WILDFIRE SMOKE AND ITS IMPACT ON THE INDOOR AIR QUALITY AROUND METRO VANCOUVER

Metro Vancouver, B.C.

November 9, 2020

OFFICIAL SPONSOR BOMA British Columbia Bronze

IAQA Corporate Member

Consulting Services for
Indoor air quality
Mould, Occupational Hygiene
Hazardous materials

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1.0 INTRODUCTION

Sterling IAQ Consultants Ltd. (Sterling IAQ) and its team members have been conducting annual proactive indoor air quality testing in commercial buildings across Canada for over 20 years. It has been the opinion of Sterling IAQ for a long time that good indoor air quality can be achieved even when the outdoor air quality is poor. And good indoor air quality can be achieved with effective ventilation with outdoor air and good filtration of that outdoor air prior to be delivered indoors.

In September of 2020, wildfire smoke from the United States significantly affected the outdoor air quality around the Metro Vancouver area for approximately 3 weeks (September 10 to October 6, 2020). And during this period where the outdoor air quality was very poor around Metro Vancouver, Sterling IAQ was scheduled to conduct routine proactive indoor air quality testing at a number of buildings.

Since we have many years of indoor and outdoor air quality testing data from around Metro Vancouver, Sterling IAQ determined it would be interesting to prepare a report that discusses how the outdoor wildfire smoke affected the indoor air quality.

This report was compiled based on IAQ tests conducted in 8 different buildings and retail spaces scattered around Metro Vancouver and are summarized below:

Building A
This one-story retail space consisted of a warehouse and showroom area enclosed in a 42,835 ft^2 space serviced by at least 8 rooftop individual HVAC units

Building B
This office building consisted of 349,169 ft^2 distributed over 27 floors with 2 main HVAC units located in a mechanical room on penthouse level.

Building C
A one-story office building allocated in a 24,600 ft^2 area with at least 8 rooftop individual HVAC units.

Building D
A two-story office building enclosed in a 60,600 ft^2 area with at least 4 rooftop individual HVAC units.

Building E
This one-story office building presented at least 4 rooftop individual HVAC units servicing an area of 79,700 ft^2.

Building F
A four-story office building with around 12 rooftop individual HVAC units servicing an area of 62,101 ft^2.

Building G
Two main rooftop HVAC units serviced this three-story office complex in an area of 44,695 ft^2.

Building H
A newer 234,746 ft^2 office space distributed over 14 floors and 2 main HVAC units located on a mechanical room on penthouse level.

2.0 SCOPE OF WORK

Sterling IAQ conducts the following scope of work when we complete proactive indoor air quality testing.

- Measurement of common indoor air quality (IAQ) parameters in various sites within the subject area using direct reading instantaneous monitors:
  - Total volatile organic compounds (TVOC) – as an indicator of potential off-gassing building materials or other indoor sources of organic compounds.
  - Carbon dioxide (CO_2) – as an indicator of the effectiveness of the ventilation system at providing sufficient amounts of outdoor air to the occupied spaces of a building.
  - Carbon monoxide (CO) – as a measurement of combustion sources potentially affecting the indoor air quality.
  - Temperature & relative humidity – comfort parameters.
  - Particulates (PM_{10}) – as a measurement of the ability of the ventilation system to remove particulate from the outdoor air and as a measurement of potential indoor sources of particulate.

For the purpose of this report on wildfire smoke, we will focus only on the PM_{10} measurements as those appear to be most applicable.

3.0 METHODOLOGY

Indoor Air Quality Monitoring

Indoor air quality monitoring was conducted by our trained site technicians using properly calibrated direct reading instantaneous instruments. Measurements for particulates were acquired using a Thermo Scientific pDR-1500 particulate meter. This instrument was connected to an AdvancedSense handheld computer and logged data instantaneously on site while Sterling IAQ denoted locations of testing.

4.0 APPLICABLE GUIDELINE

For the purpose of reporting on our proactive indoor air quality testing projects, we have been referencing the Canada Green Building Corporation (CaGBC) for a PM_{10} guideline of 50 µg/m^3.

We understand there are many guidelines available for PM_{10} around the world but believe this CaGBC guideline is the most practical for the intent of our testing and reporting.

5.0 RESULTS AND DISCUSSION

A couple of observations should be stated regarding the sites tested between September 10, 2020 and October 6, 2020:

- Through reference to our extensive database of indoor and outdoor testing data, the historical **OUTDOOR** PM_{10} concentration around Metro Vancouver is 23.9 µg/m^3.
- Additionally, through reference to our extensive database of indoor and outdoor testing data, the historical **INDOOR** PM_{10} concentration around Metro Vancouver is 11.8 µg/m^3.
- All sites visited during the period of this assessment were only partially open to the public (appointment only) and/or were operating at 50% of its maximum capacity due to Covid-19 distancing restrictions.
- All sites visited from September 10 to October 6 in 2020 were not necessarily tested during the same date ranges in 2019. Availability for testing is granted by property managers and the time of year testing is conducted often changes.

5.1 Metro Vancouver's Air Quality Index

Environment and Climate Change Canada archives historical weather data, forecast and current conditions graphics that can be found online. According to **Image 5.1.1** courtesy of Environment and Climate Change Canada, an Air Quality Health Index (AQHI) can be read as followed:

Image 5.1.1 – Air Quality Health Index Risk Assessment

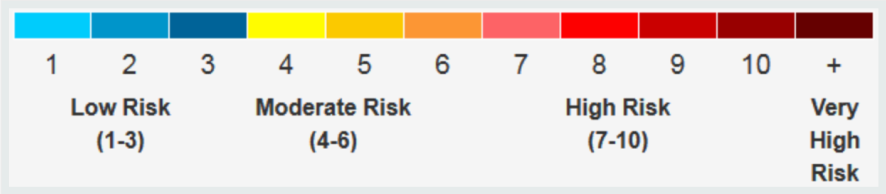
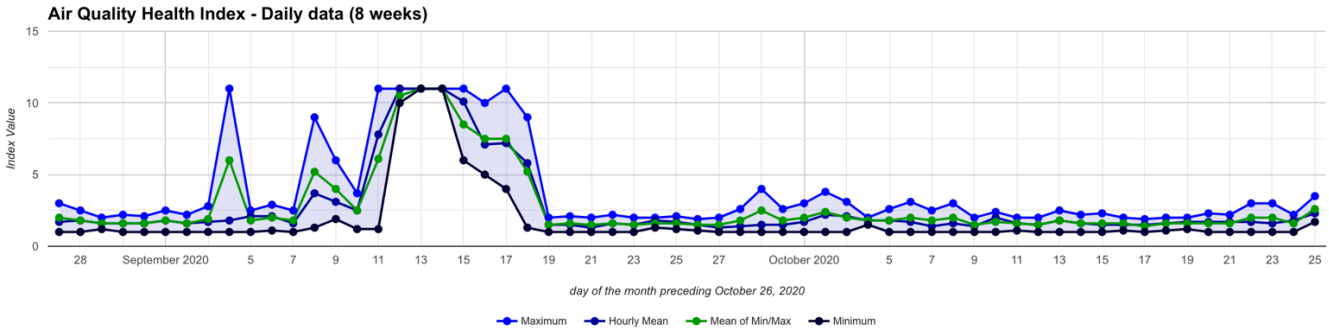


Image 5.1.2 below was acquired from https://vancouver.weatherstats.ca/charts/health_index-daily.html and presents the outdoor AQHI for Metro Vancouver in the months of September and October in 2020.

Image 5.1.2 – Air Quality Index (Metro Vancouver Area)
September – October 2020



Based on **Image 5.1.2** and **Table 5.1.1 (next page)**, the following was deduced and applied only to Metro Vancouver:

- AQHI generally remains consistent at around 2, when we exclude extremes, and this is classified as low risk
- An AQHI of 3.7 was reached on September 10, 2020 (Building A)
- An AQHI of 11 was reached on September 11, 2020 (Building B)
- An AQHI of 11 was reached on September 14, 2020 (Building C)
- An AQHI of 11 was reached on September 15, 2020 (Building D)
- An AQHI of 11 was reached on September 16, 2020 (Building E)
- An AQHI of 2 was reached on September 23, 2020 (Building F)
- An AQHI of 2.6 was reached on October 5, 2020 (Building G)
- An AQHI of 3.1 was reached on on October 6, 2020 (Building H)

Table 5.1.1 – Air Quality Index (Metro Vancouver Area)
September – October 2020

Date	Maximum	Hourly Mean	Mean of Min/Max	Minimum
Oct 6 2020	3.1	1.7	2.0	1.0
Oct 5 2020	2.6	1.8	1.8	1.0
Oct 4 2020	2.0	1.8	1.8	1.5
Oct 3 2020	3.1	2.1	2.0	1.0
Oct 2 2020	3.8	2.2	2.4	1.0
Oct 1 2020	3.0	1.7	2.0	1.0
Sep 30 2020	2.6	1.5	1.8	1.0
Sep 29 2020	4.0	1.5	2.5	1.0
Sep 28 2020	2.6	1.4	1.8	1.0
Sep 27 2020	2.0	1.3	1.5	1.0
Sep 26 2020	1.9	1.5	1.5	1.1
Sep 25 2020	2.1	1.7	1.6	1.2
Sep 24 2020	2.0	1.8	1.6	1.3
Sep 23 2020	2.0	1.5	1.5	1.0
Sep 22 2020	2.2	1.6	1.6	1.0
Sep 21 2020	2.0	1.3	1.5	1.0
Sep 20 2020	2.1	1.5	1.6	1.0
Sep 19 2020	2.0	1.5	1.5	1.0
Sep 18 2020	9.0	5.8	5.2	1.3
Sep 17 2020	11.0	7.2	7.5	4.0
Sep 16 2020	10.0	7.1	7.5	5.0
Sep 15 2020	11.0	10.1	8.5	6.0
Sep 14 2020	11.0	11.0	11.0	11.0
Sep 13 2020	11.0	11.0	11.0	11.0
Sep 12 2020	11.0	11.0	10.5	10.0
Sep 11 2020	11.0	7.8	6.1	1.2
Sep 10 2020	3.7	2.5	2.5	1.2
Sep 9 2020	6.0	3.1	4.0	1.9
Sep 8 2020	9.0	3.7	5.2	1.3

5.2 Indoor Air Quality Monitoring in Building A

Building A was first tested by Sterling IAQ in 2020 thus no reference from previous years is available. However, Building A is being shown as a way of representing the beginning of the rise of PM_{10} outdoors concentration due to smoke caused by wildfires that had started a couple of days before.

Table 5.2.1 – Average PM_{10} in Building A (Vancouver)
September 10, 2020

	PM_{10} (µg/m³)
Minimum	13.17
Maximum	23.31
Average	15.63
Outdoors	40.09
AQHI	3.7 - low to moderate risk

µg/m³ – micrograms per cubic meter

Building A appeared to provide good filtration of particulate from outdoor wildfire smoke as indoor PM_{10} concentrations consistently remained below the guideline of 50 µg/m³. And indoor results were relatively consistent with the historical indoor PM_{10} concentration of 11.8 µg/m³ found around Metro Vancouver.

It is worth noting that outdoor PM_{10} concentrations on September 10, 2020 were just starting to intensify around Vancouver and had yet to reach their peak. But it is also worth noting that the outdoor PM_{10} concentration of 40.09 µg/m³ measured on September 10, 2020 was considerably higher than the historical normal of 23.9 µg/m³ found around Metro Vancouver by Sterling IAQ.

5.3 Indoor Air Quality Monitoring in Building B

Similar to the previous building, Building B was first serviced by Sterling IAQ in 2020. Therefore, no data from previous years is available. However, it is noticeable that outdoors PM_{10} measurements had doubled in a time span of one day.

Table 5.3.1 – Average PM_{10} in Building B (Vancouver)
September 11, 2020

	PM_{10} (µg/m³)
Minimum	12.95
Maximum	68.42
Average	34.44
Outdoors	87.87
AQHI	11 - very high risk

µg/m³ – micrograms per meter cubed

Building B provided a fairly acceptable filtration of particulate from outdoor wildfire smoke as indoor PM_{10} concentrations were generally below the guideline of 50 µg/m³. Though, the maximum indoor concentration did reach 68.42 µg/m³ **(Table 5.3.1)**, the average concentration was well below 50 µg/m³.

Additionally, with the outdoor PM_{10} concentration starting to climb quite high, we began to see that the indoor concentrations also climbed higher as the indoor PM_{10} average concentration was 34.44 µg/m³ which was well above the historical normal indoor PM_{10} concentration of 11.8 µg/m³ found around Metro Vancouver.

Building B is a large downtown Vancouver office tower with centralized ventilation and filtration systems. So this data demonstrated that on a moderately high outdoor particulate day, indoor air quality was still within guideline levels for this particulate building.

5.4 Indoor Air Quality Monitoring in Building C

A comparison between PM_{10} measurements acquired in 2020 during the smoke period and in 2019 in building C can be found at **Table 5.4.1**.

Table 5.4.1 – Average PM_{10} in Building C (Richmond)
September 14, 2020 & June 10, 2019

	PM_{10} (µg/m³) 2020	PM_{10} (µg/m³) 2019
Minimum	346.13	19.56
Maximum	489.61	19.56
Average	411.49	15.37
Outdoors	688.84	17.96
AQHI	11 - very high risk	Not available

µg/m³ – micrograms per meter cubed

The 2019 data from Building C did demonstrate good indoor air quality as PM_{10} was very low and consistent with the historical norm of 11.8 µg/m³ found around Metro Vancouver. But the 2019 data was also interesting in that it did not show much filtration of particulate from the outdoor air as indoors was quite close to outdoors.

The 2020 PM_{10} data from Building C showed results consistently well above the guideline of 50 µg/m³. The average indoor PM_{10} concentration was measured to be 411.49 µg/m³ and the outdoor PM_{10} concentration was measured to be 688.84 µg/m³.

The 2020 PM_{10} data for Building C did show an improvement indoors versus outdoors. However, indoor results were still extremely elevated on this day of testing.

5.5 Indoor Air Quality Monitoring in Building D

A comparison between PM_{10} measurements acquired in 2020 during the smoke period and in 2019 in building D can be found at **Table 5.5.1**.

Table 5.5.1 – Average PM_{10} in Building D (Richmond)
September 15, 2020 & June 12, 2019

	PM_{10} (µg/m³) 2020	PM_{10} (µg/m³) 2019
Minimum	130.55	11.90
Maximum	181.53	17.10
Average	148.13	13.15
Outdoors	412.49	20.18
AQHI	11 - very high risk	Not available

µg/m³ – micrograms per meter cubed

The 2019 data from Building D did demonstrate good indoor air quality as PM_{10} was very low and consistent with the historical norm of 11.8 µg/m³ found around Metro Vancouver.

The 2020 PM_{10} data from Building D showed results consistently well above the guideline of 50 µg/m³ and historical norm of 11.8 µg/m³. The average indoor PM_{10} concentration was measured to be 148.13 µg/m³ and the outdoor PM_{10} concentration was measured to be 412.49 µg/m³.

This 2020 data did show that the overall filtration offered by the ventilation system of Building D did appear to offer a significant benefit. However, with the outdoor PM_{10} concentration being so extremely high, it is unlikely that any level of filtration could have yielded acceptable indoor PM_{10} on this particular day.

5.6 Indoor Air Quality Monitoring in Building E

A comparison between PM_{10} measurements acquired in 2020 during the smoke period and in 2019 in building E can be found at **Table 5.6.1**.

Table 5.6.1 – Average PM_{10} in Building E (Richmond)
September 16, 2020 & June 14, 2019

	PM_{10} (µg/m³) 2020	PM_{10} (µg/m³) 2019
Minimum	96.07	49.60
Maximum	157.47	58.60
Average	125.46	52.50
Outdoors	228.88	56.35
AQHI	11 - very high risk	Not available

µg/m³ – micrograms per meter cubed

The 2019 data from Building E did actually demonstrate poor indoor air quality as PM_{10} was consistently approaching or exceeding the guideline and well above the historical norm of 11.8 µg/m³ found around Metro Vancouver. But the 2019 data was also interesting in that it did not show much filtration particulate from the outdoor air.

The 2020 PM_{10} data from Building E showed results consistently well above the guideline of 50 µg/m³. The average indoor PM_{10} concentration was measured to be 125.46 µg/m³ and the outdoor PM_{10} concentration was measured to be 228.88 µg/m³.

This 2020 data did show that the overall filtration offered by the ventilation system of Building E did appear to offer a significant benefit. However, with the outdoor PM_{10} concentration being so extremely high, it is unlikely that any level of filtration could have yielded acceptable indoor PM_{10} on this particular day.

5.7 Indoor Air Quality Monitoring in Building F

A comparison between PM_{10} measurements acquired in the 2020 post-smoke period and in 2019 in building F can be found at **Table 5.7.1**.

Table 5.7.1 – Average PM_{10} in Building F (New Westminster)
September 23, 2020 & November 25, 2019

	Particulate (µg/m³) in 2020	Particulate (µg/m³) in 2019
Minimum	12.44	6.81
Maximum	46.18	22.61
Average	19.12	10.22
Outdoors	16.55	12.09
AQHI	2 – low risk	Not available

µg/m³ – micrograms per meter cubed

The 2019 data from Building F did demonstrate good indoor air quality as PM_{10} was very low and consistent with the historical norm of 11.8 µg/m³ found around Metro Vancouver. But the 2019 data was also interesting in that it did not show much filtration particulate from the outdoor air.

The 2020 PM_{10} data from Building F showed results consistently within the guideline of 50 µg/m³ but slightly higher than measured in 2019 and slightly higher than the historical norm of 11.8 µg/m³. The average indoor PM_{10} concentration was measured to be 19.12 µg/m³ and the outdoor PM_{10} concentration was measured to be 16.55 µg/m³.

On this testing day in 2020, the outdoor PM_{10} happened to be measured to be lower than found indoors and wildfire smoke did not appear to be affecting the Metro Vancouver area.

5.8 Indoor Air Quality Monitoring in Building G

A comparison between PM_{10} measurements acquired in 2020 during the smoke period and in 2019 in building G can be found at **Table 5.8.1**.

Table 5.8.1 – Average PM_{10} in Building G (Vancouver)
October 5, 2020 & June 26, 2019

	Particulate (µg/m³) in 2020	Particulate (µg/m³) in 2019
Minimum	**31.8**	**11.43**
Maximum	**56.36**	**17.12**
Average	**38.94**	**14.62**
Outdoors	**72.38**	**20.45**
AQHI	**2.6 – low risk**	Not available

µg/m³ – micrograms per meter cubed

The 2019 data from Building G did demonstrate good indoor air quality as PM_{10} was very low and consistent with the historical norm of 11.8 µg/m³ found around Metro Vancouver and within the guideline of 50 µg/m³.

In early October 2020, a second wave of wildfires in the United States resulted in smoke once again affecting the Metro Vancouver area and outdoors PM_{10} level started to climb once again.

The 2020 PM_{10} data from Building G showed results generally within the guideline of 50 µg/m³ but above the industry norm of 11.8 µg/m³ for Metro Vancouver. The average indoor PM_{10} concentration was measured to be 38.94 µg/m³ and the outdoor PM_{10} concentration was measured to be 72.38 µg/m³.

So it appears as though the filtration provided by the ventilation system of Building G did offer enough capture of particulate to ensure the indoor PM_{10} concentrations were still within guidelines.

5.9 Indoor Air Quality Monitoring in Building H

A comparison between PM_{10} measurements acquired in 2020 during the smoke period and in 2019 in Building H can be found at **Table 5.9.1**.

Table 5.9.1 – Average PM_{10} in Building H (Burnaby)
October 6, 2020 & November 28, 2019

	PM_{10} (µg/m³) 2020	PM_{10} (µg/m³) 2019
Minimum	14.84	5.86
Maximum	62.28	32.19
Average	21.14	8.41
Outdoors	63.27	9.36
AQHI	3.1 – low to moderate risk	Not available

µg/m³ – micrograms per meter cubed

The 2019 data from Building H did demonstrate good indoor air quality as PM_{10} was very low and consistent with the historical norm of 11.8 µg/m³ found around Metro Vancouver.

The 2020 PM_{10} data from Building H showed results generally within the guideline of 50 µg/m³ but higher than the historical norm of 11.8 µg/m³. The average indoor PM_{10} concentration was measured to be 21.14 µg/m³ and the outdoor PM_{10} concentration was measured to be 63.27 µg/m³.

6.0 SUMMARY OF RESULTS

Firstly, below is a summary of various details associated with our testing during the times where wildfire smoke affected Metro Vancouver in September/October 2020:

- From September 10 to October 6, 2020, Sterling IAQ conducted proactive IAQ testing in 8 buildings around Metro Vancouver.
- On days in September/October of 2020 where the AQHI was noted to be elevated, the Sterling IAQ outdoor PM_{10} measurements were also shown to be elevated when compared to our own historical data of outdoor measurements.
- During the 8 days of testing 8 different buildings, the AQHI and Sterling IAQ's outdoor particulate measurements were 'normal' only on 1 day (September 23, 2020).
- On 4 of the 8 days of testing, the AQHI was recorded at its maximum of 11.
- On 3 of the 8 days of testing, the AQHI was recorded to range from 2.6 to 3.7 and be in the low to moderate risk range.

Based on indoor and outdoor air monitoring results, comparisons to industry norms obtained from our extensive database, discussion of the Air Quality Health Index (AQHI) and comparison to data from previous years of testing, we our indoor air quality testing results are summarized below:

- When the outdoor AQHI and Sterling IAQ's outdoor PM_{10} measurements were 'normal' during testing of Building F, indoor PM_{10} was within the guideline of 50 $\mu g/m^3$, consistent with previous years of testing and consistent with the historical norm of 11.8 $\mu g/m^3$.
- When the outdoor AQHI and Sterling IAQ's outdoor PM_{10} measurements began to be slightly elevated for testing of Building A, Building G and Building H, indoor PM_{10} results still averaged within the guideline of 50 $\mu g/m^3$ but were higher than the historical norm of 11.8 $\mu g/m^3$.
    a. All PM_{10} measurements in Building A were within the guideline.
    b. PM_{10} measurements for Building G and H did exceed the guideline on a few occasions, but the overall average was comfortably below the guideline.

- When the outdoor AQHI was at its highest possible value (11) and Sterling IAQ's outdoor PM_{10} measurements were quite elevated (87.87 µg/m^3) for Building B, the indoor PM_{10} concentration averaged 34.44 µg/m^3 with a maximum level of 68.42 µg/m^3.
    a. Despite the AQHI being at its maximum of 11, this building still provided good overall PM_{10} concentrations.
    b. There were some measurements over the guideline of 50 µg/m^3 but when we reviewed all of the data, PM_{10} concentrations were usually below the guideline.
    c. This building was a larger downtown Vancouver office tower with centralized ventilation systems and filtration.
- When the outdoor AQHI was at its highest possible value (11) and Sterling IAQ's outdoor PM_{10} measurements were quite elevated (ranging from 228.88 to 688.84 µg/m^3) for Building C, Building D and Building E, the indoor PM_{10} concentrations were very elevated and well in excess of the 50 µg/m^3 guideline.
    a. These three buildings were smaller suburban type office buildings with compartment type rooftop HVAC units.
    b. In our experience, the filtration provided by these types of ventilation systems is not as efficient as that provided by centralized ventilation systems like those of high rise office towers.

7.0 OVERALL CONCLUSIONS

When the AQHI began to rise above normal around the Metro Vancouver area but still in the low to moderate risk range, indoor PM_{10} concentrations did climb above the historical norm (according to our Sterling IAQ database) but were still within guideline levels.

Therefore, this data showed that moderately elevated outdoor particulate levels were controlled adequately by the ventilation systems and filtration of the buildings. It appears as though buildings with rooftop compartment type ventilation systems (Building A and Building G) performed similarly to a newer modern building with centralized ventilation system (Building H) when the AQHI began to rise above normal background.

When the overall AQHI reached its maximum of 11, it appeared as though only buildings with centralized ventilation systems (like the office tower Building B - which is an older, professionally operated and maintained building) could offer enough filtration to still generate PM_{10} levels within guideline levels.

Smaller office/retail type buildings with various rooftop compartment type ventilation units did not appear capable of providing enough filtration to generate indoor PM_{10} concentrations within guidelines.