6 Indoor Air Pollution from Lithium-Ion Battery Overheating: Challenges, Health Impact, and Plant-Based Mitigation

Sameer Ahmed[1], Purnima Anand[2], Amandeep Kaur[3] & Shivani G. Varmani[4*]

[1,4]Department of Biomedical Science, Bhaskaracharya College of Applied Sciences, DU.
[2]Department of Microbiology, Bhaskaracharya College of Applied Sciences, DU.
[3]Department of Instrumentation, Bhaskaracharya College of Applied Sciences, DU.

*Corresponding Author: shivani.varmani@bcas.du.ac.in

Abstract

Indoor air pollution is an important issue due to the increased use of electronic devices such as laptops based on lithium-ion batteries. The overheating and aging of such batteries result in the formation of gaseous pollutants that may be converted into ultrafine particulate matter, hence deteriorating indoor air quality. People spend a considerable amount of time indoors and are also exposed to these devices that are source of particulate pollution. So, an exposure to such pollutants has adverse impacts on human wellness, such as respiratory, cardiovascular, and neurological health. This chapter discusses plant-based mitigation aimed at decreasing indoor particulate matter arising from lithium-ion battery. It has been found that indoor plants may decrease the level of particulate matter in air through surface deposition, electrostatic interaction, and stomata uptake. The impact of indoor plants on the discussed phenomenon depends on several factors, including their morphology and environmental conditions. Further research is required to understand the problem, its health impact and possible mitigation strategies.

Keywords: *Lithium-ion Batteries, Indoor air Pollution, Indoor Plants, Particulate Matter, Phytoremediation*.

Introduction

This chapter highlights the growing concern surrounding indoor air pollution resulting from lithium-ion battery overheating, a source that is often underestimated despite the extensive use of electronic devices in indoor environment. The findings indicate that the release of fine and ultrafine particulate matter during battery overheating can significantly affect indoor air quality (IAQ) and may pose health-related risks. Evidences suggest that plant species have the capacity to reduce particulate matter through natural mechanisms such as phytoremediation (Meister et al., 2025).

Indoor Air Pollution Concerns

Around 80-90% of people spend their time indoors, which increases their exposure to particulate matter (PM) present over there. Exposure to particulate matter has an adverse health impact, regardless of the size of PM (Tran et al., 2020).

The ultrafine particulate matters (UFPs) are highly dangerous and yet overlooked. The challenge associated with UFP is that distinct sources can release these particulates of varied chemical compositions (Dahiya et al., 2025).

Many sources emit highly toxic pollutants, but the electronic devices like laptop, remain a highly overlooked contributor to particulate air pollution (Nilsson & Ahlberg Tidblad, 2024).

Lithium-Ion Battery and its Overheating

A lithium-ion battery (LIB) is combination of solid and liquid materials that are designed to remain stable over time. These materials gradually undergo a slow and continuous degradation process known as ageing. During ageing, unwanted decomposition and chemical reactions occur within the battery components, giving rise to small amounts of gaseous by-products (Koech et al., 2024).

The introduction of LIBs in the 1990s marked a transformation in modern society. LIB is assembled by linking individual Li-ion cells. Repeated battery cells can be incorporated into a battery module, and multiple battery modules can be incorporated into a Li-ion battery pack (Shahjalal et al., 2021).

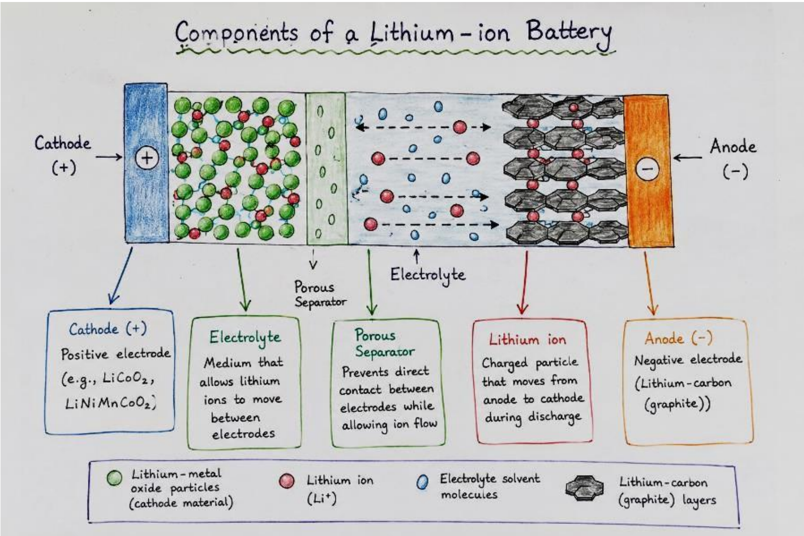

Fig. 1: Cross-Sectional Representation of a LIB

Despite their advantages, the extensive use of LIBs has led to safety concerns, mainly due to overheating and thermal runaway (Pilali et al., 2025). When LIB cells are compiled into a pack in large numbers, it increases the chances of the battery overheating (Wang et al., 2021).

Regular use of LIBs generates gas in small amounts by slow material

ISBN: 978-93-49468-43-6

degradation, which occurs during the ageing process. Solid electrolyte interphase (SEI) is responsible for the production of these gases (Wu et al., 2023).

Macro causes of overheating of LIB are mechanical, electrical (overcharge and overdischarge) and thermal abuses (Chen et al., 2025).

Lithium-Ion Battery Management System and Sensing Material for PM Detection

The most typical batteries used in laptops are lithium-ion batteries due to their high energy density and long cycle life. But they are highly sensitive to changes in temperature, overcharging and deep discharge. A Battery Management System (BMS) is a must for safe and efficient operation (Ghaeminezhad et al., 2023).

Thermal management and cell balancing are also important goals for today's lithium-ion battery management systems. Excessive heat generation can reduce the efficiency of the battery and may cause thermal runaway, which is a major safety concerns of lithium-ion batteries. Therefore, the BMS controls the charging rates, monitors the temperature of the battery and balances the individual cells in the battery pack, ensuring uniform performance and longer battery life (Xu et al., 2025).

The BMS constantly monitors voltage, current, temperature and charge status. It also estimates State of Charge and State of Health, which helps to improve battery performance, life span and safety (Yao & Kowal, 2025). Integrating nanomaterials into gas-sensing technology is changing the face of early detection systems, taking us from bulky, power-hungry equipment to seamless, wearable monitors (Pawar et al., 2024).

Now, researchers are working on Graphene Metal-Oxide hybrids to optimize performance. By merging the high electrical conductivity of graphene with the specialty chemical sensitivity of metal oxides such as SnO_2 or ZnO, the sensors can reach detection limits of parts per billion (PPB) (Meng et al., 2015; Deb et al., 2024).

Indoor UFP Emissions from Electronic Devices

During the overheating of LIBs, the degradation of SEI causes the production of certain gases (Zhang et al., 2026; Chen et al., 2023; Mama et al., 2025; Haoyang et al., 2025), which, when released from the electronic devices, enter the cold environment, leading to the formation of aerosols. These aerosols or particulate matter (PM) are generally UFP. Low-cost sensors can easily detect this diversified particulate matter (PM). These sensors are capable of measuring the amount of light scattered by these aerosols (Park et al., 2023; Giordano et al., 2021; Tryner et al., 2020).

The gases released from the breakdown of electrolyte, separator, and electrode material are: CO, CO_2, H_2, C_2H_4, CH_4, HF, and other organic radicals (Bugryniec et al., 2024).

Work-From-Home Culture and Frequent Use of Electronic Devices

After 2020, due to COVID-19, self-employed individuals working on a part-time basis were more likely to do remote working compared to salaried employees that were working on a part-time basis. Salaried workers with a graduate degree have a higher likelihood of working from home compared to salaried workers without a graduate degree (Jain, 2024). Nearly 12.7% of India's full-time workforce was working remotely by 2024, while 28.2% combine remote and on-site work in a hybrid model (Aiva Strelca, 2024).

Due to the work-from-home culture, the laptops, mobile phones and other electronic devices are used more frequently in the indoor environment. This leads to rise in ultrafine particulates and a decline in IAQ. With digital technologies now deeply embedded in daily life, the indoor use of electronic devices has increased substantially, highlighting the need to pay closer attention to emerging indoor environmental risks associated with this growing technological reliance (Polyakova et al., 2024). The addiction to social media and frequent use of laptops and mobile phones, among the young generation, is also a big concern, as this is directly affecting their brain and lungs (Pyhältö et al., 2025; Husøy & Mignon, 2025).

Particulate Matter and its Effect on Health

Particulate matter comprises suspended liquid and solid particles in the air. These are of different sizes, shapes, sources, and chemical compositions. Numerous forms of particulate matter can be dangerous. (González-Martín et al., 2021).

Particulate matter has multiple sources inside the home. The ambient PM can invade the indoor spaces. However, these particulates generally have a size distribution that is limited, as fine and UFPs are specifically removed during transmission (Cowell et al., 2023).

Classification of particulate matter is based on particle diameter, with coarse, fine, and ultrafine fractions corresponding to PM_{10}, $PM_{2.5}$, and particles less than 0.1 μm, respectively. Indoor air quality can be evaluated through PM concentration measurements. Chronic exposure to PM can lead to cardiovascular, respiratory, and neurological disorders. It leads to coughing, dizziness, fatigue, sneezing, and eye irritation. UFPs specifically hamper Heart Rate Variability (HRV) in patients that has a medical history of cardiovascular conditions (Tran et al., 2020; Nie et al., 2025; Ravi et al., 2025).

The airborne ultrafine particulate matter can penetrate and damage alveolar regions within lungs (Kumar et al., 2023). The UFP can induce DNA damage, oxidative stress, and cellular senescence. Repeated exposure to these particles can result in chronic respiratory disease (Chamseddine et al., 2025).

Table 1: The category of people more susceptible to indoor air pollution (Maung et al., 2022)

S. No.	Vulnerable group	Adverse health effects
1	Children	Developing lungs, higher breathing rates
2	Elderly	Lowered immunity and respiratory system
3	Pregnant women	Risks to fetal development
4	People with chronic diseases	Asthma, COPD, and cardiovascular illness.
5	Low-income households	Higher exposure, limited mitigation options

Particulate matter can also come from other sources, which can be grouped into natural and human-made. Natural sources include gaseous emissions, rock debris, salt, volcanic eruptions, storms, forest fires, and spray. Human activities, on the other hand, contribute through fuel burning, industrial processes like steel, cement, and glass production, emissions from power plants, mining, and coal burning. Prolonged time spent in an indoor environment with exposure to UFP can specifically damage the lower respiratory tract (Kumar et al., 2023).

Indoor UFP concentrations frequently exceed outdoor UFP concentrations. Indoor sources dominate exposure, especially in poorly ventilated spaces. Poor ventilation significantly prolongs the particle residence time (Audignon-Durand et al., 2023; Mustață et al., 2025).

Plant-Based Mitigation of Indoor Air Pollution

Although, the occurrence of PM in the air is a major concern for public health around the world, there are ways to protect human health in the indoor environment from harmful impacts of particulate matter (Dabanlis et al., 2022).

Anthropogenic activities and technologies have polluted the indoor environment. However, many effective air-cleaning plants naturally remove pollutants from the air. Therefore, one of the ways to mitigate the effects of pollution is to increase flora in the indoor spaces. The mitigation of particulate matter by plants happens due to deposition of particles on leaves, trunk surfaces, branches, and the plant's stomata. PM1 is most rapidly reduced as compared to PM2.5 and PM10 (Marval & Tronville, 2022). However, increasing diverse plant species in the indoor environment may pose challenge due to limited spaces.

Indoor plants can influence particulate matter (PM) levels directly by trapping particles on leaves and indirectly by changing indoor humidity. When humidity increases, the UFP tends to absorb moisture, become heavier, and agglomerate. The effect depends on plant species, leaf area, transpiration rate, and the number of plants in the space (Kaur et al., 2025). Due to the tiny size of PM1 and the ability to interact with biological and chemical surfaces, it settles more slowly in comparison to PM2.5 and PM10 (Kwon., 2020; Zhang et al., 2025).

As the effectiveness of particle removal differs among plant species, careful selection based on leaf morphology and surface characteristics is essential. The table 2 shows some of the indoor plants commonly used in Indian households and workspaces. In comparison with conventional mechanical air purifiers, plant-based approaches represent a more sustainable, low-cost, and energy-efficient option for improving IAQ (Han et al., 2022).

Table 2: List of some of the common indoor plants in India

S. No.	Common Names	Scientific Names	Photograph
1	Snake Plant	*Dracaena trifasciata*	

ISBN: 978-93-49468-43-6

2	Money Plant	*Epipremnum aureum*	
3	Spider Plant	*Chlorophytum comosum*	
4	Peace Lily	*Spathiphyllum wallisii*	
5	Areca Palm	*Dypsis lutescens*	
6	Aloe Vera	*Aloe vera*	

As shown in Figure 2, frequent and prolonged use of laptops can lead to heating of lithium-ion batteries, especially during continuous operation. Rise in battery temperature leads to release of small amounts of gaseous emissions. Under cooler indoor conditions, some of these emissions can condense and form aerosol particles, contributing to the presence of ultrafine PM in the environment.

These particles can be retained on the leaf surfaces of indoor plants by natural deposition processes. It will help to reduce particulate levels indoors and contributing to a better air quality. This further demonstrates that indoor plants can be a simple and environment friendly way to decrease pollution associated with the electronic devices (Pietrogrande et al., 2021).

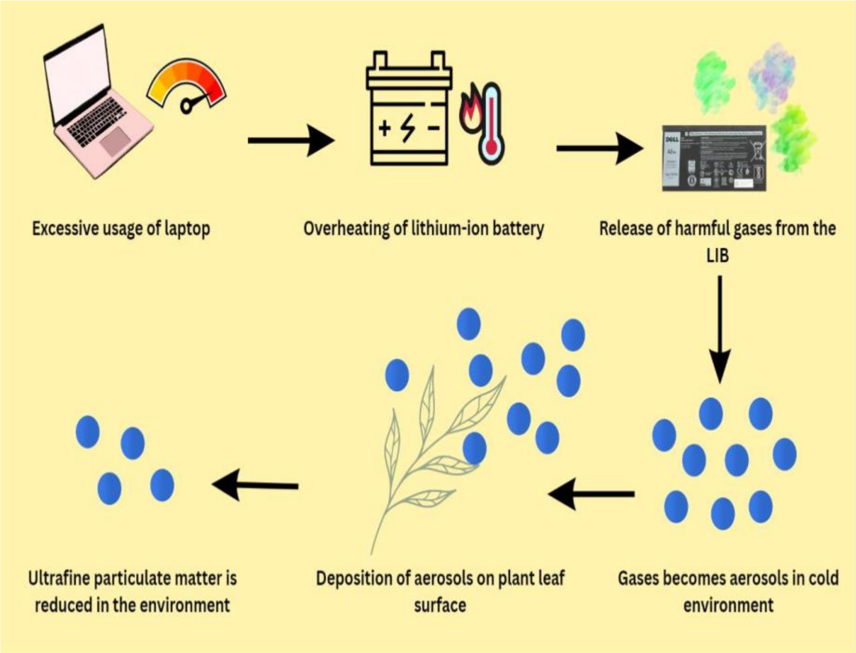

Fig. 2: Schematic representation of the mechanism of removal of particulate matter by plants (Rasheed & Jayasree, 2025)

Conclusion and Future Prospects

Lithium-ion battery overheating is emerging as a potential source of indoor air pollution. It releases fine and ultrafine particles along with some harmful gases. They significantly deteriorate IAQ and may present health-related risks. This problem is elevated in small and poorly ventilated spaces. Additionally, the factors like humidity, occupancy level and human activities etc. may amplify the issue.

One of the solutions for this problem is possible use of indoor plants for improvising IAQ through natural pollutant-removal processes. Particles that settle on the surface of leaves can reduce airborne contaminants. This natural mechanism known as phytoremediation has become an environmentally sustainable approach to mitigate indoor air pollution. Owing to their low maintenance requirements, cost-effectiveness and ecological benefits, the indoor plants serve as invaluable method in addition to conventional air-cleaning techniques.

It is highly imperative to conduct comprehensive study on this challenge as people are spending substantial time indoors and with electronic gadgets which is detrimental to human health. It is important to understand characteristics of emission generated during battery overheating and their health impact. Such research will support the development of possible mitigation measures like use of indoor air plants and further refinement of air quality guidelines for healthier indoor spaces.

References

1. Abhijith, K. V., & Kumar, Prashant. (2020). Quantifying particulate matter reduction and their deposition on the leaves of green infrastructure. Environmental Pollution. 265, 114884.
https://doi.org/10.1016/j.envpol.2020.114884
2. Aiva, S., (2024), The ultimate list of remote work statistics: 2024 edition, Forbes. https://desktime.com/blog/remote-work
3. Audignon-Durand, Sabyne, Ramalho, Olivier, Mandin, Corinne, Roudil, Audrey, Le Bihan, Olivier, Delva, Fleur, & Lacourt, Aude. (2023). Indoor exposure to ultrafine particles related to domestic activities: A systematic review and meta-analysis. Science of The Total Environment. 904, 166947.
https://doi.org/10.1016/j.scitotenv.2023.166947
4. Budaniya, Mukesh, & Rai, Aakash C. (2022). Effectiveness of plants for passive removal of particulate matter is low in the indoor environment. Building and Environment. 222, 109384.
https://doi.org/10.1016/j.buildenv.2022.109384
5. Bugryniec, Peter J., Resendiz, Erik G., Nwophoke, Solomon M., Khanna, Simran, James, Charles, & Brown, Solomon F. (2024). Review of gas emissions from lithium-ion battery thermal runaway failure—Considering toxic and flammable compounds. Journal of Energy Storage. 87, 111288.
https://doi.org/10.1016/j.est.2024.111288
6. Chamseddine, Ashraf, Elzein, I. M., & Hassan, Norr. (2025). Indoor Air Quality in Critical Indoor Environments: A Review Paper. Water, Air, & Soil Pollution. 236(13), 885.
https://doi.org/10.1007/s11270-025-08512-y
7. Chen, Haodong, Kalamaras, Evangelos, Abaza, Ahmed, Tripathy, Yashraj, Page, Jason, & Barai, Anup. (2023). Comprehensive analysis of thermal runaway and rupture of lithium-ion batteries under mechanical abuse conditions. Applied Energy. 349, 121610.
https://doi.org/10.1016/j.apenergy.2023.121610
8. Chinnam, Santosh, Seo, Seo Eun, & Boddapati, Venkateswarlu. (2024). Impact of external heating and state of charge on discharge performance and thermal runaway risk in 21700 Li-ion batteries. Case Studies in Thermal Engineering. 63, 105299. https://doi.org/10.1016/j.csite.2024.105299

ISBN: 978-93-49468-43-6

9. Cowell, Nicole, Chapman, Lee, Bloss, William, Srivastava, Deepchandra, Bartington, Suzanne, & Singh, Ajit. (2023). Particulate matter in a lockdown home: evaluation, calibration, results and health risk from an IoT enabled low-cost sensor network for residential air quality monitoring. Environmental Science: Atmospheres. 3(1), 65–84. https://doi.org/10.1039/D2EA00124A
10. Dahiya, Khushbu, Rani, Shivani, & Gupta, Ranu. (2025). Oxidative potential, morphological and chemical functional group analysis of particulate matter (PM2.5 and PM1): A case study over Delhi. Atmospheric Pollution Research. 16, 102835. https://doi.org/10.1016/j.apr.2025.102835
11. Deb, Sourav, Mondal, Anibrata, & Ashok Kumar Reddy, Y. (2024). Review on development of metal-oxide and 2-D material based gas sensors under light-activation. Current Opinion in Solid State and Materials Science. 30, 101160. https://doi.org/10.1016/j.cossms.2024.101160
12. Drosos, Georgios, Laskari, Glykeria, & Lazaridis, Dimitrios. (2022). The Effect of Students, Computers, and Air Purifiers on Classroom Air Quality. Applied Sciences. 12(23), 11911. https://doi.org/10.3390/app122311911
13. Ghaeminezhad, Nourallah, Wang, Zhisheng, & Ouyang, Quan. (2023). A Review on lithium-ion battery thermal management system techniques: A control-oriented analysis. Applied Thermal Engineering. 219, 119497. https://doi.org/10.1016/j.applthermaleng.2022.119497
14. Giordano, Michael R., Malings, Carl, Pandis, Spyros N., Presto, Albert A., McNeill, V. F., Westervelt, Daniel M., Beekmann, Matthias, & Subramanian, R. (2021). From low-cost sensors to high-quality data: A summary of challenges and best practices for effectively calibrating low-cost particulate matter mass sensors. Journal of Aerosol Science. 158, 105833. https://doi.org/10.1016/j.jaerosci.2021.105833
15. González-Martín, Javier, Kraakman, Norbertus Johannes Richardus, Pérez, Cristina, Lebrero, Raquel, & Muñoz, Raúl. (2021). A state-of-the-art review on indoor air pollution and strategies for indoor air pollution control. Chemosphere. 262, 128376. https://doi.org/10.1016/j.chemosphere.2020.128376
16. Guanjun, C., Rui, T., Chunlin, Z. (2025), Developing safe and high-performance lithium-ion batteries: Strategies and approaches, 154, 101516. https://doi.org/10.1016/j.pmatsci.2025.101516
17. Han, Yang, Lee, Jechan, Haiping, Gu, Kim, Ki-Hyun, Wanxi, Peng, Bhardwaj, Neha, Oh, Jong-Min, & Brown, Richard J. C. (2022). Plant-based remediation of air pollution: A review. Journal of Environmental Management. 301, 113860. https://doi.org/10.1016/j.jenvman.2021.113860

18. Haoyang, Li, Jian, Lu, Jianhao, Wang, & Liping, Yang. (2025). Study on extinguishing performance and suppression mechanism of thermal runaway combustible gas flame of lithium battery by NH4H2PO4 water mist. Case Studies in Thermal Engineering. 71, 106208. https://doi.org/10.1016/j.csite.2025.106208
19. Husøy, Sigrid Johanne, & Mignon, Doriane. (2025). Well-being and technology: The effect of individual laptops in high school. Economics of Education Review. 106, 102653. https://doi.org/10.1016/j.econedurev.2025.102653
20. Jain, Deepty. (2024). Impact of COVID-19 led transition of work culture and travel to work patterns on society and environment in Delhi. Urban Governance. 4(4), 388-400. https://doi.org/10.1016/j.ugj.2024.10.002
21. Kaur, Supreet, Mishra, Sumit Kumar, Goel, Vikas, Kumar, Mayank, Singh, Rishabh, Devi, Mamta, Chandra, Harish, Narayanasamy, Vijayan, Singh, S. P., Sharma, Parag, & Kumar, Prashant. (2025). Impact of indoor plant-induced relative humidity on PM concentration in indoor urban environment. Atmospheric Pollution Research. 16(6), 102468. https://doi.org/10.1016/j.apr.2025.102468
22. Kibet, Alex, Mwangi, Gershom, Mugo, Francis, & Muthoni, Phenny. (2024). Lithium-ion battery fundamentals and exploration of cathode materials: A review. Materials Today: Proceedings. 50, 321–339. https://doi.org/10.1016/j.sajce.2024.09.008
23. Knutsson, Elna J., N., & Ahlberg, Annika. (2024). Gas Emissions from Lithium-Ion Batteries: A Review of Experimental Results and Methodologies. Batteries. 10(12), 443. https://doi.org/10.3390/batteries10120443
24. Kumar, Pradeep, Singh, A. B., Arora, Taruna, Singh, Sevaram, & Singh, Rajeev. (2023). Critical review on emerging health effects associated with the indoor air quality and its sustainable management. Science of The Total Environment. 872, 162163. http://dx.doi.org/10.1016/j.scitotenv.2023.162163
25. Kumar, Raghawendra, Verma, Vipasha, Thakur, Meenakshi, Singh, Gurpreet, & Bhargava, Bhavya. (2023). A systematic review on mitigation of common indoor air pollutants using plant-based methods: a phytoremediation approach. Air Quality, Atmosphere & Health. 16(8), 1501–1527. https://doi.org/10.1007/s11869-023-01326-z
26. Kwon, Kei-Jung, Urrintuya, Odsuren, Kim, Sang-Yong, Yang, Jong-Cheol, Sung, Jung-Won, & Park, Bong-Ju. (2020). Removal Potential of Particulate Matter of 12 Woody Plant Species for Landscape Planting. Journal of People, Plants, and Environment. 23(6), 647–654. https://doi.org/10.11628/ksppe.2020.23.6.647

27. Mama, Magui, Solai, Elie, Capurso, Tommaso, Danlos, Amelie, & Khelladi, Sofiane. (2025). Comprehensive review of multi-scale Lithium-ion batteries modeling: From electro-chemical dynamics up to heat transfer in battery thermal management system. Energy Conversion and Management. 325, 119223. https://doi.org/10.1016/j.enconman.2024.119223
28. Maung, Tun Z., Bishop, Jack E., Holt, Eleanor, Turner, Alice M., & Pfrang, Christian. (2022). Indoor Air Pollution and the Health of Vulnerable Groups: A Systematic Review Focused on Particulate Matter (PM), Volatile Organic Compounds (VOCs) and Their Effects on Children and People with Pre-Existing Lung Disease. International Journal of Environmental Research and Public Health. 19(14), 8752. https://doi.org/10.3390/ijerph19148752
29. Meister, Maureen, Sharma, Shaligram, He, Xiaojia, Chepaitis, Patrick S., Waddey, Taryn, Wilson, Mark, Premnath, Vinay, Jeevarajan, Judith, Black, Marilyn, & Wright, Christa. (2025). Evaluating inhalation risks and toxicological impacts of lithium-ion battery thermal runaway emissions. Environment International. 199, 109466. https://doi.org/10.1016/j.envint.2025.109466
30. Meng, Fan-Li, Guo, Zheng, & Huang, Xing-Jiu. (2015). Graphene-based hybrids for chemiresistive gas sensors. TrAC Trends in Analytical Chemistry. 68, 37. http://dx.doi.org/10.1016/j.trac.2015.02.008
31. Morawska, Jesus M., & Turró, Paolo. (2022). Ultrafine particles: A review about their health effects, presence, generation, and measurement in indoor environments. Building and Environment. 216, 108992. https://doi.org/10.1016/j.buildenv.2022.108992
32. Mustață, Dan-Marius, Bisorca, Daniel, Ionel, Ioana, Adjal, Ahmed, & Balogh, Ramon-Mihai. (2025). Real-Time Insights into Indoor Air Quality in University Environments: PM and CO2 Monitoring. Atmosphere. 16(8), 972. https://doi.org/10.3390/atmos16080972
33. Nie, Tong, Zhang, Guofu, Sun, Yinan, Wang, Wenhao, Wang, Tianai, & Duan, Haoyan. (2025). Effects of Indoor Air Quality on Human Physiological Impact: A Review. Buildings. 15(8), 1296. https://doi.org/10.3390/buildings15081296
34. Ossola, Roberto, Elser, Maja, Houle, Danielle, George, Christian, & Donaldson, D. James. (2024). Development of a sampling protocol for collecting leaf surface material for multiphase chemistry studies. Environmental Science: Processes & Impacts. 26(6), 1008–1021. https://doi.org/10.1039/D4EM00065J
35. Park, Seongjun, Lee, Shinhye, Yeo, Myoungsouk, & Rim, Donghyun. (2023). Field and laboratory evaluation of PurpleAir low-cost aerosol sensors in monitoring indoor airborne particles. Building and Environment. 234, 110127. https://doi.org/10.1016/j.buildenv.2023.110127

36. Parhizi, Ebrahim, Sadrameli, Madjid, Hosseini, Mohammad, & Shabani, Safiye. (2025). Passive thermal management systems with phase change material-based methods for lithium-ion batteries: A state-of-the-art review. Journal of Power Sources. 632, 236345. https://doi.org/10.1016/j.jpowsour.2025.236345
37. Pawar, Krishna Kiran, Kumar, Ashok, Mirzaei, Ali, Kumar, Mahesh, Kim, Hyoun Woo, & Kim, Sang Sub. (2024). 2D nanomaterials for realization of flexible and wearable gas sensors: A review. Chemosphere. 352, 141234. https://doi.org/10.1016/j.chemosphere.2024.141234
38. Pietrogrande, Maria Chiara, Bacco, Dimitri, Trentini, Arianna, & Russo, Mara. (2021). Effect of filter extraction solvents on the measurement of the oxidative potential of airborne PM2.5. Environmental Science and Pollution Research. 28(23), 29551–29561. https://doi.org/10.1007/s11356-021-12604-7
39. Polyakova, V., Streltsova, E., Iudin, I., & Kuzina, L. (2024). Irreversible effects? How the digitalization of daily practices has changed after the COVID-19 pandemic. Technology in Society. 76, 102447. https://doi.org/10.1016/j.techsoc.2023.102447
40. Pyhältö, Kirsi, Rekola, Hanna, Salovuori, Salli, Kosola, Silja, & Anttila, Henrika. (2025). The relationship between academic achievement and off-task social media and smartphone usage: Evidence from a systematic literature review. Acta Psychologica. 260, 105645. https://doi.org/10.1016/j.actpsy.2025.105645
41. Rasheed, Hind, & Jayasree, T. K. (2025). The multifaceted role of indoor plants: A comprehensive review of their impact on air quality, health, and perception. Energy and Buildings. 330, 115312. https://doi.org/10.1016/j.enbuild.2025.115312
42. Ravi, Ramya Kundayi, Javeth, Athar, Edwin, Vimala, Muthu, Priyalatha, & Priya, Sivan Padma. (2025). Individual and Household Practices for Mitigating and Preventing Indoor Air Pollution Among Health Professional Students: A Self-Report Study. The Open Environmental Research Journal. 18(1), e18742130376608. http://dx.doi.org/10.2174/0118742130376608250508080038
43. Santunione, Giulia, Barbieri, Alice, & Sgarbi, Elisabetta. (2024). Analysis of particulate matter (PM) trapped by four different plant species in an urban forest: Quantification and characterization. Trees, Forests and People. 16, 100585. https://doi.org/10.1016/j.tfp.2024.100585
44. Shahriar, Mohammad, Sultana, Tamanna, Islam, Md. Emtiajul, Ahmed, Wasif, & Mahmud, Mrinmoy. (2021). A review of thermal management for Li-ion batteries: Prospects, challenges, and issues. Journal of Energy Storage. 39, 102518. https://doi.org/10.1016/j.est.2021.102518

45. Tryner, Jessica, Mehaffy, John, Miller-Lionberg, Daniel, & Volckens, John. (2020). Effects of aerosol type and simulated aging on performance of low-cost PM sensors. Journal of Aerosol Science. 150, 105654. https://doi.org/10.1016/j.jaerosci.2020.105654

46. Van, T. V., Park, D., & Lee, Y.-C. (2020). Indoor Air Pollution, Related Human Diseases, and Recent Trends in the Control and Improvement of Indoor Air Quality. International Journal of Environmental Research and Public Health. 17(8), 2927. https://doi.org/10.3390/ijerph17082927

47. Wang, Guo-Lin, Chan, Kok Keong, & Lee, Wen-Jen. (2023). Understanding the lithium-ion battery's aging mechanisms of mesophase graphite negative electrodes with/without amorphous titanium (IV) oxide nanocoating by atomic layer deposition. Journal of Energy Storage. 73, 108951. https://doi.org/10.1016/j.est.2023.108951

48. Wang, Zhenpo, Yang, Jing, Zhang, Xiaoqing, & Wang, Hsin. (2021). Overcharge-to-thermal-runaway behaviour and safety assessment of commercial lithium-ion cells with different cathode materials: A comparison study. Journal of Power Sources. 55, 484–498. https://doi.org/10.1016/j.jechem.2020.07.028

49. Xu, Yiming, Ge, Xiaohua, Guo, Ruohan, & Shen, Weixiang. (2025). Recent Advances in Model-Based Fault Diagnosis for Lithium-Ion Batteries: A Comprehensive Review. Renewable and Sustainable Energy Reviews. 207, 114922. https://doi.org/10.1016/j.rser.2024.114922

50. Han, Yang, Lee, Jechan, Gu, Haiping, Kim, Ki-Hyun, Peng, Wanxi, Bhardwaj, Neha, Oh, Jong-Min, & Brown, Richard J. C. (2022). Plant-based remediation of air pollution: A review. Journal of Environmental Management, 301, 113860. https://doi.org/10.1016/j.jenvman.2021.113860

51. Yao, Jiaqi, & Kowal, Julia. (2025). Towards a smarter battery management system: A critical review on deep learning-based state of charge estimation of lithium-ion batteries. Energy and AI. 21, 100585. https://doi.org/10.1016/j.egyai.2025.100585

52. Zhang, Ling, Ou, Changjin, Magana-Arachchi, Dhammika, Vithanage, Meththika, Vanka, Kanth Swaroop, Palanisami, Thava, Masakorala, Kanaji, Wijesekara, Hasintha, Yan, Yubo, Bolan, Nanthi, & Kirkham, M. B. (2021). Indoor Particulate Matter in Urban Households: Sources, Pathways, Characteristics, Health Effects, and Exposure Mitigation. International Journal of Environmental Research and Public Health. 18(21), 11055. https://doi.org/10.3390/ijerph182111055

53. Zhang, Pingping, Li, Wenchao, Wang, Jiehua, Jiao, Zhiqiang, Wang, Penglong, Bai, Xiuling, Fan, Jinyue, Zhang, Songwei, Zhao, Bing, & Ren, Xiubo. (2025). Unveiling environmental dynamics of dissolved and particulate organic matter in high-sediment waters. Environmental Technology & Innovation. 40, 104537. https://doi.org/10.1016/j.eti.2025.104537

54. Zhang, Ying, Mo, Taohua, Wu, Xingyue, Yu, Hang, & Mao, Binbin. (2026). Comparative study of gas generation during thermal runaway in high-capacity sodium-ion batteries and lithium iron phosphate battery for energy storage applications. Journal of Power Sources. 662, 238780. https://doi.org/10.1016/j.jpowsour.2025.238780.

☯☯☯