms. The outdoor ACH was calculated by multiplying the total ACH by the outdoor air fraction. The classrooms in a building designed to the highest ASHRAE standards (62.1 2004) did not meet ACGIH COVID-19 recommendations. Four of the classrooms met the ASHRAE criteria. However, a classroom that was anticipated to fail based on expert knowledge met the ASHRAE and ACGIH criteria. Only two classrooms passed stringent ACGIH recommendations (outdoor ACH >6). None of the classrooms that passed ACGIH criteria were originally expected to pass. There was no significant difference in ACH measured in the front and back of classrooms, suggesting that all classrooms were well-mixed with no dead zones. From these results, schools should assess classroom ventilation considering a combination of classroom design criteria, expert knowledge, and ACH measurements.

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Karami, S., Lakzian, E., Lee, B. J., Warkiani, M. E., Mahian, O., Ahmadi, G.
COVID-19 Spreading Prediction in a Control Room of Power Plant Using CFD Simulation (preprint).
Environmental Science and Pollution Research, (2022)

Coughing and sneezing are the main ways of spreading coronavirus-2019 (SARS-CoV-2). Strategically critical facilities such as power plants cannot be shut down even in challenging situations like the COVID-19 outbreak. The personnel of the power plants' control room need to work together at close distances. This study presents the computational fluid dynamics (CFD) simulation results on the dispersion and transport of respiratory droplets emitted by an infected person coughs in a control room with an air ventilation system. This information would be helpful for risk assessment and for developing mitigation measures to prevent the spread of infection. The turbulent airflow in the control room is simulated using the k-ε model. The particle equation of motion included the drag, the Saffman lift, the Brownian, gravity/buoyancy, and thermophoresis forces. The simulation results showed that after 115 s, the cough droplets are dispersed in the entire room, and there is no safe (virus-free) space in the control room. Therefore, a safer design for the ventilation system is proposed by placing the ventilation air inlet and outlet registers across the control room and creating airflow patterns similar to air curtains that divided the room into three compartments.

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Asif, Z., Chen, Z., Stranges, S., Zhao, X., Sadiq, R., Olea-Popelka, F.*, et al.*

Dynamics of SARS-CoV-2 spreading under the influence of environmental factors and strategies to tackle the pandemic : A systematic review.
Sustainable Cities and Society, Vol. **81**, (2022)

COVID-19 is deemed as the most critical world health calamity of the 21st century, leading to dramatic life loss. There is a pressing need to understand the multi-stage dynamics, including transmission routes of the virus and environmental conditions due to the possibility of multiple waves of COVID-19 in the future. In this paper, a systematic examination of the literature is conducted associating the virus-laden-aerosol and transmission of these microparticles into the multimedia environment, including built environments. Particularly, this paper provides a critical review of state-of-the-art modelling tools apt for COVID-19 spread and transmission pathways. GIS-based, risk-based, and artificial intelligence-based tools are discussed for their application in the surveillance and forecasting of COVID-19. Primary environmental factors that act as simulators for the spread of the virus include meteorological variation, low air quality, pollen abundance, and spatial-temporal variation. However, the influence of these environmental factors on COVID-19 spread is still equivocal because of other non-pharmaceutical factors. The limitations of different modelling methods suggest the need for a multidisciplinary approach, including the 'One-Health' concept. Extended One-Health-based decision tools would assist policymakers in making informed decisions such as social gatherings, indoor environment improvement, and COVID-19 risk mitigation by adapting the control measurements.

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Watson, R., Oldfield, M., Bryant, J. A., Riordan, L., Hill, H. J., Watts, J. A.*, et al.*
Efficacy of antimicrobial and anti-viral coated air filters to prevent the spread of airborne pathogens.
Scientific reports, Vol. **12** n°(1), (2022)

The COVID-19 pandemic has demonstrated the real need for mechanisms to control the spread of airborne respiratory pathogens. Thus, preventing the spread of disease from pathogens has come to the forefront of the public consciousness. This has brought an increasing demand for novel technologies to prioritise clean air. In this study we report on the efficacy of novel biocide treated filters and their antimicrobial activity against bacteria, fungi and viruses. The antimicrobial filters reported here are shown to kill pathogens, such as Candida albicans, Escherichia coli and MRSA in under 15min and to destroy SARS-CoV-2 viral particles in under 30s following contact with the filter. Through air flow rate testing, light microscopy and SEM, the filters are shown to maintain their structure and filtration function. Further to this, the filters are shown to be extremely durable and to maintain antimicrobial activity throughout the operational lifetime of the product. Lastly, the filters have been tested in field trials onboard the UK rail network, showing excellent efficacy in reducing the burden of microbial species colonising the air conditioning system.

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Baig, T. A., Zhang, M., Smith, B. L., King, M. D.
Environmental Effects on Viable Virus Transport and Resuspension in Ventilation Airflow.
Viruses, Vol. **14** n°(3), (2022)

To understand how SARS-CoV-2 spreads indoors, in this study bovine coronavirus was aerosolized as simulant into a plexiglass chamber with coupons of metal, wood and plastic surfaces. After aerosolization, chamber and coupon surfaces were swiped to quantify the virus concentrations using quantitative polymerase chain reaction (qPCR). Bio-layer interferometry showed stronger virus association on plastic and metal surfaces, however, higher dissociation from wood in 80% relative humidity. Virus aerosols were collected with the 100 L/min wetted wall cyclone and the 50 L/min MD8 air sampler and quantitated by qPCR. To monitor the effect of the ventilation on the virus movement, PRD1 bacteriophages as virus simulants were disseminated in a ¾ scale air-conditioned hospital test room with twelve PM2.5 samplers at 15 L/min. Higher virus concentrations were detected above the patient' head and near the foot of the bed with the air inlet on the

ceiling above, exhaust bottom left on the wall. Based on room layout, air measurements and bioaerosol collections computational flow models were created to visualize the movement of the virus in the room airflow. The addition of air curtain at the door minimized virus concentration while having the inlet and exhaust on the ceiling decreased overall aerosol concentration. Controlled laboratory experiments were conducted in a plexiglass chamber to gain more insight into the fundamental behavior of aerosolized SARS-CoV-2 and understand its fate and transport in the ambient environment of the hospital room.

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Persing, A., Roberts, B., Lotter, J., Russman, E., Pierce, J.

Evaluation of ventilation, indoor air quality, and probability of viral infection in an outdoor dining enclosure.

Journal of Occupational and Environmental Hygiene, (2022), pp. 1-10

ABSTRACTIn 2020, many cities closed indoor dining to curb rising COVID-19 cases. While restaurants in warmer climates were able to serve outdoors year-round, restaurants in colder climates adopted various solutions to continually operate throughout the colder months, such as the use of single-party outdoor dining enclosures to allow for the continuation of outdoor dining. This study evaluates indoor air quality and the air exchange rate using carbon dioxide as a tracer gas in a dining enclosure (12.03 m3) and models the probability of COVID-19 infection within such an enclosure.The air exchange rates were determined during two trials for the following scenarios: 1) door closed, 2) door opened, and 3) door opened intermittently every 15 min for one min per opening. The probability of COVID-19 infection was evaluated for each of these scenarios for one hour, with occupancy levels of two, four, and six patrons. The Wells-Riley equation was used to predict the probability of infection inside the dining enclosure.The air exchange rates were lowest in the closed-door scenarios (0.29 to 0.59 ACH), higher in the intermittent scenarios (2.36 to 2.49 ACH), and highest in the open-door scenarios (3.61 to 33.35 ACH). As the number of subjects inside the enclosure increased, the carbon dioxide accumulation increased in the closed-door and intermittent scenarios. There was no identifiable accumulation of carbon dioxide in the open-door scenario. The probability of infection (assuming one infected person without a mask) was inversely proportional to the airflow rate, and ranged from 0.0002 to 0.84 in the open-door scenario, 0.0034 to 0.94 for the intermittent scenarios, and 0.015 to 1.0 for the closed-door scenarios.The results from this study indicate that under typical use, the indoor air quality inside dining enclosures degrades during occupancy. The probability of patrons and workers inside dining enclosures being infected with COVID-19 is high when dining or serving a party with an infected person.

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Ma, J., Qian, H., Liu, F., Sui, G., Zheng, X.

Exposure Risk to Medical Staff in a Nasopharyngeal Swab Sampling Cabin under Four Different Ventilation Strategies.

Buildings, Vol. **12** n°(3), (2022)

Medical staff working in a nasopharyngeal swab sampling cabin are exposed to a higher exposure risk of COVID-19. In this study, computational fluid dynamics (CFD) are used to evaluate the exposure risk to medical staff in a nasopharyngeal swab sampling cabin of Chinese customs under four different ventilation strategies, i.e., multiple supply fans ventilation (MSFV), multiple exhaust fans ventilation (MEFV), single exhaust fan and outer windows closed ventilation (SEFV), and single exhaust fan and outer windows opened ventilation (SEFV-W). The impact of physical partitions on exposure risk is also discussed. The results show that MSFV performed best in reducing exposure risk. No significant difference was found between MEFV and SEFV. SEFV-W performed better than SEFV with a ventilation rate of 10-50 L/(s/Person), while it performed worse with a ventilation rate of 50-90 L/(s/Person). The exposure risk to medical staff did not decrease linearly with the increase in the ventilation flow rate under the four ventilation strategies. For MSFV, the installation of

partitions is conducive to the reduction in the exposure risk. This study is expected to provide some guidance for ventilation designs in sampling cabins.

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Mallakpour, S., Azadi, E., Hussain, C. M.
Fabrication of air filters with advanced filtration performance for removal of viral aerosols and control the spread of COVID-19.
Advances in Colloid and Interface Science, Vol. **303**, (2022)

COVID-19 is caused via the SARS-CoV-2 virus, a lipid-based enveloped virus with spike-like projections. At present, the global epidemic of COVID-19 continues and waves of SARS-CoV-2, the mutant Delta and Omicron variant which are associated with enhanced transmissibility and evasion to vaccine-induced immunity have increased hospitalization and mortality, the biggest challenge we face is whether we will be able to overcome this virus? On the other side, warm seasons and heat have increased the need for proper ventilation systems to trap contaminants containing the virus. Besides, heat and sweating accelerate the growth of microorganisms. For example, medical staff that is in the front line use masks for a long time, and their facial sweat causes microbes to grow on the mask. Nowadays, efficient air filters with anti-viral and antimicrobial properties have received a lot of attention, and are used to make ventilation systems or medical masks. A wide range of materials plays an important role in the production of efficient air filters. For example, metals, metal oxides, or antimicrobial metal species that have anti-viral and antimicrobial properties, including Ag, ZnO, TiO2, CuO, and Cu played a role in this regard. Carbon nanomaterials such as carbon nanotubes, graphene, or derivatives have also shown their role well. In addition, natural materials such as biopolymers such as alginate, and herbal extracts are employed to prepare effective air filters. In this review, we summarized the utilization of diverse materials in the preparation of efficient air filters to apply in the preparation of medical masks and ventilation systems. In the first part, the employing metal and metal oxides is examined, and the second part summarizes the application of carbon materials for the fabrication of air filters. After examination of the performance of natural materials, challenges and progress visions are discussed.

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Vio, M., Gattone, A.
The importance of recirculation air filtration incontainment of SARS-CoV-2 contagion : the role of photocatalytic filters installed in the fan coils.
Vol. **343**, (2022) 52nd A iCARR International Conference

In containing the contagion of viral diseases transmitted by air, it is essential to reduce the concentration of elementary dose of airborne nuclei present in inhabited rooms, that is reduced by increasing the renewal outdoor air flow, with the same other factor. The increase in the outdoor air flow, however, finds limits due to energy consumption, the maximum generators power required, the ducts size, which are not always compatible with the spaces available, especially in the case of the renovation of existing buildings. The alternative is the filtration of the recirculated indoor air flow. The paper describes possible strategies. Good filtration can always be possible in all-air systems for cinemas, theatres or supermarkets, or in VAV systems, because the AHUs have dimensions and characteristics such as to allow the housing of any type of filter. VAV systems suffer from the defect of spreading the virus in all rooms, while primary air systems leave it confined only where there is the presence of the infected subject, but filtration is necessary through filters installed directly in the fan coil units. In particular, the paper focuses on the studies carried out in the laboratories of the University of Medicine of Padua for photocatalytic filters and shows the results. The most interesting aspect of this type of filter is that they are effective not only on the finer particles that make up the aerosol, but also on the heavier particles deposited on the surfaces of the room

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Allen, G. R., Benner, K. J., Bahnfleth, W. P.

Inactivation of Pathogens in Air Using Ultraviolet Direct Irradiation Below Exposure Limits.

Journal of Research of the National Institute of Standards and Technology, Vol. **126**, (2022)

A method is described for inactivation of pathogens, especially airborne pathogens, using ultraviolet (UV) radiation emitted directly into occupied spaces and exposing occupants to a dose below the accepted actinic exposure limit (EL). This method is referred to as direct irradiation below exposure limits, or DIBEL. It is demonstrated herein that low-intensity UV radiation below exposure limits can achieve high levels of equivalent air changes per hour (ACH(eq)) and can be an effective component of efforts to combat airborne pathogens such as the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus that causes coronavirus disease 2019 (COVID-19). An ACH(eq) of 4 h(-1) is presently achievable over a continuous 8 h period for the SARS-CoV-2 virus with UV-C light-emitting diodes (LEDs) having peak wavelength at 275 nm, and future improvements in LED technology and optics are anticipated to enable improvements up to 150 h(-)(1) in the coming decade. For example, the actinic EL is 60 J/m(2) at 254 nm, and human coronaviruses, including SARS-CoV-2, have a UV dose required for 90 % inactivation of about 5 J/m(2) at 254 nm. Irradiation by 254 nm UV-C at the EL is expected to provide 90 % inactivation of these organisms in air in about 40 min when the UV-C is delivered at a constant irradiance over 8 h, or in about 5 min if the UV-C is delivered at a constant irradiance over 1 h. Since the irradiation is continuous, the inactivation of initial contaminants accumulates to 99 % and then 99.9 %, and it also immediately begins inactivating any newly introduced (e.g., exhaled) pathogens at the same rate throughout the 8 h period. The efficacy for inactivating airborne pathogens with DIBEL may be expressed in terms of ACH(eq), which may be compared with conventional ventilation-based methods for air disinfection. DIBEL may be applied in addition to other disinfection methods, such as upper room UV germicidal irradiation, and mechanical ventilation and filtration. The ACH(eq) of the separate methods is additive, providing enhanced cumulative disinfection rates. Conventional air disinfection technologies have typical ACH(eq) values of about h(-1) to 5 h(-1) and maximum practical values of about 20 h(-1). UV-C DIBEL currently provides ACH(eq) values that are typically about 1 h(-1) to 10 h(-)(1), thus either complementing, or potentially substituting for, conventional technologies. UV-C DIBEL protocols are forecast herein to evolve to >100 ACH(eq) in a few years, potentially surpassing conventional technologies. UV-A (315 nm to 400 nm) and/or UV-C (100 nm to 280 nm) DIBEL is also efficacious at inactivating pathogens on surfaces. The relatively simple installation, low acquisition and operating costs, and unobtrusive aesthetic of DIBEL using UV LEDs contribute value in a layered, multi-agent disinfection strategy.

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Van Dyke, M., King, B., Esswein, E., Adgate, J., Dally, M., Kosnett, M.

Investigating dilution ventilation control strategies in a modern U.S. school bus in the context of the COVID-19 pandemic.

Journal of Occupational and Environmental Hygiene, (2022), pp. 1-16

ABSTRACTFresh air ventilation has been identified as a widely accepted engineering control effective at diluting air contaminants in enclosed environments. The goal of this study was to evaluate the effects of selected ventilation measures on air change rates in school buses. Air changes per hour (ACH) of outside air were measured using a well-established carbon dioxide (CO2) tracer gas decay method. Ventilation was assessed while stationary and while traversing standardized route during late autumn/winter months in Colorado. Seven CO2 sensors located at the driver's seat and at passenger seats in the front, middle, and rear of the bus yielded similar and consistent measurements. Buses exhibited little air exchange in the absence of ventilation (ACH =0.13 when stationary; ACH =1.85 when mobile). Operating the windshield defroster to introduce fresh outside air increased ACH by approximately 0.5-1 ACH during mobile and stationary phases. During the mobile phase (average speed of 23 miles per hour (mph)), the combination of the defroster and two open ceiling hatches (with a powered fan on the rear hatch) yielded an ACH of approximately 9.3 ACH. A

mobile phase ACH of 12.4 was achieved by the combination of the defroster, ceiling hatches, and six passenger windows open 2 inches in the middle area of the bus. A maximum mobile phase ACH of 22.1 was observed by using the defroster, open ceiling hatches, driver window open 4 inches, and every other passenger window open 2 inches. For reference, ACHs recommended in patient care settings where patients are being treated for airborne infectious diseases range from 6 to ≥12 ACHs. The results indicate that practical ventilation protocols on school buses can achieve air change rates thought to be capable of reducing airborne viral transmission to the bus driver and student passengers during the COVID-19 pandemic.

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Redmond, S. N., Navas, M. E.

Investigation of a cluster of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infections in a hospital administration building.

Infection Control & Hospital Epidemiology, Vol., (2022), 7 p.

Objective:
To investigate a cluster of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infections in employees working on 1 floor of a hospital administration building.
Methods:
Contact tracing was performed to identify potential exposures and all employees were tested for SARS-CoV-2. Whole-genome sequencing was performed to determine the relatedness of SARS-CoV-2 samples from infected personnel and from control cases in the healthcare system with coronavirus disease 2019 (COVID-19) during the same period. Carbon dioxide levels were measured during a workday to assess adequacy of ventilation; readings >800 parts per million (ppm) were considered an indication of suboptimal ventilation. To assess the potential for airborne transmission, DNA-barcoded aerosols were released, and real-time polymerase chain reaction was used to quantify particles recovered from air samples in multiple locations.
Results:
Between December 22, 2020, and January 8, 2021, 17 coworkers tested positive for SARS-CoV-2, including 13 symptomatic and 4 asymptomatic individuals. Of the 5 cluster SARS-CoV-2 samples sequenced, 3 were genetically related, but these employees denied higher-risk contacts with one another. None of the sequences from the cluster were genetically related to the 17 control sequences of SARS-CoV-2. Carbon dioxide levels increased during a workday but never exceeded 800 ppm. DNA-barcoded aerosol particles were dispersed from the sites of release to locations throughout the floor; 20% of air samples had >1 log10 particles.
Conclusions:
In a hospital administration building outbreak, sequencing of SARS-CoV-2 confirmed transmission among coworkers. Transmission occurred despite the absence of higher-risk exposures and in a setting with adequate ventilation based on monitoring of carbon dioxide levels.

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Arjmandi, H., Amini, R., Kashfi, M., Abikenari, M. A., Davani, A.

Minimizing the COVID-19 spread in hospitals through optimization of ventilation systems Note: This paper is part of the special topic, Flow and the Virus.

Physics of fluids (Woodbury, N.Y. : 1994), Vol. **34** n°(3), (2022)

The rapid spread of SARS-CoV-2 virus has overwhelmed hospitals with patients in need of intensive care, which is often limited in capacity and is generally reserved for patients with critical conditions. This has led to higher chances of infection being spread to non-COVID-19 patients and healthcare workers and an overall increased probability of cross contamination. The effects of design parameters on the performance of ventilation systems to control the spread of airborne particles in intensive care units are studied numerically. Four different cases are considered, and the spread of particles is studied. Two new criteria for the ventilation system—viz., dimensionless timescale and extraction timescale—are introduced and their performances are

compared. Furthermore, an optimization process is performed to understand the effects of design variables (inlet width, velocity, and temperature) on the thermal comfort conditions (predicted mean vote, percentage of people dissatisfied, and air change effectiveness) according to suggested standard values and the relations for calculating these parameters based on the design variables are proposed. Desirability functions that are comprised of all three thermal condition parameters are used to determine the range of variables that result in thermally comfortable conditions and a maximum desirability of 0.865 is obtained. The results show that a poorly designed ventilation system acts like a perfectly stirred reactor—which enormously increases the possibilities of contamination—and that when air is injected from the ceiling and extracted from behind the patient beds, the infection spread is least probable since the particles exit the room orders of magnitude faster.

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Cheng, V. C.-C., Lung, D. C., Wong, S.-C., Au, A. K.-W., Wang, Q., Chen, H.*, et al.*
Outbreak investigation of airborne transmission of Omicron (B.1.1.529) SARS-CoV-2 variant of concern in a restaurant: Implication for enhancement of indoor air dilution.
Journal of Hazardous Materials, Vol. **430**, (2022)

Airborne transmission of SARS-CoV-2 has been increasingly recognized in the outbreak of COVID-19, especially with the Omicron variant. We investigated an outbreak due to Omicron variant in a restaurant. Besides epidemiological and phylogenetic analyses, the secondary attack rates of customers of restaurant-related COVID-19 outbreak before (Outbreak R1) and after enhancement of indoor air dilution (Outbreak R2) were compared. On 27th December 2021, an index case stayed in restaurant R2 for 98 min. Except for 1 sitting in the same table, six other secondary cases sat in 3 corners at 3 different zones, which were served by different staff. The median exposure time was 34 min (range: 19-98 min). All 7 secondary cases were phylogenetically related to the index. Smoke test demonstrated that the airflow direction may explain the distribution of secondary cases. Compared with an earlier COVID-19 outbreak in another restaurant R1 (19th February 2021), which occurred prior to the mandatory enhancement of indoor air dilution, the secondary attack rate among customers in R2 was significantly lower than that in R1 (3.4%, 7/207 vs 28.9%, 22/76, $p<0.001$). Enhancement of indoor air dilution through ventilation and installation of air purifier could minimize the risk of SARS-CoV-2 transmission in the restaurants.

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Kaushik, A. K., Dhau, J. S.
Photoelectrochemical oxidation assisted air purifiers; perspective as potential tools to control indoor SARS-CoV-2 Exposure.
Applied Surface Science Advances, Vol. **9**, (2022)

Coronavirus diseases 2019 (COVID-19), a viral infection pandemic, arises due to easy human-to-human transmission of severe acute respiratory syndrome coronavirus (SARS-CoV-2). The SARS-CoV-2 causes severe respiratory disorders and other life-threatening diseases (during/post-infection) such as black mold disease, diabetes, cardiovascular, and neurological disorders/diseases. COVID-19 infection emerged challenging to control as SARS-CoV-2 transmits through respiratory droplets (> 10 μm size range), aerosols (< 5 μm), airborne, and particulate matter (PM1.0 PM2.5 and PM10.0). SARS-CoV-2 is more infective in indoor premises due to aerodynamics where droplets, aerosols, and PM1.0/2.5/10.0 float for a longer time and distance leading to a higher probability of it entering upper and lower respiratory tracts. To avoid human-to-human transmission, it is essential to trap and destroy SARS-CoV-2 from the air and provide virus-free air that will significantly reduce indoor viral exposure concerns. In this process, an efficient nano-enable photoelectrochemical oxidation (PECO, a destructive approach to neutralize bio-organism) assisted air purification is undoubtedly a good technological choice. This technical perspective explores the role of PECO-assisted Air-Purifiers (i.e., Molekule as a focus example for proof-of-concept) to trap and destroy indoor

microorganisms (bacteria and viruses including Coronaviruses), molds, and allergens, and other indoor air pollutants, such as volatile organic compounds (VOCs) and PM1.0/2.5/10.0. It is observed through various standard and non-standard tests that stimuli-responsive nanomaterials coated filter technology traps and destroys microbial particles. Due to technological advancements according to premises requirements and high-performance desired outcomes, Molekule air purifiers, Air Pro Air -Rx, Air Mini, and Air Mini+, have received Food and Drug Administration (FDA) clearance as a Class II medical device for the destruction of bacteria and viruses.

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Lau, Z., Griffiths, I. M., English, A., Kaouri, K.
Predicting the spatio-temporal infection risk in indoor spaces using an efficient airborne transmission model.
Proceedings. Mathematical, physical, and engineering sciences, Vol. **478** n°(2259), (2022)

We develop a spatially dependent generalization to the Wells-Riley model, which determines the infection risk due to airborne transmission of viruses. We assume that the infectious aerosol concentration is governed by an advection-diffusion-reaction equation with the aerosols advected by airflow, diffused due to turbulence, emitted by infected people, and removed due to ventilation, inactivation of the virus and gravitational settling. We consider one asymptomatic or presymptomatic infectious person breathing or talking, with or without a mask, and model a quasi-three-dimensional set-up that incorporates a recirculating air-conditioning flow. We derive a semi-analytic solution that enables fast simulations and compare our predictions to three real-life case studies-a courtroom, a restaurant, and a hospital ward-demonstrating good agreement. We then generate predictions for the concentration and the infection risk in a classroom, for four different ventilation settings. We quantify the significant reduction in the concentration and the infection risk as ventilation improves, and derive appropriate power laws. The model can be easily updated for different parameter values and can be used to make predictions on the expected time taken to become infected, for any location, emission rate, and ventilation level. The results have direct applicability in mitigating the spread of the COVID-19 pandemic.

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Yokogawa, S., Ishigaki, Y., Kitamura, H., Saito, A., Kawauchi, Y., Hiraide, T.
Prevention of SARS-CoV-2 airborne transmission in a workplace based on CO2 sensor network.
medRxiv, (2022)

We measured the compartmental air change per hour (ACH) using a CO2 sensor network in an office space where a cluster of COVID-19 infections attributed to aerosol transmission occurred. Generalized linear mixed models and dynamic time warping were used for a time series data analysis, and the results indicated that the ventilation conditions were poor at the time of the cluster outbreak, and that the low ACH in the room likely contributed to the outbreak. In addition, the adverse effects of inappropriate partitions and the effectiveness of ventilation improvements were investigated in detail. ACH of less than 2 /h was considered a main contributor for the formation of the COVID-19 cluster in the studied facility.Practical Implications A systematic method for measuring and evaluating indoor ventilation to prevent the spread of infectious diseases caused by aerosols is presented. Ventilation bias caused by ventilation pathways and inappropriate use of plastic sheeting can be detected by a CO2 sensor network and time series data analysis. Estimated ventilation rate will be a good index to suppress the formation of the COVID-19 cluster.

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Justo Alonso, M., Jørgensen, R. B., Mathisen, H. M.
Short term measurements of indoor air quality when using the home office in Norway.
E3S Web of Conferences Cold Climate HVAC & Energy 2021

In 2020, due to the outbreak of COVID-19 many workers have been sent home to avoid the sickness spread. As a result, rooms that otherwise had domestic use, living rooms or bedrooms, have become offices. This change has happened in many houses without improving the ventilation systems. In many cases, the rooms were overcrowded, and no attention was paid to ventilation. Thus, this study collects measurements of one to two weeks in different home offices. Measurements were taken in home offices used by one or more occupants. These home offices were designed as bedrooms and living rooms with and without separation from the kitchen. During the pandemic they are used as offices during working hours and as designed otherwise. One or more occupants shared the rooms. Natural and mechanically ventilated and older and newer home offices were studied. Winter measurements of CO2, temperature, relative humidity, particulate matter, formaldehyde and TVOC were collected via low-cost sensors. The sensors were placed on the working space in front of the user to map the exposure to pollutants. The results show an analysis of the concentration of pollutants close to the breathed air. Some users were smart, remembering the aeration, whereas others were exposed to high concentrations of CO2 and other pollutants sometimes higher than the health-based thresholds.

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Dubois, C. K., Murphy, M. J., Kramer, A. J., Quam, J. D., Fox, A. R., Oberlin, T. J.*, et al.*
Use of portable air purifiers as local exhaust ventilation during COVID-19.
Journal of Occupational and Environmental Hygiene, (2022), 1-9 p.

The purpose of this study was to determine if strategic placement of portable air purifiers would improve effectiveness of aerosol reduction in a space as compared to use as a general room air purifier. Two sizes of portable air purifiers were placed in two different positions intended to function similar to either a local exhaust ventilation hood or an air curtain to determine if strategic placement would lead to a reduction of particles in a worker's position at a desk in an office environment. Particle generators were used to introduce particulate into the air and personal aerosol monitors measured particles during each test condition. Results showed that when the medium room portable air purifiers used in this study were set to high, corresponding to 98 CFM, placed near the breathing zone of each office worker with the unit's filter cover removed, the particle concentration was reduced 35% beyond the reduction that would be expected if the same units were placed on the floor behind the occupant's workstation. Results also indicated that the larger portable air purifier tested, positioned as close as reasonable to each occupant's breathing zone with the largest capture area possible (i.e., removing the unit's filter cover), delivers the best aerosol reduction performance. The authors concluded that as a layer of protection against transmission of airborne infectious organisms for office occupants, installing a portable air purifier, sized and operated similar to the units tested in this study on the desk 12 inches from the breathing zone of the worker, has the potential to reduce airborne particulate to a greater degree than if the same units were placed outside of the breathing zone, in the general cubicle area.

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Ren, C., Zhu, H.-C., Cao, S.-J.
Ventilation Strategies for Mitigation of Infection Disease Transmission in an Indoor Environment: A Case Study in Office.
Buildings, Vol. **12** n°(2), (2022)

During the normalization phase of the COVID-19 epidemic, society has gradually reverted to using building space, especially for public buildings, e.g., offices. Prevention of airborne pollutants has emerged as a major challenge. Ventilation strategies can contribute to mitigating the spread of airborne disease in an indoor environment, including increasing supply air rate, modifying ventilation mode, etc. The larger ventilation rate can inevitably lead to high energy consumption, which may be also ineffective in reducing infection risk. As a critical factor affecting the spread of viral contaminant, the potential of ventilation modes for control of

COVID-19 should be explored. This study compared several ventilation strategies in the office, including mixing ventilation (MV), zone ventilation (ZV), stratum ventilation (SV) and displacement ventilation (DV), through analyzing ventilation performance and infection risk for the optimal one. By using ANSYS Fluent, the distributions of airflow and pollutant were simulated under various ventilation modes and infected occupants. The SV showed greater performance in mitigating infection disease spread than MV, ZV and DV, with an air distribution performance index (ADPI) of 90.5% and minimum infection risk of 13%. This work can provide a reference for development of ventilation strategies in public space oriented the prevention of COVID-19.

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