2025 White Paper

Advancing Indoor Air Quality with NanoJet Technology

INNOVA NANOJET
TECHNOLOGIES LIMITED

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Executive Summary

This white paper aims to address the severe challenges of indoor air pollution in South America and its critical impact on public health. The region faces worsening air quality due to rapid urbanization, industrial activities, and widespread use of biomass fuels, leading to alarming rates of respiratory and cardiovascular diseases. Poor indoor air quality (IAQ) disproportionately affects vulnerable populations, such as children, the elderly, and those with pre-existing health conditions, contributing to millions of premature deaths annually. This white paper discusses the air quality issues through exploring:

- **The Public Health Crisis**: Examining the severe health impacts of PM2.5, PM10, bioaerosols, and airborne allergens, which significantly increase respiratory illnesses, heart disease, and mortality rates.
- **Regional Air Quality Challenges**: Highlighting the sources and extent of air pollution in South American urban and rural settings, including vehicular emissions, industrial discharges, and indoor biomass burning.
- **Limitations of Current Solutions**: Discussing the inefficiencies and shortcomings of conventional air purifiers in addressing South America's air quality issues.

This white paper further presents Innova NanoJet's proprietary CDa product as an innovative solution for mitigating indoor air pollutants effectively and sustainably. Key findings presented in this paper about CDa includes:

- CDa provides rapid action with prolonged protection.
- Higher removal efficiency and faster results than traditional methods.
- Reduced maintenance costs due to advanced design.
- Third-party lab testing demonstrates effectiveness against viruses and allergens.

Chapter 01 I **Introduction**

The Importance of Air Quality

Air quality is a critical environmental and public health issue that affects populations worldwide. In South America, the challenge of maintaining clean air is shaped by a complex interplay of natural and anthropogenic factors. Rapid urbanization, industrial activities, vehicular emissions, and deforestation contribute significantly to air pollution. This is compounded by natural phenomena such as wildfires, volcanic eruptions, and seasonal pollen dispersal, creating a multifaceted air quality problem.

Air pollution, both indoor and outdoor, encompasses a wide range of harmful pollutants that have far-reaching impacts on health and ecosystems. Key pollutants include:

- Particulate Matter (PM2.5 and PM10):

These particles originate from sources such as vehicle emissions, industrial discharges, construction activities, and biomass burning.

Due to their small size, they can penetrate deep into the lungs and enter the bloodstream, causing respiratory and cardiovascular diseases [1].

- Bio-aerosols (Viruses and Bacteria):

Airborne bio-aerosols, including viruses, bacteria, and fungal spores, significantly influence indoor air quality.

These microbial contaminants are associated with infections, allergic reactions, and other respiratory conditions, especially in poorly ventilated environments [2].

- Airborne Allergens (Pollen):

Pollen from plants contributes to seasonal allergies and exacerbates conditions like asthma and hay fever. Climate change and urbanization are intensifying pollen dispersal and allergenic potential, worsening air quality in many regions [3].

Indoor air quality (IAQ) remains a pressing issue in South America, particularly in rural and underserved communities. Millions of households rely on traditional biomass fuels for cooking and heating, leading to the release of pollutants like fine particulate matter, carbon monoxide (CO), and volatile organic compounds (VOCs). Given that individuals spend approximately 90% of their time indoors, the health implications of poor IAQ are

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[1] World Health Organization (2022). Global Air Quality Guidelines. Geneva: WHO. https://iris.who.int/bitstream/handle/10665/345329/9789240034228-eng.pdf.

[2] Lee, T., and Jo, W. K. (2006). Characteristics of indoor and outdoor bio-aerosols at Korean high-rise apartment buildings. Environmental Research, 101(1), pp. 11-17.

[3] Beggs, P. J., Clot, B., , M., & Johnston, F. H. (2023). Climate change, airborne allergens, and three translational mitigation approaches. EBioMedicine, 93, 104478. https://doi.org/10.1016/j.ebiom.2023.104478.

profound. Vulnerable groups, including children, pregnant women, the elderly, and those with pre-existing respiratory conditions, are disproportionately affected.

The impacts of poor air quality extend beyond human health. Ecosystem degradation, reduced agricultural yields, and climate change are direct consequences of unaddressed pollution. In the Amazon, for instance, forest fires contribute to regional air pollution while accelerating deforestation and biodiversity loss. Urban centers like São Paulo, Santiago, and Bogotá face growing challenges from vehicular and industrial emissions, while rural areas grapple with biomass burning and insufficient access to clean energy solutions.

This white paper provides an in-depth analysis of indoor and outdoor air quality conditions in South America. It explores the key pollutants and their health and environmental impacts, evaluates current mitigation measures, and offers recommendations for improving air quality management. This paper aims to contribute to sustainable and equitable solutions for air quality improvement in South America.

Chapter 02 I **The Hidden Dangers of Poor Indoor Air Quality**

Indoor air quality (IAQ) significantly impacts human health contributing to various adverse health outcomes. Understanding the dangers and sources of these pollutants is crucial for effective mitigation.

Key findings

- Fine particulate matter (PM2.5) and other indoor air pollutants are strongly associated with respiratory and cardiovascular diseases.
- Indoor air pollution is responsible for over 3.2 million premature deaths annually.
- On average, people spend 90% of their time indoors, where pollutant levels can be up to 100 times higher than outdoor concentrations.

Health Impacts of Indoor Air Pollutants

- Particulate Matter (PM): Fine particles, especially PM2.5, can penetrate deep into the lungs and bloodstream, leading to respiratory and cardiovascular diseases. The World Health Organization (WHO) reports that indoor air pollution, primarily from particulate matter, leads to approximately **3.2 million premature deaths** annually. 32% are from ischaemic heart disease, 23% are from stroke, 21% are due to lower respiratory infection, 19% are from chronic obstructive pulmonary disease (COPD), and 6% are from lung cancer. Household air pollution accounted for the **loss of an estimated 86 million healthy life years** in 2019, with the largest burden falling on women living in low- and middle-income countries [4].
- Bioaerosols: These include bacteria, viruses, fungal spores, and pollen. Exposure to bioaerosols can lead to infectious diseases, allergic reactions, and respiratory disorders. Damp indoor environments promote the growth of mold, which releases spores into the air, exacerbating asthma and causing allergic responses [5]. The COVID-19 pandemic highlighted the significance of airborne transmission of viruses. There have been reported **7,079,129** [6] (updated 30 December 2024)

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[4] Household air pollution – World Health Organization (WHO). https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health?utm_source=chatgpt.com

[5] Bernstein, J. A., Alexis, N., Bacchus, H., Bernstein, I. L., Fritz, P., Horner, E., Li, N., Mason, S., Nel, A., Oullette, J., Reijula, K., Reponen, T., Seltzer, J., Smith, A., & Tarlo, S. M. (2008). The health effects of non-industrial indoor air pollution. The Journal of allergy and clinical immunology, 121(3), 585–591. https://doi.org/10.1016/j.jaci.2007.10.045

[6] Mathieu, Edouard; Ritchie, Hannah; Rodés-Guirao, Lucas; Appel, Cameron; Giattino, Charlie; Hasell, Joe; Macdonald, Bobbie; Dattani, Saloni; Beltekian, Diana; Ortiz-Ospina, Esteban; Roser, Max (2020–2024). "Coronavirus Pandemic (COVID-19)". Our World in Data. Retrieved 30 December 2024.

confirmed COVID-induced deaths worldwide. emphasizing the need for proper indoor air quality management globally [7].

- Airborne Allergens: Common indoor allergens include dust mites, pet dander, and cockroach droppings. Exposure to these allergens can trigger allergic reactions and asthma attacks, particularly in sensitized individuals. The EPA notes that biological contaminants are often found in areas that provide food and moisture, such as humidifiers, bedding, and carpeting [8].

Indoor pollutant levels can often exceed outdoor levels, especially in poorly ventilated spaces. The EPA reports that indoor levels of pollutants may be 2 to 5 times, and occasionally more than 100 times, higher than outdoor levels [9]. These levels of indoor air pollutants are of particular concern, because most people spend about 90 percent of their time indoors [10].

Indoor air pollution is closely tied to everyday human activities. Particulate matter primarily arises from combustion processes, such as cooking with solid fuels or using fireplaces and candles. Smoking indoors also contributes significantly to PM levels. Nitrogen oxides are emitted from unvented appliances like gas stoves and heaters, exacerbated by insufficient ventilation. Ozone, often a byproduct of outdoor air infiltration, is also generated by certain air purifiers and electronic devices. Bioaerosols, including viruses and bacteria, thrive in damp conditions and are spread through HVAC systems, poorly maintained ventilation, and overcrowded living spaces. Airborne allergens, such as dust mites and pet dander, proliferate in soft furnishings, carpets, and humid environments. Together, these sources demonstrate how common household activities and inadequate indoor air management significantly contribute to health risks.

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[7] Rosário Filho, N. A., Urrutia-Pereira, M., D'Amato, G., Cecchi, L., Ansotegui, I. J., Galán, C., Pomés, A., Murrieta-Aguttes, M., Caraballo, L., Rouadi, P., Chong-Neto, H. J., & Peden, D. B. (2021). Air pollution and indoor settings. The World Allergy Organization journal, 14(1), 100499. https://doi.org/10.1016/j.waojou.2020.100499

[8] Indoor Air Pollution: An Introduction for Health Professionals. https://www.epa.gov/indoor-air-quality-iaq/indoor-air-pollution-introduction-health-professionals?utm_source=chatgpt.com

[9] Wallace, Lance A., et al. Total Exposure Assessment Methodology (TEAM) Study: Personal exposures, indoor-outdoor relationships, and breath levels of volatile organic compounds in New Jersey. Environ. Int. 1986, 12, 369-387. https://www.sciencedirect.com/science/article/pii/0160412086900516

[10] Why Indoor Air Quality is Important to Schools. https://www.epa.gov/iaq-schools/why-indoor-air-quality-important-schools#:~:text=EPA%20studies%20of%20human%20exposure,times%20%E2%80%94%20higher%20than%20outdoor%20levels.&text=These%20levels%20of%20indoor%20air,percent%20of%20their%20time%20indoors.

Chapter 03 I **Indoor Air Quality in *South America***

Indoor air quality (IAQ) in South American cities is a pressing public health issue, with pollutants such as particulate matter (PM), nitrogen oxides (NOx), ozone (O_3), bioaerosols (including viruses and bacteria), and airborne allergens adversely affecting urban populations.

Key findings

- PM2.5 exposure across 337 cities in South America has been linked to higher mortality rates, underscoring the severe long term health risks of particulate matter pollution within the region.
- Health impacts include higher emergency department visits for asthma and COPD. In Lima, a 3.7% increase in ED visits was reported for every 6.02 µg/m^3 rise in PM2.5.
- Urbanisation, vehicle emissions and biomass fuel use within households significantly elevate PM levels beyond those recommended by WHO guidelines.

PMs

In South America, urban centre experience significant PM pollution. For instance, Santa Gertrudes in Brazil recorded PM10 levels averaging 95 µg/m^3 in 2018, making it one of the most polluted cities in South America [11]. Similarly, Lima, Peru, has reported PM2.5 concentrations exceeding the World Health Organization's (WHO) recommended limits, contributing to respiratory and cardiovascular diseases among its population [12]. In Bogotá, Colombia, studies have shown that PM2.5 levels frequently surpass WHO guidelines, leading to increased hospital admissions for respiratory issues [13].

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[11] Most air polluted cities in South America 2018. https://www.statista.com/statistics/913881/south-america-air-pollution-level/

[12] Tapia, V., Steenland, K., Vu, B., Liu, Y., Vásquez, V., & Gonzales, G. F. (2020). PM2.5 exposure on daily cardio-respiratory mortality in Lima, Peru, from 2010 to 2016. Environmental health : a global access science source, 19(1), 63. https://doi.org/10.1186/s12940-020-00618-6

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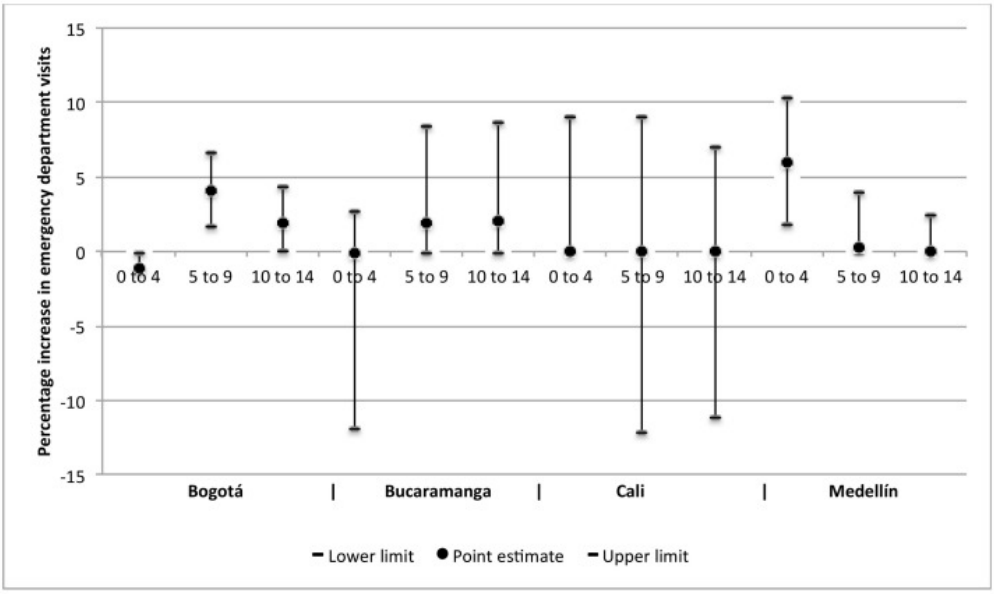

Figure 1 Percentage increases in emergency department visits by children for respiratory diseases associated with PM2.5 concentrations, per age group, in the four cities in Colombia, 2011–2014. Point estimates and 95% confidence intervals for age groups of children in years [13].

A study from Drexel University Urban Health Collaborative (2024) found that **PM2.5 exposure across 337 cities** in Latin America is associated with increased death rates in Latin American cities [14]. In Bogotá, Colombia, **PMs exposure led to a rise in emergency visits** for asthma and chronic obstructive pulmonary disease (COPD) [13]. In Lima, Peru, researchers reported a **3.7% increase in Emergency Department (ED) visits** for every interquartile range (IQR, 6.02 µg/m3) increase in PM2.5. For the **0–18 years age group**, a **4.5% increase** was observed in ED visits for every IQR increase in PM2.5 exposure. For the **19–64 years age group**, a **6.0% increase** was observed in ED visits for every IQR increase in PM2.5 exposure. For the **65 years and up age group**, a **16.0% increase** was observed in ED visits for every IQR increase in PM2.5 exposure [15].

The significant indoor PM pollutions can be caused by various factors. On one hand, the worsens outdoor air infiltrates indoor environment. Urbanization and industrial activities contribute significantly to the high PM levels. For instance, in São Paulo, Brazil, vehicular emissions are a major source of PM2.5, with studies indicating that traffic contributes to approximately 60% of PM2.5 concentrations [16]. On the other hand, indoor activities like using biomass fuels for cooking and heating in households leads to elevated indoor PM

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[14] New Study Connects Air Pollution to Increased Death Rates in Latin American Cities. https://drexel.edu/uhc/about/News/2024/March/New%20Study%20Connects%20Air%20Pollution%20to%20Increased%20Death%20Rates%20in%20Latin%20American%20Cities/#:~:text=A%20newly%20published%20study%20from,nine%20countries%20in%20Latin%20America.

[15] Vu, B. N., Tapia, V., Ebelt, S., Gonzales, G. F., Liu, Y., & Steenland, K. (2021). The association between asthma emergency department visits and satellite-derived PM2.5 in Lima, Peru. Environmental research, 199, 111226. https://doi.org/10.1016/j.envres.2021.111226

[16] Miranda, R. M. de, Andrade, M. de F., Ribeiro, F. N. D., Francisco, K. J. M., & Martínez, P. J. P. (2018). Source apportionment of fine particulate matter by positive matrix factorization in the metropolitan area of São Paulo, Brazil. Journal of Cleaner Production, No 2018, 253-263. doi:10.1016/j.jclepro.2018.08.100

levels. In South America, a substantial portion of the population relies on solid fuels [17], this could result in indoor PM concentrations to be 10–50 times higher than WHO guideline values [18].

Countries such as Chile have established air quality monitoring networks and enacted legislation to control air pollution [19]. However, challenges persist due to limited coverage of monitoring stations, especially in smaller cities and rural areas. In Honduras, the social enterprise Mirador has installed nearly 200,000 improved biomass cookstoves, leading to significant reductions in indoor PM levels [20]. However, adoption rates of cleaner technologies can be low due to cultural preferences, lack of awareness, and financial constraints. Sustaining these programs requires continuous funding and community engagement.

Bioaerosols

The COVID-19 pandemic has underscored the significance of bioaerosols in indoor environments. As of July 2024, South America has reported over **1.3 million deaths due to COVID-19**, with **Brazil** accounting for approximately **700,000 fatalities** [21]. In Lima, Peru, There were 128,700 cases and 2382 deaths due to COVID-19. The case fatality rate was 1.93%. Previous exposure to PM2.5 (2010-2016) was associated with the number of COVID-19- cases and deaths, highlighting the interplay between pandemics and air quality. Reduction in air pollution from a long-term perspective are needed to prevent the spread of virus outbreaks [22].

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[17] Troncoso, K., & Soares da Silva, A. (2017). LPG fuel subsidies in Latin America and the use of solid fuels to cook. Energy Policy, 107. https://doi.org/10.1016/j.enpol.2017.04.046

[18] Pope, D., Bruce, N., Dherani, M., Jagoe, K., & Rehfuess, E. (2017). Real-life effectiveness of 'improved' stoves and clean fuels in reducing PM2.5 and CO: Systematic review and meta-analysis. In Environment International (Vol. 101). https://doi.org/10.1016/j.envint.2017.01.012

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[20] New Report Analyzes Impacts of Air Pollution on Public Health in Latin America from 2020 to 2030. https://www.climatelinks.org/blog/new-report-analyzes-impacts-air-pollution-public-health-latin-america-2020-2030

[21] COVID-19 deaths in Latin America & Caribbean 2024, by country. https://www.statista.com/statistics/1103965/latin-america-caribbean-coronavirus-deaths/

[22] Vasquez-Apestegui, B. V., Parras-Garrido, E., Tapia, V., Paz-Aparicio, V. M., Rojas, J. P., Sanchez-Ccoyllo, O. R., & Gonzales, G. F. (2021). Association between air pollution in Lima and the high incidence of COVID-19: findings from a post hoc analysis. BMC public health, 21(1), 1161. https://doi.org/10.1186/s12889-021-11232-7

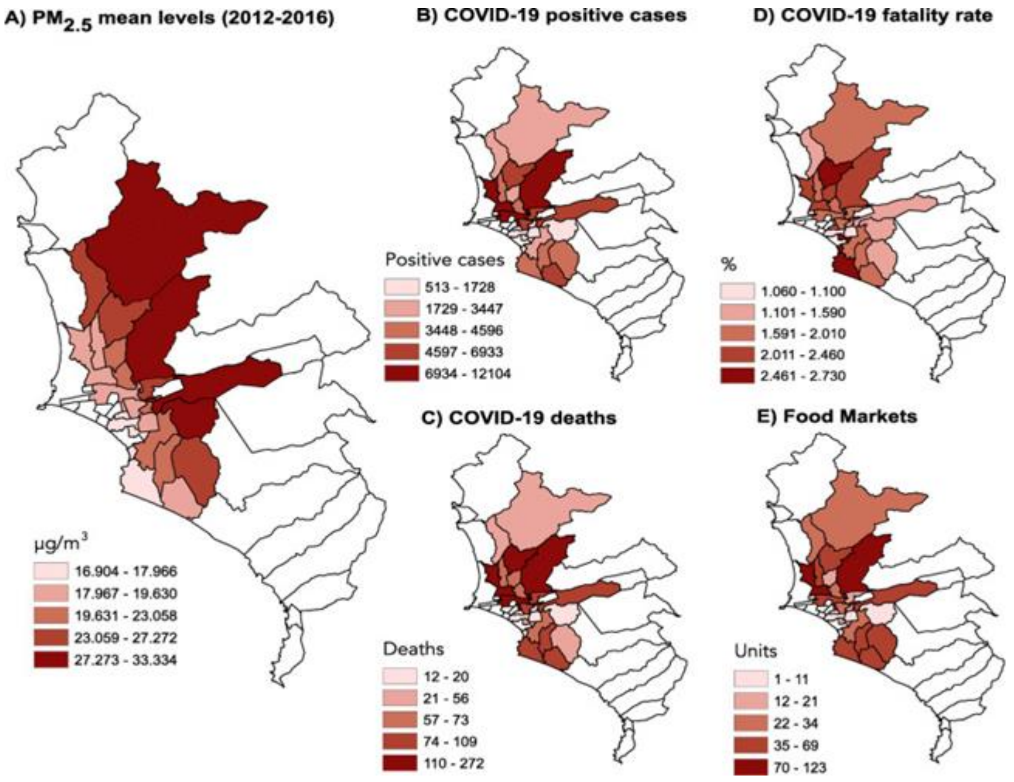

*Figure 2 Distribution of air pollution and COVID-19 cases in Lima. A Particulate matter ≤2.5 μm (PM2.5), B incidence of COVID-19 cases, C incidence of COVID-19 deaths, D COVID-19 fatality rate (Deaths/Cases*100), and E abundance of food markets. Environmental data are expressed as µm/m3 and refer to the mean values for 2012–2016. The distribution data for COVID-19 were obtained from the Ministry of Health of Peru (COVID-19 data updated until June 12, 2020)* [22].

Poor ventilation and high occupancy rates in indoor environments can lead to increased concentrations of bioaerosols, facilitating the spread of infectious diseases. To mitigate this, measures such as improved ventilation, air filtration, and ultraviolet (UV) air purification systems have been employed in indoor environments. However, implementing advanced air purification technologies can be cost-prohibitive, particularly in resource-limited settings. Moreover, conventional air purifiers, including those with High-Efficiency Particulate Air (HEPA) filters, may struggle to effectively capture ultrafine particles (0.1–1.0 µm), which include viruses and some bacteria [23]. This limitation reduces their efficacy in mitigating bioaerosols responsible for pandemics.

Airborne Allergens

Pollens with other allergens has posted challenges to many cities in South America, leading to increased cases of hay fever and allergic rhinitis. A study reported that In Mexico City, the prevalence of allergic rhinitis is about 19.6% in the open population; meanwhile, in the pediatric population, it is ranging from 11.3% to 15% [24]. Another study

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[23] Filtration and Indoor Air Quality: Benefits and Limitations. https://gpsair.com/blogs/filtration-and-indoor-air-quality-benefits-and-limitations

[24] Cid del Prado, M., Zarco-Cid del Prado, O., Guerrero-Parra, H. A., & Juárez Contreras, K. E. (2023). Airborne Pollen Calendar of Toluca City, Mexico. Aerobiology, 1(1), 54-69. https://doi.org/10.3390/aerobiology1010005

found that Airborne allergic diseases were prevalent amongst 12.0% of the adolescents, with house dust mites as the primary allergen (11.2%) [25].

The main sources of airborne allergens are pollens, mold spores, and dust mites. Most pollens are released from Urban vegetation, particularly trees and grasses. In Medellín, Colombia, studies have identified pollen from Fraxinus chinensis and Cecropia species as predominant, contributing to allergic reactions among residents [26]. For mold spores, high humidity levels in tropical and subtropical climates promote its growth. In urban areas, inadequate ventilation and building maintenance can lead to increased indoor mold spore concentrations, contributing to respiratory allergies. And for dust mites, they thrive in warm, humid conditions prevalent in many South American cities. They are common in household dust and are a significant source of indoor allergens, leading to conditions such as allergic rhinitis and asthma [27].

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[25] Morillo-Argudo, D. A., Andrade Tenesaca, D. S., Rodas-Espinoza, C. R., Perkin, M. R., Gebreegziabher, T. L., Zuñiga, G. A., Andrade Muñoz, D. D., Ramírez, P. L., García García, A. A., & Ochoa-Avilés, A. M. (2020). Food allergy, airborne allergies, and allergic sensitisation among adolescents living in two disparate socioeconomic regions in Ecuador: A cross-sectional study. The World Allergy Organization journal, 13(11), 100478. https://doi.org/10.1016/j.waojou.2020.100478

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Chapter 04 I **Limitations of Conventional Air Purification**

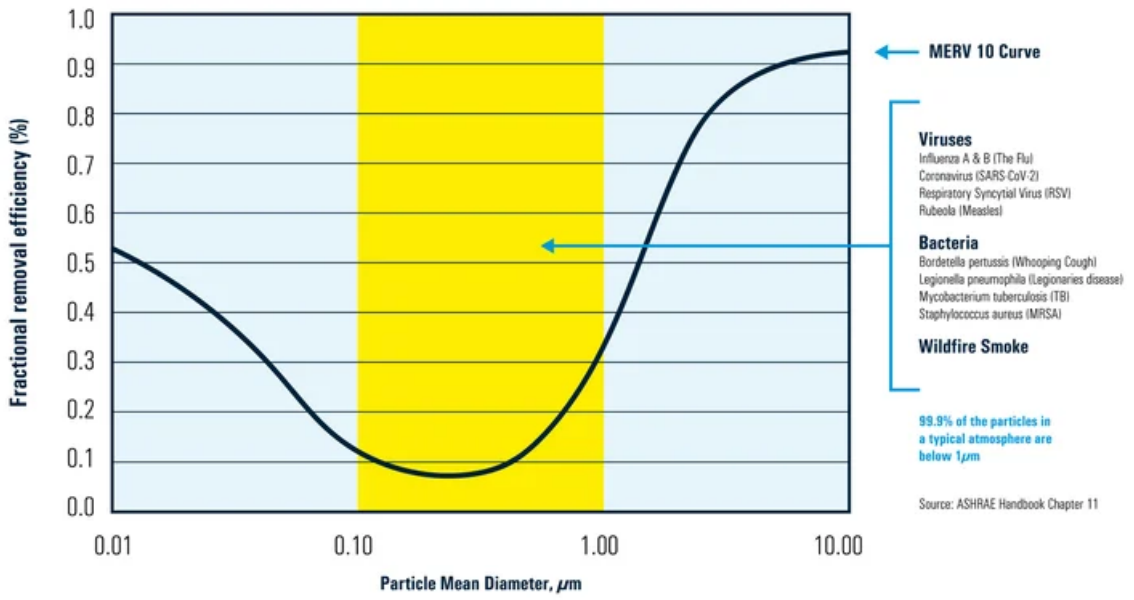
HEPA-filtered air purifiers are widely used to tackle indoor air pollution through removing particulate matter. Despite their widespread adoption these devices face significant challenges when deployed in real-world settings.

Key findings

- HEPA filtration used in conventional air purification devices struggle to capture ultrafine particles ranging from 0.1 to 1.0 µm.
- Continuous operation of air purifiers can be energy-intensive, contributing to higher carbon emissions and conflicting with sustainability goals.

Although, theoretically, purifiers with HEPA filters are capable of removing dust, pollen, mold, bacteria, and any airborne particles, they face challenges and limitations when conducting purification in real living and working environments.

- **Particle Size Filtration Efficiency**. As mentioned above, conventional air purifiers with HEPA filters may find it difficult to effectively capture viruses, some bacteria and other ultrafine particle with the size ranging from 0.1 to 1.0 µm [23]. This limitation reduces their efficacy in mitigating bioaerosols responsible for pandemics.



99.9% of the particles in a typical atmosphere are below 1µm

Source: ASHRAE Handbook Chapter 11

Figure 3 Minimum Efficiency Reporting Values (MERV) Curve indicating the filter efficacy of particles in different sizes [23].

- **Operational Costs and Maintenance**. The effectiveness of air purifiers depends on regular maintenance, including filter replacements and cleaning. Inconsistent maintenance can lead to reduced performance and potential secondary contamination [28]. Additionally, the operational costs associated with high-quality air purifiers can be a barrier in low-resource settings.

- **High Energy Usage**. To maintain optimal air quality, air purifiers often need to operate continuously, which can be energy-intensive and costly. The high energy usage of conventional air purifiers contributes to increased carbon emissions, which goes against global efforts to combat climate change [29].
- **Coverage**. Conventional air purifier usually requires placing one machine for each room to ensure adequate coverage, increasing the overall expense and maintenance burden.
- **Time for Air Circulation and Purification**. Air purifiers require sufficient time to circulate and filter the air within a space effectively. In environments with high pollutant influx or large volumes, achieving complete air turnover can be time-consuming, potentially leaving occupants exposed to pollutants during this period.

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[28] Mata, T. M., Martins, A. A., Calheiros, C. S. C., Villanueva, F., Alonso-Cuevilla, N. P., Gabriel, M. F., & Silva, G. V. (2022). Indoor Air Quality: A Review of Cleaning Technologies. Environments, 9(9), 118. https://doi.org/10.3390/environments9090118

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Chapter 05 I **Our Technology**

CDa is the world's first nano-droplet spraying product overcoming the limitations and inefficiencies of conventional large-droplet spray apparatuses and existing filter-based air purifiers, especially in handling nano-scale pollutants and viruses. It offers the global community a safe (using only water), effective (>99%), and fast (within minutes) solution for combating aerosol-transmitted viruses like COVID-19 and influenza, air pollutants, allergens and pollens. The product generates trillions of ultrafine nano-sized water droplets that collide and encapsulate aerosol contaminants and viruses in the air, and increase the mass of aggregated aerosol particles, causing them to be rapidly removed from the air.

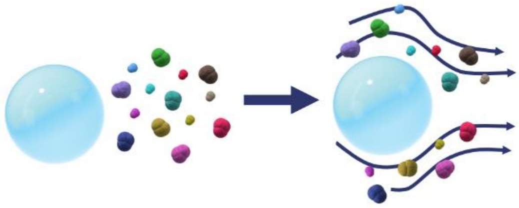
Key findings

- CDa produces trillions of nano-sized droplets that encapsulate and remove airborne pollutants, allergens, and pathogens, effectively addressing nano-scale challenges where conventional sprays and HEPA filters fall short.
- NanoJet technology utilises encapsulation, electric charge effects, oxidative stress, and humidity regulation to neutralise pathogens and reduce particulate matter with over 99% efficiency.
- CDa eliminates the need for traditional filters by using NanoJet technology, making it more efficient and cost-effective.

How does CDa work?

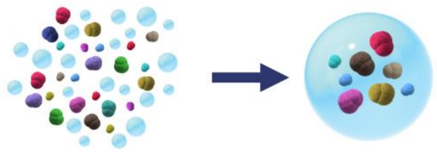
In conventional spray technology with large droplets, the aerosol particles are simply pushed away by the droplets because of the **slip stream effect**, meaning the large spray droplet induces airflow causing the airborne contaminants to be pushed around its surface. Hence spraying large droplets will not be effective to remove smaller pollutants and viruses from the air.

Conventional Spray Technology



The aerosol particles are pushed away by the larger spray droplet

Innova Nanojet Technology



The aerosol particles collide with and are enveloped by the smaller spray droplets.

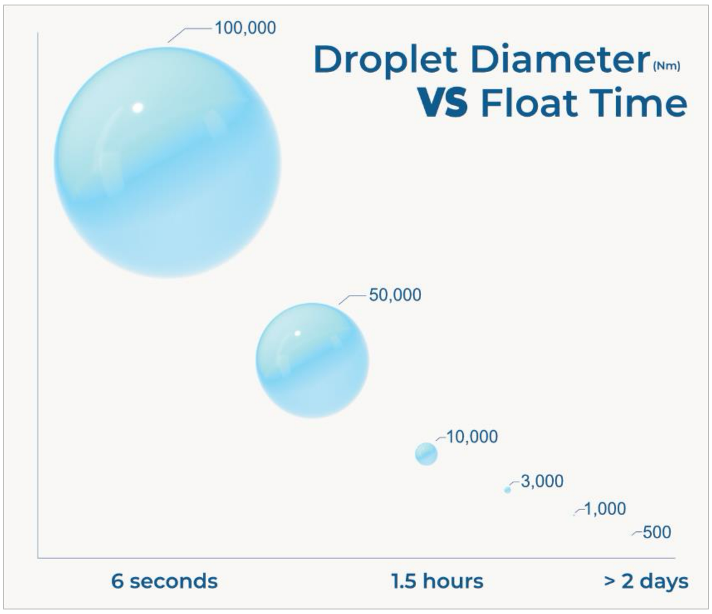
In contrast, NanoJet Technology represents a revolutionary advancement over conventional spray methods, allowing a wide range of ultra-fine droplets to be released into the air. The released NanoJet droplets achieve wide-range particle removal.

Encapsulation and Physical Isolation dominants aerosol particles removal. Nano-sized droplets produced by NanoJet technology can collide with and fully envelop and encapsulate suspended airborne viruses and pollutants, isolating and removing them from the air. For viruses and bacteria, this process can significantly mitigate their ability to interact with host cells. This isolation is crucial in inhibiting viral activity.

Experimental studies demonstrate that droplets of submicron size (~800 nm) significantly reduce particulate matter (PM1.0 including combustion particles, bacteria and viruses) concentrations. In controlled chamber experiments, PM1.0 levels decreased by 30% within the first 30 minutes when exposed to submicron water droplets [30], [31]. This high efficacy is attributed to the size and dynamics of the droplets, which closely match the physical characteristics of ultrafine particulate matter, including viruses and bacteria. The combination of inertial collision and diffusion forces ensures that these droplets actively capture pathogens, encapsulating them to form aggregates that settle out of the air. Furthermore, the smaller droplet size substantially improves interaction rates, doubling removal efficiency compared to droplets with larger diameters [30]. This physical encapsulation mechanism is a vital step in reducing pathogen viability, preventing transmission, and removing particulate matter in airborne environments.

Rapid Action with Prolonged Impact

The longevity of any airborne particle is directly influenced by its size. Particles with larger mass, will fall to the floor quickly. However, airborne particles that take form as viruses, smoke or allergens can linger for hours in the air, due to their small size. Through utilising NanoJet Technology, our system generates ultra-fine spray droplets that remain suspended in the air for hours, meaning enhanced coverage and prolonged efficacy can be achieved.



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[30] Kim, D., Kim, J., & Lee, S. J. (2021). Effectual removal of indoor ultrafine PM using submicron water droplets. Journal of Environmental Management, 296. https://doi.org/10.1016/j.jenvman.2021.113166

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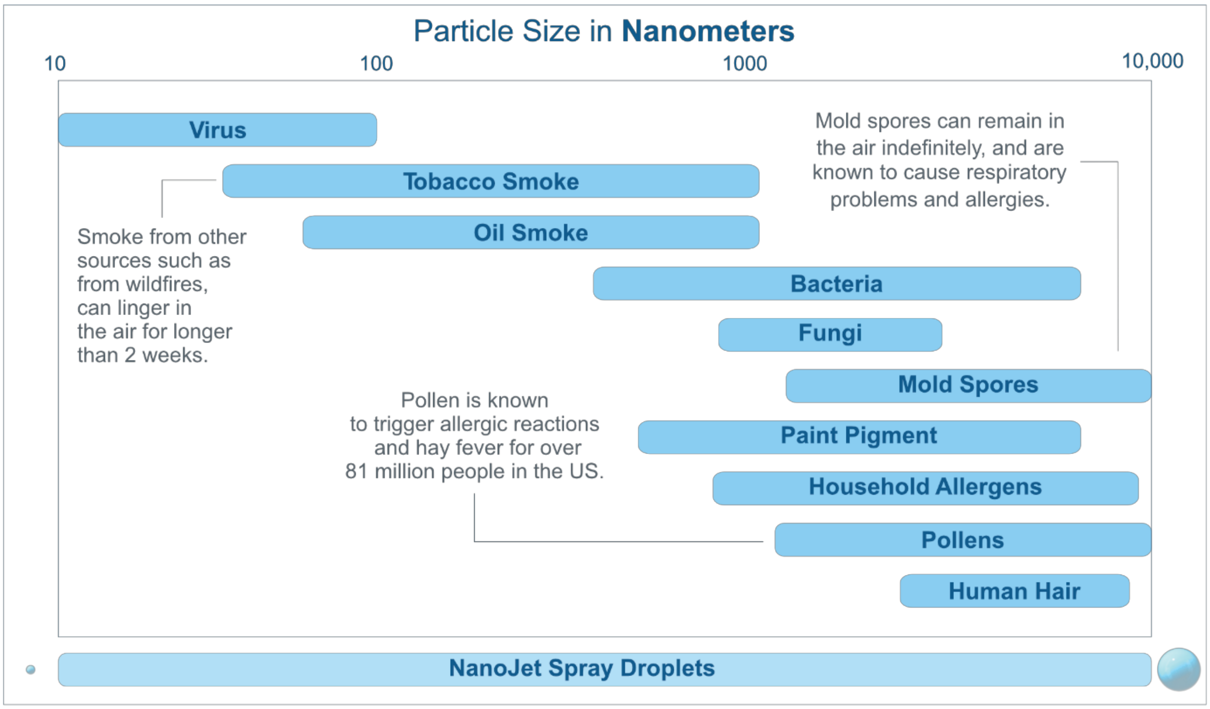
What can CDa Remove?

The Innova NanoJet CDa system is designed to effectively remove a wide range of airborne contaminants including PM2.5-5-10, viruses such as COVID-19, and common allergens such as pollen or dust. Through generating a wide range of spray droplets, our system can target even the smallest airborne particles.



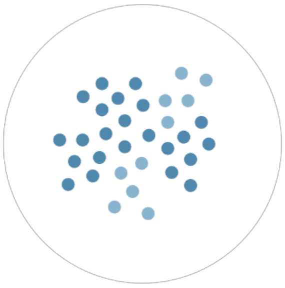
Filter-Free, Hassle free

Unlike traditional air purifiers that often demand costly filter replacements every 6-12 months, each replacement incurring up to 20-30% of the device's initial cost, our innovative solutions ensure long-lasting efficiency and cost effectiveness. We believe in offering not only cutting-edge technology but also a sustainable and economical choice for clean and healthy indoor environments.

What does CDa Target?

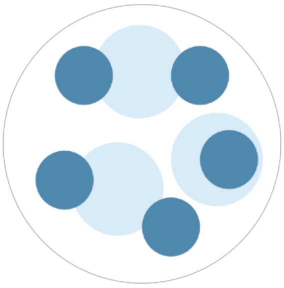
Viruses

Infectious and respirable viruses.



PM0.1

Ultra-fine particulates.



PM2.5

Combustion related particulates.

PM5

Bacteria & industrial emissions.

PM10

Pollen & mold spores.

Dander

Matter shed from pets.

Odours

Allergens

From airborne sources.

Dust

From indoor and outdoor sources.

Chapter 06 I **Lab testing**

3rd-party testing

CDa against MS2 Virus

Lab: LMS Technologies, INC

Date: July 12,2023

Key Findings:

- **94% reduction** of virus from air **in 20 minutes** after CDa with water for 5 minutes.
- **99.93% reduction** of virus from air **in 20 minutes** after CDa with diluted disinfectant for 5 minutes.

Test procedure:

In this test, MS2 bacteriophage was used as a viral representative to measure the efficacy of CDa for virus removal. MS2 virions are 23-28 nm in diameter, putting them in the category of small non-enveloped viruses which are recognized by EPA as the most difficult viruses to inactivate. In the test, 20-ml MS2 virus released into 4000 cf test chamber. The concentration of MS2 virus in the air is **3×10^9 – 5×10^9** PFU/m^3 (plaque forming units per cubic metre of air) which is much higher than typical airborne virus concentration. As reference, the typical airborne virus concentrations at different locations are in the range of **1 – 75** PFU/m^3 (mostly **< 20** PFU/m^3) as listed below.

Location	Measured virus	Total IAV concentration (genome copies/m^3)	**Equivalent viral concentration (PFU/m^3)**
Health Centre[a]	Influenza A viruses	5.8e3 – 1.6e4	**1.9 – 5.3** [32]
Day-Care Facility[b]	Influenza A viruses	1.6e4 – 3.7e4	**5.3 – 12.3** [32]
Airplane[c]	Influenza A viruses	1.1e4 – 3.4e4	**3.7 – 11.3** [32]
Laboratory	Human coronavirus 229E		**1.2** [33]
Pig Pens	Porcine respiratory coronavirus		**< 74.2** [34]

a. A health centre at Virginia Tech. The samples were collected from a waiting room, which is a semi-open space about 8.5 m × 5 m.
b. A day-care centre in Blacksburg, Virginia. The samples were collected in two toddlers' rooms and a babies' room. Each of the toddlers' rooms is about 8 × 4 m and holds 16 children plus four adults, and the babies' room is about 8 × 3.5 m and holds 12 children and four adults.
c. Cross-country flights between Roanoke and San Francisco.

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[32] Yang, W., Elankumaran, S., & Marr, L. C. (2011). Concentrations and size distributions of airborne influenza A viruses measured indoors at a health centre, a day-care centre and on aeroplanes. Journal of the Royal Society, Interface, 8(61), 1176–1184. https://doi.org/10.1098/rsif.2010.0686

[33] Bhardwaj, J., Hong, S., Jang, J., Han, C. H., Lee, J., & Jang, J. (2021). Recent advancements in the measurement of pathogenic airborne viruses. *Journal of hazardous materials*, *420*, 126574. https://doi.org/10.1016/j.jhazmat.2021.126574

[34] Bourgueil, E., Hutet, E., Cariolet, R., & Vannier, P. (1992). Experimental infection of pigs with the porcine respiratory coronavirus (PRCV): measure of viral excretion. Veterinary microbiology, 31(1), 11–18. https://doi.org/10.1016/0378-1135(92)90136-h

Organisms were harvested and titrated, and suspensions of the organisms were then aerosolized into the chamber for 60 minutes using a nebulizer prior to powering the test device. The test chamber air was sampled at different intervals time using a SKC Bio Stage cascade impactor for 1-minute sampling periods. The cascade impinger was calibrated to an airflow rate of 12.5 liters/min and the sampling inlet was situated at the off midpoint of the test chambers. The recovered organisms were enumerated after 24-48 hours of incubation.

Results:

In order to test the efficacy of CDa on viruses removal, two different tests were performed:

- Test A: 5 minutes of ONLY WATER sprayed with CDa, after the release of MS2 virus
    - Achieve 1 ACH (air change of room per hour) [35] in approx. 16 minutes.
    - 94% virus removed from air in 20 minutes.
    - 98% virus removed from air in 60 minutes.
- Test B: 5 minutes of disinfectant (which is diluted with 10 times water) sprayed with CDa, after the release of MS2 virus
    - Achieve 1 ACH (air change of room per hour) in less than 5 minutes.
    - 99.93% virus removed from air in 20 minutes.
    - 99.98% virus removed from air in 60 minutes.

	Nominalized MS2 Virus Residual*		
Time	Natural Decay	Nano Jet device	Nano Jet device + LMS disinfectant
0 min	1	1	1
20 min	0.51	0.06	0.0006
60 min	0.14	0.02	0.0002
Removal Efficient in 60 min		98.2%	99.98%

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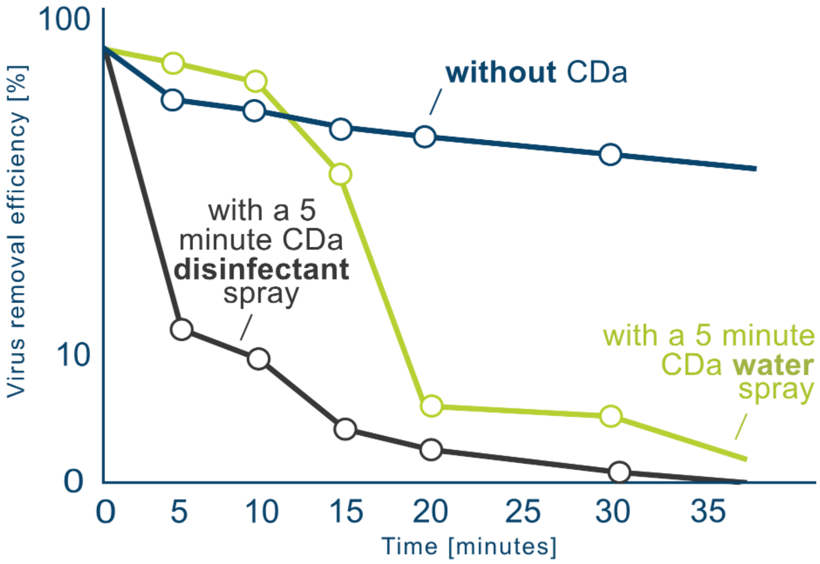
[35] ACH (Air changes per hour) determine how quickly pollutants can be removed from a room once the source is eliminated. With each air change, approximately 63% of the pollutants are removed, leaving 37% behind. Consequently, after three air changes, only about 5% of the pathogens remain, with 95% being removed.

Virus Removal Efficiency



CDa against Pollen

Lab: LMS Technologies, INC

Date: August 6,2023

Key Findings:

- **82.2% reduction** in particles larger than **0.3 microns**.
- **Almost 100% reduction** in particles larger than **3.0 microns.**

Test procedure:

Initially, the task was based on generating pollen particles which were fed to the room by a venturi system. The generation continued till counts reached 224000 per cfm. The levels were monitored for one hour with no reduction in the level of the pollen counts. This would be considered to be empty chamber.

During the next step the test unit was turned on and water particles were injected for only two minutes. Since the water particles would have interfered with particle counts, a heater unit was turned on for a period of 2 hours. During this time the mixing fans kept the particles airborne.

Results:

The reduction in total number of particles was 82.2% for all particles above 0.3 micron and almost 100% for all particles larger than 3.0 micron.

Conclusion

This white paper highlights the state of air pollution in South America and its direct impact on public health, emphasizing the urgency for effective solutions. This paper provides detailed evidence on the links between air pollution and increased rates of chronic diseases, hospitalizations, and premature deaths. It also provides an analysis of pollution sources, trends, and the widespread failure of current air purification technologies to address the problem effectively. Regions in south America face severe and escalating air quality crisis, driven by rapid urbanization, industrial emissions, and biomass fuel use. Additionally, this paper presents third-party lab results showcasing the effectiveness of Innova NanoJet's CDa against pollutants and pathogens. The findings call for urgent action to combat the air quality crisis. Specifically, they highlight the need for:

- **Deployment of New Technologies**: Innovative solutions like CDa technology that are scientifically proven to reduce harmful indoor air pollutants.
- **Collaborative Efforts**: Policymakers, healthcare institutions, and industry leaders must drive efforts to promote and adopt advanced air purification technologies.
- **Public Awareness**: Increased efforts to inform the public about the dangers of poor air quality and the importance of adopting innovative solutions.

Innova NanoJet's CDa is positioned as a pivotal solution to mitigate the devastating impact of air pollution and foster healthier indoor environments across South America.