Air Quality
White Paper

Data independently
verified by Bureau Veritas

Whiz

SoftBank
Robotics

Why is **air quality** important?

The importance of the quality of the air we breathe has always been intuitively understood and historic evidence of bad air quality living and working conditions are rife.

The headlines of increases in asthma, increases in the incidences and severity of COPD, and the increases in mortality because of bad air quality and pollution make for depressing reading. According to the World Health Organization, clean air is considered to be a basic requirement of human health and well-being. However, air pollution continues to pose a significant threat to health worldwide.

According to a WHO assessment of the burden of disease due to air pollution, more than 2 million premature deaths each year can be attributed to the effects of urban outdoor air pollution and indoor air pollution.

(Source: WHO Global air quality guidelines 2021)

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The last 18 months has increased this awareness enormously due to the impact of COVID-19 and people's understanding of how the virus is transmitted.

The WHO continues with: *"The evidence on airborne particulate matter (PM – see appendices) and its public health impact is consistent in showing adverse health effects at exposures that are currently experienced by urban populations. The range of health effects is broad, but are predominantly to the respiratory and cardiovascular systems.*

The low end of the range of concentrations (of PMs) at which adverse health effects has been demonstrated is not greatly above the background concentration, which for particles smaller than 2.5 µm (PM2.5) has been estimated to be 3–5 µg/m3 in both the United States and western Europe. The epidemiological evidence shows adverse effects of PM following both short-term and long-term exposures."

(Source: WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide Global update 2005)

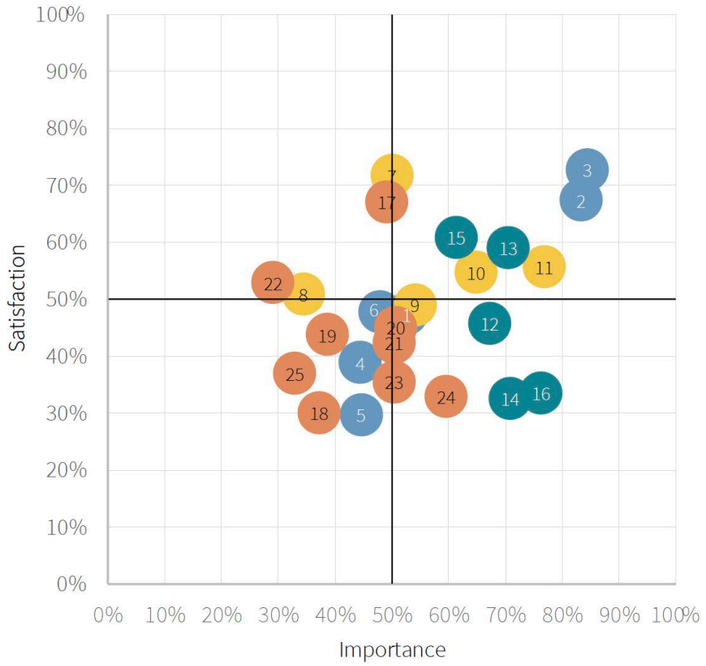
"In addition, PM of between 0.1 µm and 1 µm in diameter can remain in the atmosphere for days or weeks and thus be subject to long-range transboundary transport in the air." The next logical consideration is, therefore, where do these particulates settle and what potential for harm does this present? This intense scrutiny of air quality is therefore undiminished as society returns to a new normal. Facility Managers and Real Estate providers are working with their clients on what measures can be done to enhance the comfort levels of employees returning to their workplace and what good employers can do to reduce the infection likelihood within their estates and thus reduce the anxieties of these returning employees.

And these anxieties are real.

For over a decade, the **Leesman Index** has been asking employees of the importance of air quality to them and how they rate their air quality. The results have been drawn from over 890,000 individual surveys and, in consideration of the question *"Thinking about the work that you do, which of the following physical features are important and how satisfied are you with them?"*, the net result is that 67.2% of employees believe that air quality is important but the satisfaction level of that air quality was down at 45.8%.

Leesman

Thinking about the work that you do, which of the following physical features are important and how satisfied are you with them?



		% Importance	% Satisfaction
Individual Work			
1	Ability to personalise my workstation	52.6%	47.4%
2	Chair	83.3%	67.4%
3	Desk	84.4%	72.7%
4	Dividers (between desk/areas)	44.4%	38.9%
5	People walking past your workstation	44.6%	29.7%
6	Space between work settings	47.9%	47.8%
Collaboration			
7	Accessibility of colleagues	50.0%	71.7%
8	Audio-Visual equipment	34.4%	50.9%
9	Desk/room booking systems	54.1%	49.0%
10	Meeting rooms (large)	64.8%	54.7%
11	Meeting rooms (small)	76.8%	55.7%
Indoor Environment Quality			
12	Air quality	67.2%	45.8%
13	Natural light	70.5%	59.1%
14	Noise levels	70.8%	32.6%
15	Office lighting	61.3%	60.9%
16	Temperature control	76.3%	33.6%

		% Importance	% Satisfaction
Design and layout			
17	Access (e.g. lifts, stairways, ramps)	49.1%	67.1%
18	Art & photography	37.2%	30.1%
19	Atriums & communal areas	38.6%	43.8%
20	General décor	50.7%	45.1%
21	Informal work areas/break-out zones	50.4%	42.4%
22	Internal signage	29.1%	52.9%
23	Plants & greenery	50.4%	35.5%
24	Quiet rooms for working alone or in pairs	59.6%	33.0%
25	Variety of different types of workspace	32.9%	37.0%

This importance is endorsed by many other authorities. Saint-Gobain, the world leader in the sustainable habitat and construction markets, has identified five key elements that contribute to our comfort levels in buildings and, unsurprisingly, indoor air quality ranks highly alongside visual, audio, thermal and economic comfort. Building owners and FM companies are also acutely focused on this to ensure comfort is provided in the buildings they own and manage for the safety of their employees – not only as it is of key topical interest but, actually, it's the right thing to do!

At the industry leading conference, **WORKPLACE FUTURES** in summer of 2021, the importance of air quality was again in the spotlight. **Tim Oldman, CEO and Founder of Leesman highlighted this and Craig Butt, Managing Director Corporate, ENGIE concurred stating** *"Stimulating: buildings must now be so much more than simply safe and compliant. They need to be places where people want to come to work or visit; places that demonstrate the organisation cares about the people who use the space; places with excellent air quality that are welcoming and inspiring"*

The debate continued and was picked up by **Graeme Fox at Building Engineering Services Association (BESA) –** *"The Covid-19 pandemic has brought about a sea-change in attitude towards indoor air quality and better ventilated buildings. With airborne transmission of viruses now more readily understood by the general public, and with building owners and managers now understanding they need to properly maintain their ventilation systems, the hope going forward would be that building designers will pay more attention to how the building works, not just on how it looks.*

IAQ – indoor air quality – has been something we have been looking at within the BESA for several years now, and our Health & Wellbeing in Buildings group have produced a Beginners Guide to IAQ and a definitive Guide to Good Practice on IAQ to aid building managers and occupiers"

Beyond the theory

In recent years, several companies have explored the importance of air quality even further.

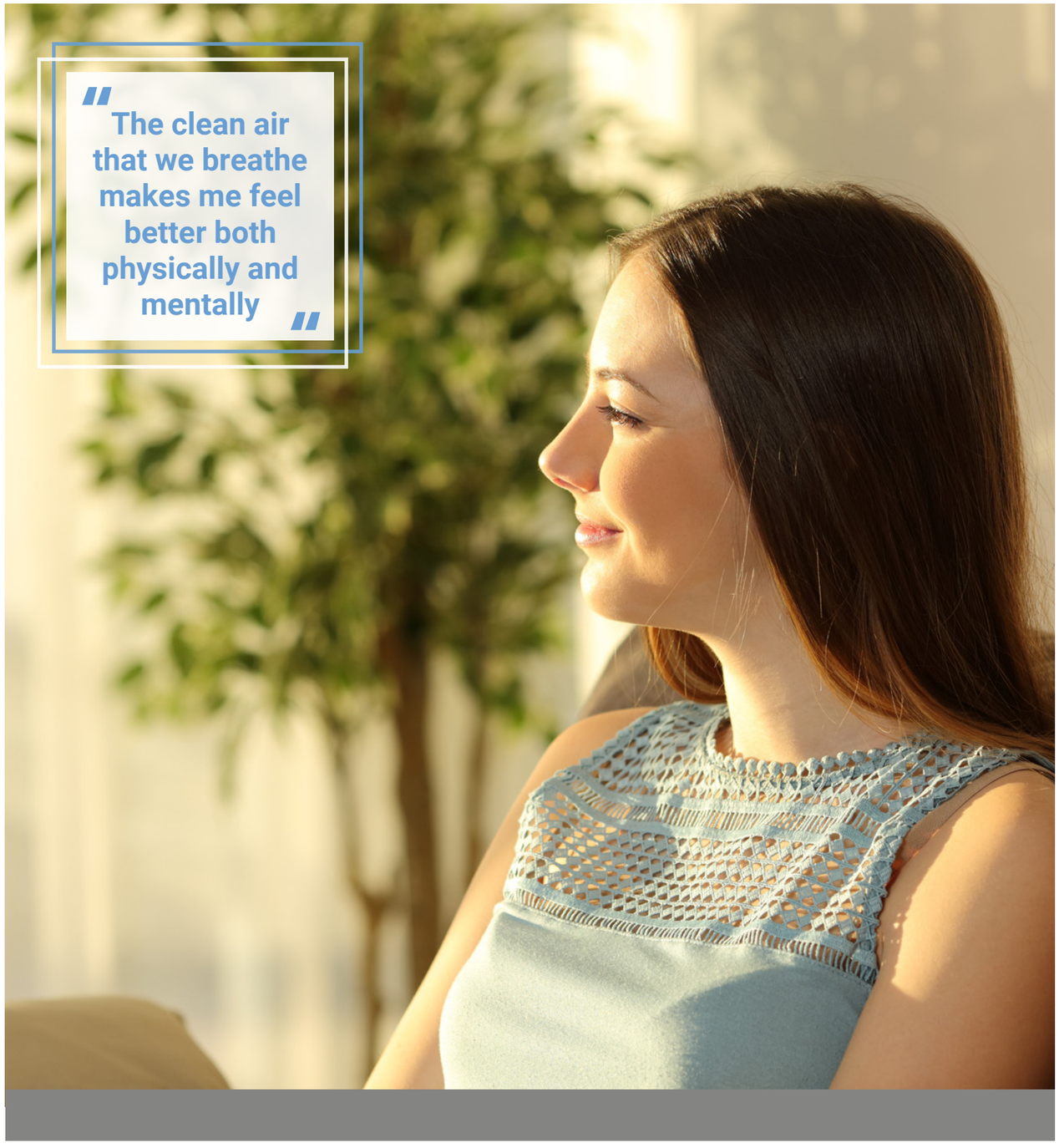
Landsec Workplace leveraged to create a collaborative, innovative workplace to connect employees to their partners, customers and communities. Landsec implemented features like LED circadian lighting system to match external light levels, enhanced fresh air ventilation filtration to ensure optimum air quality and adaptable spaces to increase employee productivity and cooperation.

They reported a 40% increase in satisfaction with air quality, a 25% increase in satisfaction with lighting and 88% agreed that the new office design increased work productivity. In a Leesman survey of Landsec employees, over 90% felt that the workplace environment has a positive effect on workplace culture. Employee feedback put Landsec in the top 5% of 1,900 organisations surveyed worldwide by the Leesman Index for workplace wellbeing and productivity.

Another project to note is the **Haworth Kerry Organic Office and Showroom**.

Their goals included healthier indoor air quality, promoting ergonomic appropriate posture and preventing prolonged sitting, and improved mental health with stress reduction. Haworth Kerry implemented a WELL thermal comfort feature to reduce physical strain and maximise ergonomic comfort and safety, a feature to improve air filtration and a health and wellbeing awareness feature. These all resulted in a more comfortable, versatile workspace, community areas for relaxation and connection, and healthy conditions for employees and visitors.

One employee remarked: *"The clean air that we breathe makes me feel better both physically and mentally, as I feel reassured that during the whole time I spend at work my health is being protected as much as possible."* **- Ann Marie Aguilar, Senior Vice President EMEA Region, International WELL Building Institute**



Further still, GSK has conducted trials within their Workplace Performance Hub (WPH) with interesting results as reported in the **Corporate Real Estate Journal** (Volume 9 Number 4). Over a six-month period. The WPH facilitated the testing of a number of environmental variables on the occupants' physiology, wellbeing and productivity.

The experiment was designed to understand the impact of the built environment on individual and group performance and created a series of sprints in a controlled environment to understand the effect of light, air quality, temperature, sound and work setting design. Other variables which were introduced and measured included circadian lighting and biophilia.

The study showed that physical environment has a considerable impact on employee health, wellbeing and performance. Participants experienced an increase in cognitive performance after their residency of the WPH, while also reporting a reduction in stress. In addition, occupants saw a rise of 17% ininnovation cycles during their stay.

Whilst this was, admittedly, a small sample group, the initial results were of great interest.

Cognitive capability

Perhaps even more compelling is the latest report from Harvard (Harvard Report 12th September 2021) – "Office air quality can affect the way you think and work."

The study worked with over 300 individuals for more than a year with personalised cognitive tests on an app triggered at specific times and when air quality sensors detected a depletion in air quality.

The one-year study, which included participants in offices across six countries working in a variety of fields, including engineering, real estate investment, architecture, and technology, found that increased concentrations of fine particulate matter (PM2.5) and lower ventilation rates (measured using carbon dioxide (CO_2) levels as a proxy) were associated with slower response times and reduced accuracy on a series of cognitive tests. The researchers noted that they observed impaired cognitive function at concentrations of PM2.5 and CO_2 that are common within indoor environments.

"Our study adds to the emerging evidence that air pollution has an impact on our brain. The findings show that increases in PM2.5 levels were associated with acute reductions in cognitive function. It's the first time we've seen these short-term effects among younger adults," **said Jose Guillermo Cedeño Laurent, a research fellow in the Department of Environmental Health and lead author of the study.** The study also confirmed how low ventilation rates negatively impact cognitive function. Overall, the study suggests that poor indoor air quality affects health and productivity significantly more than we previously understood.

"The world is rightly focused on COVID-19, and strategies like better ventilation and filtration are key to slowing infectious disease transmission indoors," **said Joseph Allen, associate professor of exposure assessment of science and senior author on the study.** *"Our research consistently finds that the value proposition of these strategies extends to cognitive function and productivity of workers, making healthy buildings foundational to public health and business strategy moving forward."*

The Impact of standard operations and equipment on the quality of internal air

Given the masses of evidence and focus on the quality of air, particularly enhanced by the pandemic and the developed understanding of air-borne viruses, within the built environment, SoftBank Robotics (SBR) considered what impact its equipment has on this.

In particular, with air-borne particulates settling onto floor surfaces, we wanted to understand what effect does vacuuming have on these? A study was constructed to establish this impact involving industry-leading sensors from Infogrid and the use of the autonomous vacuum sweeper, Whiz, from SBR.

Introduction to Infogrid

CLICK HERE FOR INTRODUCTION

The Infogrid platform is capable of handling millions of data events from hundreds of thousands of sensors every day.

With cutting-edge, low-cost micro sensors provided by 3rd party technology partners, Infogrid is able to turn any building into a smart building at a fraction of the cost of existing providers.

The simplicity of the solution enables clients to self-install thousands of sensors in a matter of hours, and receive immediate real time data.

With the analytics and reporting they generate, companies can run more efficiently, pre-empt failures, save money, improve compliance and deliver a better working environment.

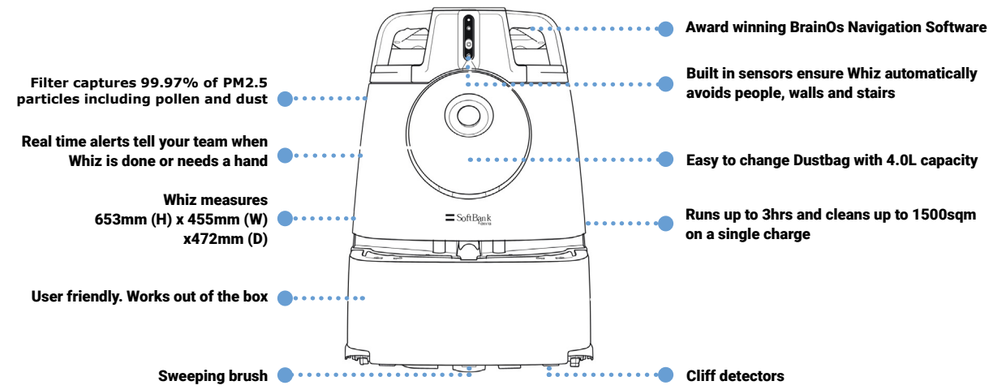
In particular, for our study, we deployed dozens of air quality sensors which had the ability to monitor CO_2, VOCs (Volatile Organic Compounds), radon, humidity, light levels, ventilation, virus risk factor, air pressure, and a range of pollutants including particulate matter (1, 2.5, and indicative for 10 microns) – the latter being the main focus for the study. The real-time data monitoring was captured and displayed through the Infogrid cloud dashboard.

Introduction to SoftBank Robotics & Whiz

CLICK HERE FOR INTRODUCTION

SoftBank Robotics EMEA delivers innovative automation and collaborative robotic (cobotic) solutions to a range of industries in the EMEA region.

Our cobots (collaborative robots) are designed to support and empower people in their work, removing the strain of repetitive and time-consuming tasks and enabling staff to focus on higher value activities which makes a real difference to clients whilst driving greater performance and consistency in specific areas of service delivery. Whiz is an autonomous vacuum sweeper and was the solution used for this study.



Methodology

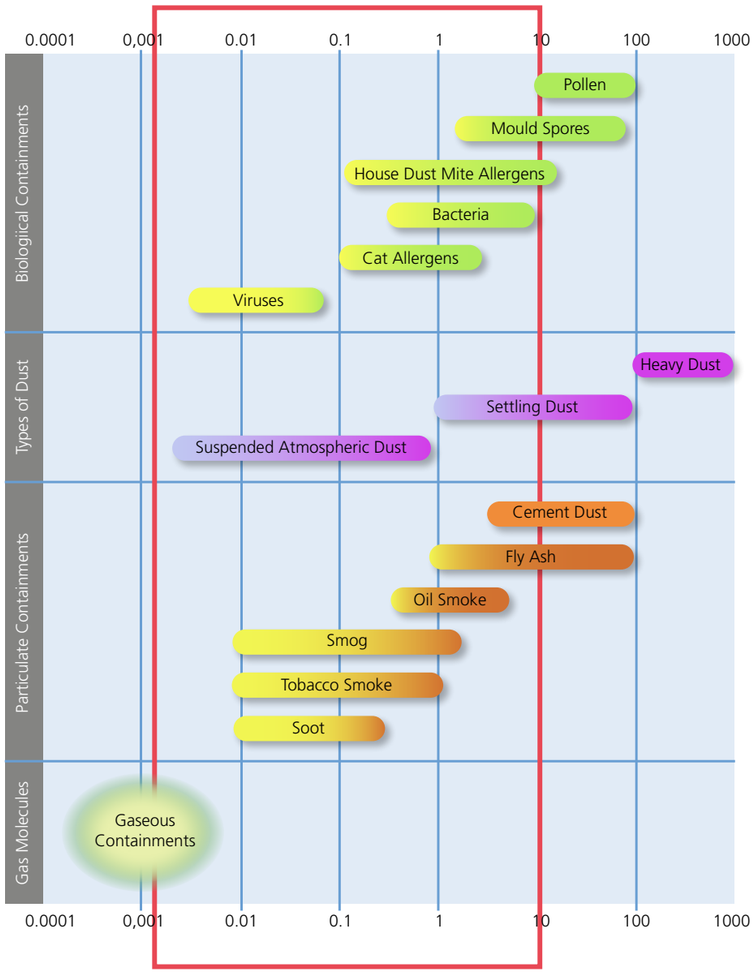
2.1. Study design
Two unrelated test sites were created

- Corporate Bank Headquarters
- Corporate office environment

Infogrid Air Quality Sensors were deployed to each site and readings taken for two weeks whilst the incumbent cleaning teams continued to service the areas according to their normal cleaning schedules and using their normal cleaning equipment.

The sensors were installed in a variety of positions across each floor and the floors were chosen for medium traffic throughout the study.

Subsequently, Whiz was deployed for a two-week period and normal vacuum cleaning practices were suspended. The Infogrid sensors continued to measure the air quality and the results compared. In each case, the Infogrid sensors were calibrated to detect particulate volumes at three sizes (see chart below)[1] - <10µm, <2.5µm and <1µm



2.2. Sensor Deployment Maps
The sensors were deployed widely across each floor –

- Corporate office environment in London (31 sensors across 3 floors)

Sensor Key:
(Colours relate to readings at the time the map was downloaded)

Air Monitoring Hub

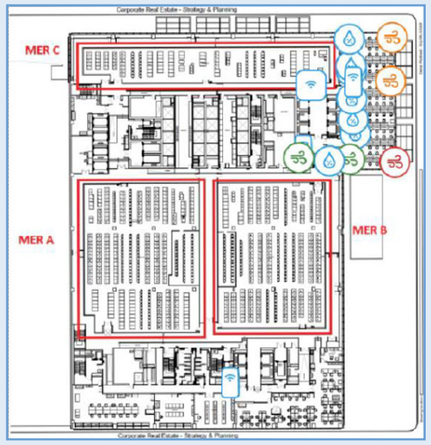
Humidity

Cloud Connector

Air Quality

FLOOR 1

FLOOR 2



FLOOR 7

Methodology

Sensor Key:
(Colours relate to readings at the time the map was downloaded)

Air Monitoring Hub

Humidity

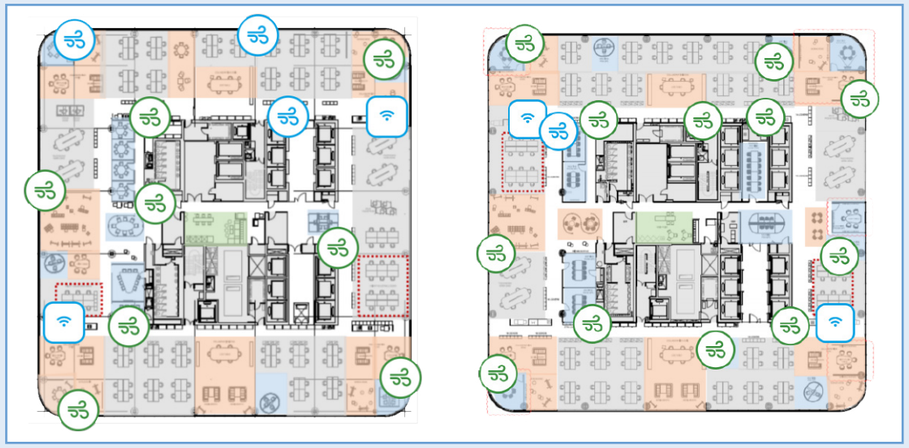
Cloud Connector

Air Quality

Corporate Bank Headquarters in London (24 sensors across 2 floors)

FLOOR 31

FLOOR 37



Results

2.3. Air quality results

From the number of sensors deployed and the associated frequency of sampling, over 400,000 data points were taken across the study.

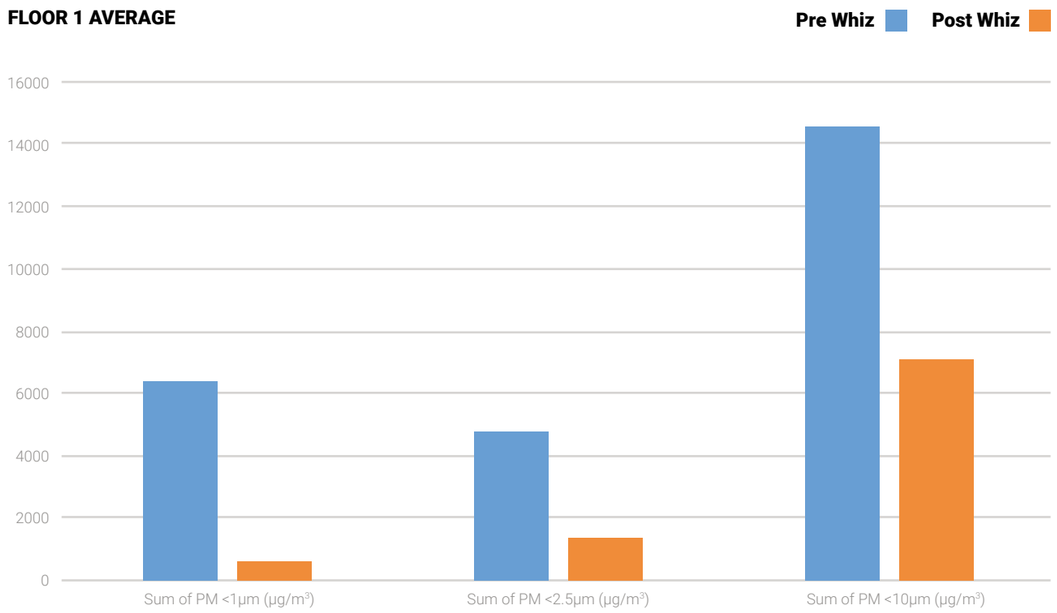
Analysis of the resulting comparisons of particulates at the 3 different sizes between pre and post Whiz deployment provide the following headlines –

- **The variety of change was wide across the entire sensor deployment but all with a positive reduction and the supermajority being in the 50% reduction range**
- **There were no negative results – ie there was no increase in particulates created through the operation of Whiz**

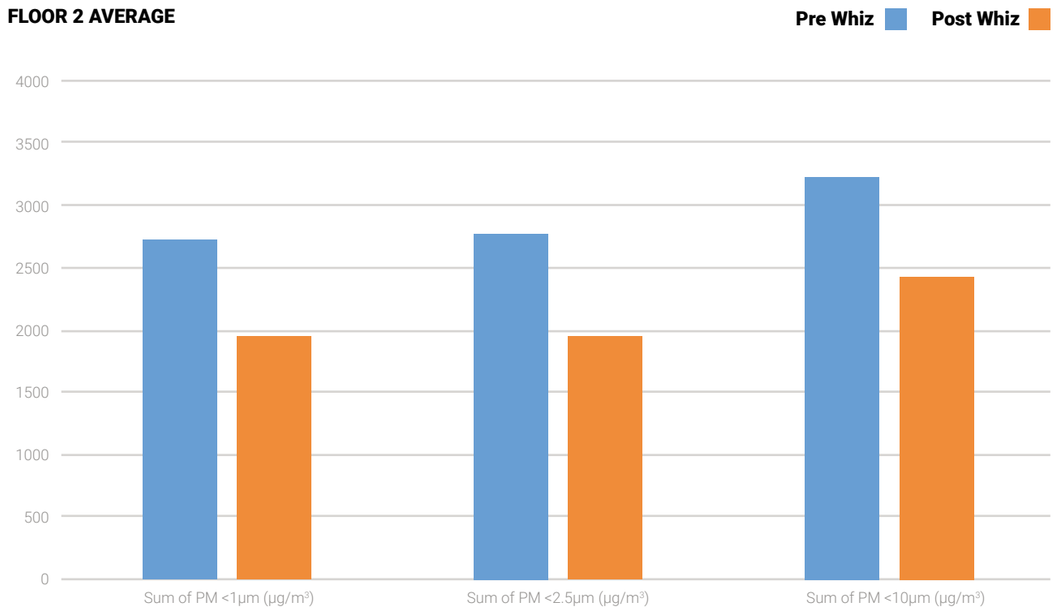
The average individual floor results are shown below

Corporate office environment in London

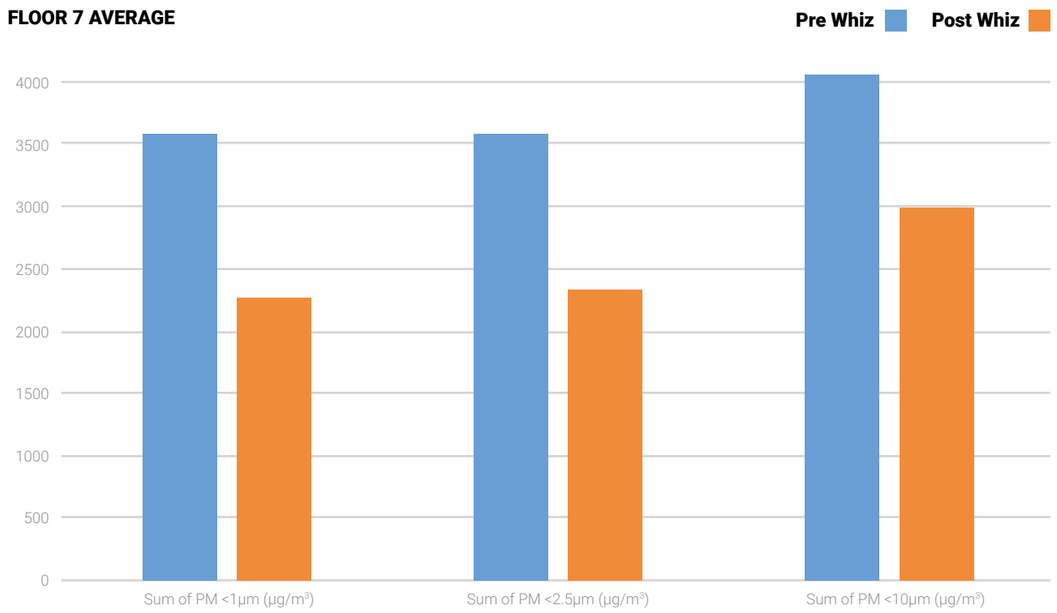
FLOOR 1 AVERAGE



FLOOR 2 AVERAGE



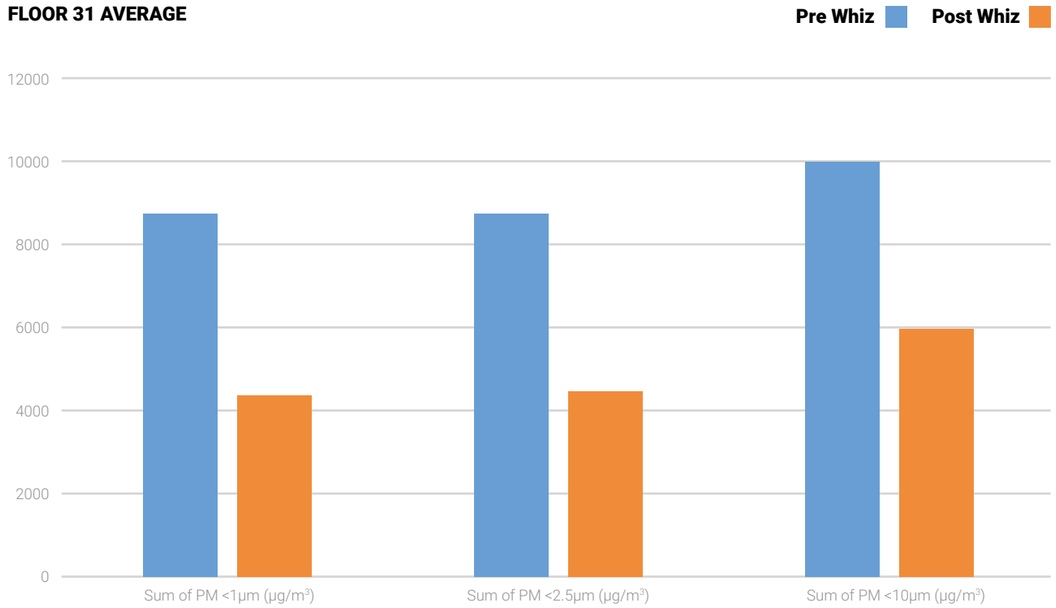
FLOOR 7 AVERAGE



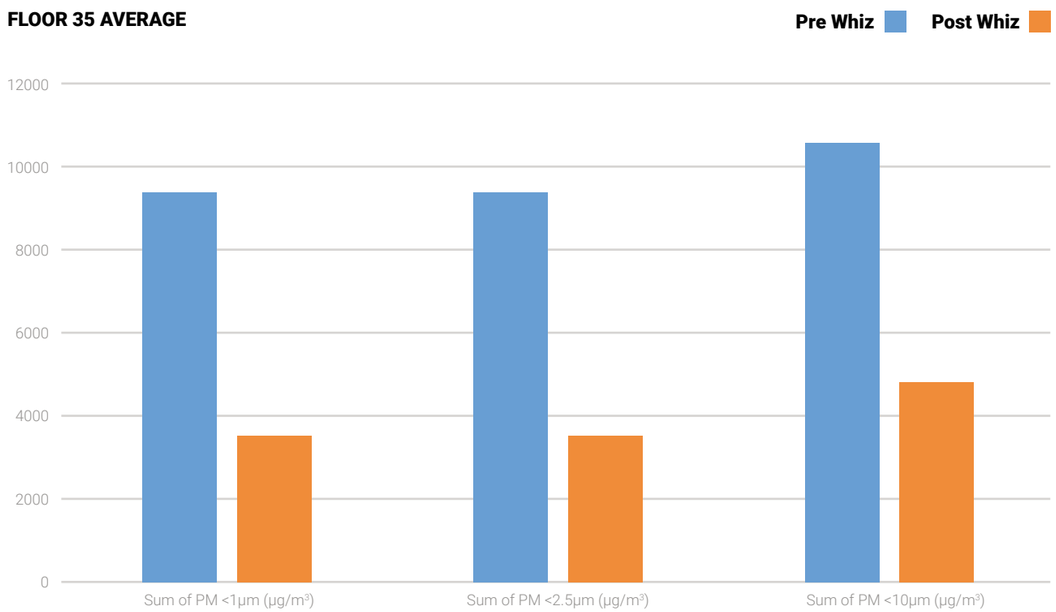
Results

Corporate Bank Headquarters in London

FLOOR 31 AVERAGE



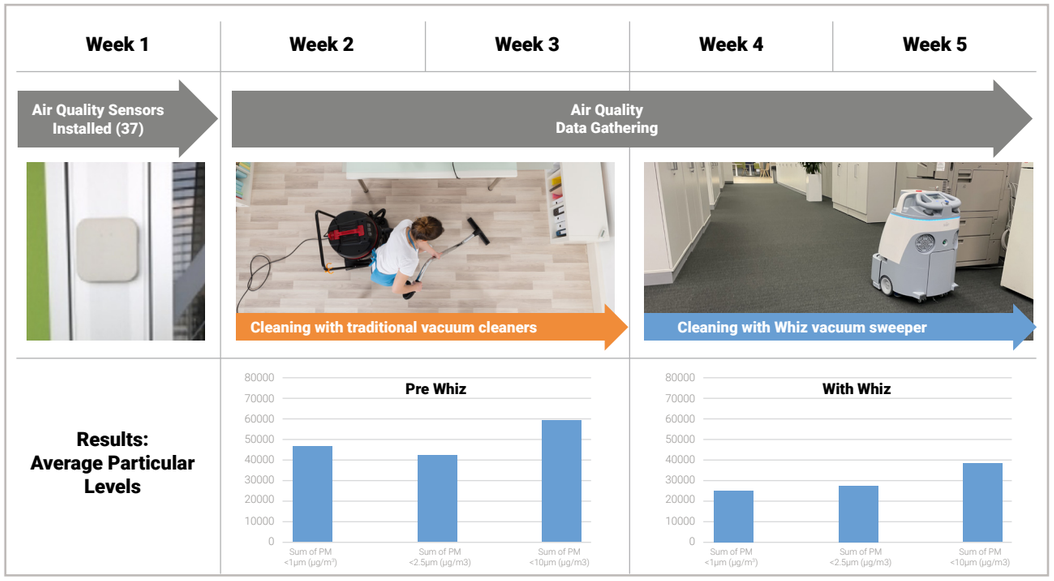
FLOOR 35 AVERAGE



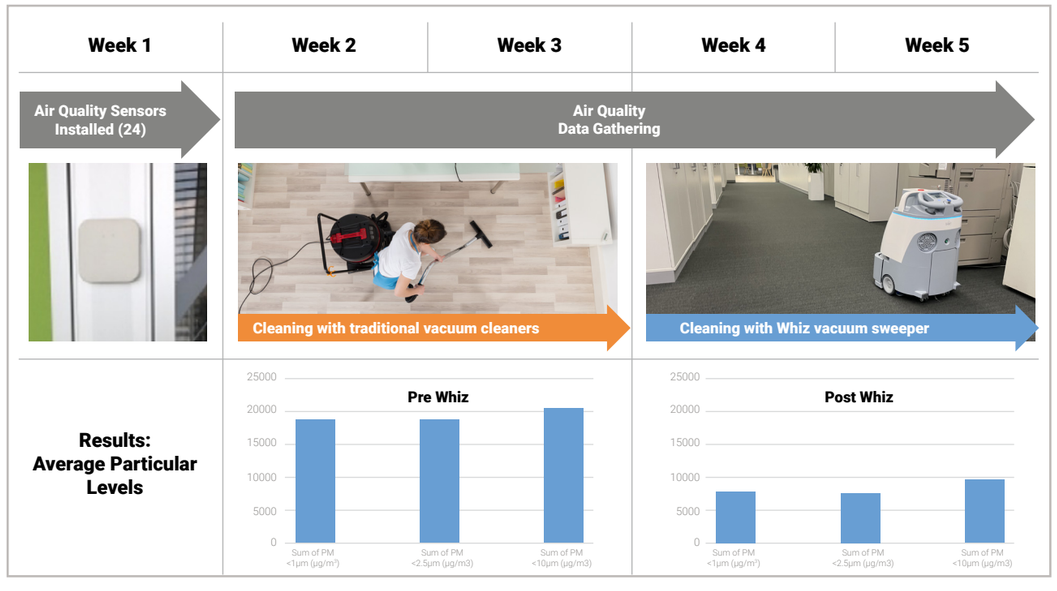
Results

2.3. Overall Average Results

Corporate office environment in London



Corporate Bank Headquarters in London



Discussion and **conclusion**

On this evidence, the use of Whiz dramatically improves the air quality through its normal operation. The detailed measurements and volumes of data collected (over 400,000 data points) by the Infogrid sensors show compelling evidence that not only does Whiz not increase harmful particulates agitated from the floor surface but actually decreases these through its normal operation.

Of course, a holistic approach should be taken in consideration of improving a building's air quality and this should include the building's HVAC system, general airflow, the deployment of the correct filters within this system, the use of peripheral air improvement devices such as purifiers and other air disinfection components.

Traditionally, the act of vacuuming a floor (especially a carpeted floor) agitates the settled air-borne particulates deteriorating the general air quality. The deployment of Whiz is shown to dramatically improve this and be more beneficial than traditional vacuum cleaning equipment and methodology.

And whilst it is important that this should not be considered as a solution in itself of improving the air quality within a workspace, there really is no better substitute for vacuuming in this way to remove air-borne, settled particulates.

BUREAU VERITAS 1828

"Data analysis performed by Bureau Veritas UK Ltd showed a reduction in particulate matter concentrations (PM1.0, PM2.5 and PM10) following the implementation of the Whiz Autonomous Vacuum Sweeper. It should be noted that all information contained in the aforementioned report and interpretation of data was solely based on information provided by Softbank Robotics UK Ltd. Bureau Veritas UK Ltd was in no way directly involved with the gathering of data or development of the study methodology."

Appendices

From WHO: “HEALTH EFFECTS OF PARTICULATE MATTER”

PM is a widespread air pollutant, consisting of a mixture of solid and liquid particles suspended in the air. Commonly used indicators describing PM that are relevant to health refer to the mass concentration of particles with a diameter of less than 10 μm (PM10) and of particles with a diameter of less than 2.5 μm (PM2.5). PM2.5, often called fine PM, also comprises ultrafine particles having a diameter of less than 0.1 μm. In most locations in Europe, PM2.5 constitutes 50–70% of PM10.

PM between 0.1 μm and 1 μm in diameter can remain in the atmosphere for days or weeks and thus be subject to long-range transboundary transport in the air.

PM is a mixture with physical and chemical characteristics varying by location. Common chemical constituents of PM include sulfates, nitrates, ammonium, other inorganic ions such as ions of sodium, potassium, calcium, magnesium and chloride, organic and elemental carbon, crustal material, particle-bound water, metals (including cadmium, copper, nickel, vanadium and zinc) and polycyclic aromatic hydrocarbons (PAH). In addition, biological components such as allergens and microbial compounds are found in PM.

WHO
Air quality guidelines and their rationale
Particulate matter
GuidelinesPM2.5: 10 μg/m3 annual mean
25 μg/m3 24-hour mean
PM10: 20 μg/m3 annual mean
50 μg/m3 24-hour mean
Guidelines
PM2.5: PM10: Rationale

The evidence on airborne particulate matter (PM) and its public health impact is consistent in showing adverse health effects at exposures that are currently experienced by urban populations in both developed and developing countries. The range of health effects is broad, but are predominantly to the respiratory and cardiovascular systems.

All population is affected, but susceptibility to the pollution may vary with health or age. The risk for various outcomes has been shown to increase with exposure and there is little evidence to suggest a threshold below which no adverse health effects would be anticipated. In fact, the low end of the range of concentrations at which adverse health effects has been demonstrated is not greatly above the background concentration, which for particles smaller than 2.5 μm (PM2.5) has been estimated to be 3–5 μg/m3 in both the United States and western Europe. The epidemiological evidence shows adverse effects of PM following both short-term and long-term exposures.

As thresholds have not been identified, and given that there is substantial inter-individual variability in exposure and in the response in a given exposure, it is unlikely that any standard or guideline value will lead to complete protection for every individual against all possible adverse health effects of particulate matter. Rather, the standard-setting process needs to aim at achieving the lowest concentrations possible in the context of local constraints