HVAC Air Quality, Ventilation & Covid-19

Sep 2022
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Indoor Air Quality

Terms used to describe indoor air quality

Odour/Smell , Dust/Gas Particles, Humidity, Temperature,

Vast subject e.g. car parks, process rooms, schools, offices etc.

Spaces which are occupied by human for considerable time of day e.g. schools & offices.

Dispersion of virus from a source in an enclosure.

NZS 4303 – 1990 Ventilation for Acceptable Indoor Air Quality

NZS 4303: 1990 using ASHRAE standard 62 – 1989 with amendments to suit New Zealand conditions.

Indoor air should not contain contaminants that exceed concentrations known to impair health or cause discomfort to occupants.

Function of factors e.g

1. Incoming outdoor air,
2. Usage of enclosed space,
3. Presence of contaminant sources and strength of such sources ,

Section 6.1 Ventilation Rate Procedure,

Section 6.2 Indoor Air Quality Procedure,

Section 6.1 Ventilation Rate Procedure

6.1.1 Acceptable Outdoor Air,

6.1.2 Outdoor Air Treatment,

Compare outdoor air contaminants with table 1,

If exceedance, then treat it.

If quality isn't achieved by treating with BEST technology, reduce volume for Rush times.

6.1.3 Ventilation Requirements & snippet of Note from Table 2.

TABLE 1
National Primary Ambient-Air Quality Standards for Outdoor Air as Set by the U.S. Environmental Protection Agency (Ref 19)

Contaminant	Long term Concentration ug/m³	Long term Concentration ppm	Long term Averaging	Short term Concentration ug/m³	Short term Concentration ppm	Short term Averaging
Sulfur dioxide	80	0.03	1 year	365	0.14	24 hours
Total Particulate	75[a]	—	1 year	260	—	24 hours
Carbon monoxide				40,000	35	1 hour
Carbon monoxide				10,000	9	8 hours
Oxidants (ozone)				235[b]	0.12[b]	1 hour
Nitrogen dioxide	100	0.055	1 year			
Lead	1.5	—	3 months[c]			

[a] Arithmetic mean

[b] Standard is attained when expected number of days per calendar year with maximal hourly average concentrations above 0.12 ppm (235 ug/m³) is equal to or less than 1, as determined by Appendix H to subchapter C, 40 CFR 50

[c] Three-month period is a calendar quarter.

Application	Estimated Maximum Occupancy P/100 m2	Outdor Air Requirements cfm /person	Outdor Air Requirements L/s /person
Offices			
Office space	7	20	10
Reception areas	60	15	8
Telecommunication centers and data entry areas	60	20	10
Conference rooms	50	20	10

* Table 2 prescribes supply rates of acceptable outdoor air required for acceptable indoor air quality. These values have been chosen to control CO_2 and other contaminants with an adequate margin of safety and to account for health variations among people, varied activity levels, and a moderate amount of smoking. Rationale, for CO_2 control is presented in Appendix D.

**Net occupiable space.

Section 6.1 Ventilation Rate Procedure

6.1.1 Acceptable Outdoor Air,

6.1.2 Outdoor Air Treatment,

Compare outdoor air contaminants with table 1,

Can this be applied to some area in NZ now ?

If exceedance, then treat it.

Treatment method to be decided to suit the particle size encountered.

If quality isn't achieved by treating with BEST technology, reduce volume for Rush times.

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National Primary Ambient-Air Quality Standards for Outdoor Air as Set by the U.S. Environmental Protection Agency (Ref 19)

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Section 6.1 Ventilation Rate Procedure

6.1.3 Ventilation Requirements & snippet of Note from Table 2.

		Outdor Air Requirements	
Application	Estimated Maximum Occupancy P/100 m2	cfm /person	L/s /person
2.2 INSTITUTIONAL FACILITIES			
Education			
Classroom	50	15	8
Laboratories	30	20	10
Offices			
Office space	7	20	10
Reception areas	60	15	8
Telecommunication centers and data entry areas	60	20	10
Conference rooms	50	20	10

3. DEFINITIONS (see Fig. 1)

absorption: the process of one substance entering into the inner structure of another.

acceptable indoor air quality: air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction.

Section 6.1 Ventilation Rate Procedure

6.1.3.2 Re-Circulation Criteria

Application	Estimated Maximum Occupancy P/100 m2	Outdor Air Requirements	
		cfm /person	L/s /person
2.2 INSTITUTIONAL FACILITIES			
Education			
Classroom	50	15	8
Laboratories	30	20	10
Offices			
Office space	7	20	10
Reception areas	60	15	8
Telecommunication centers and data entry areas	60	20	10
Conference rooms	50	20	10

It is to recoup portion of energy spent in conditioning air in enclosure.

Outdoor air + Recirculated air = Supply Air , Min Supply air rate to be as per Table 2.

Supply air's quality acceptance criteria is then determined by NZ4303-1990 Section 6.2.

Use air cleaning system in re-circulated air line or after mixing outdoor air with re-circulated.

Section 6.2 Indoor Air Quality Procedure

Compliance to section 6.1 deems indoor air quality acceptable.

However Section 6.2 uses a targeted approach.

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National Primary Ambient-Air Quality Standards for Outdoor Air as Set by the U.S. Environmental Protection Agency (Ref 19)

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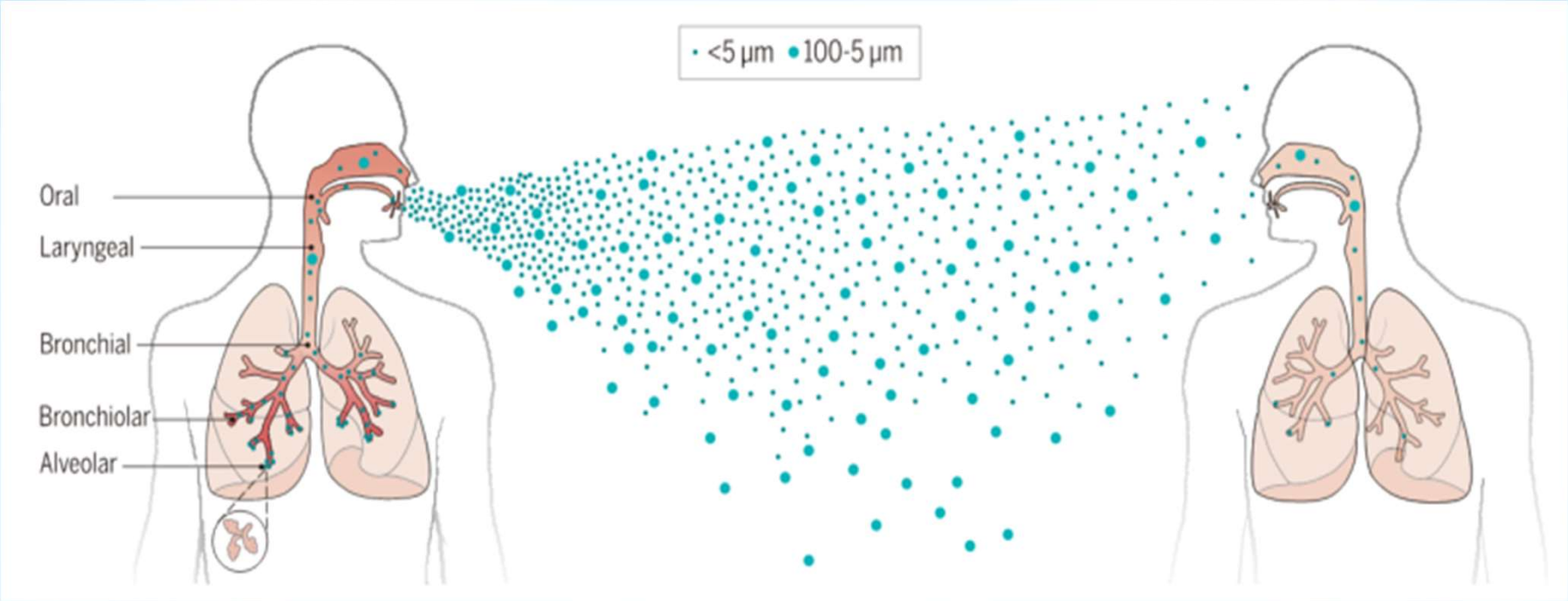
Table 1 from 6.1.1 & Table 3 from Section 6.2 show max contaminant concentration, exceedance of which deems air quality un comfortable, doesn't necessarily pose a health risk. The ventilation rates must then be worked out to ensure we do not exceed rates prescribed in afore mentioned table.

TABLE 3
GUIDELINES FOR SELECTED AIR CONTAMINANTS OF INDOOR ORIGIN

Contaminant	Concentration	ppm	Exposure Time	Comments
Carbon Dioxide	1.8 g/m³	1000*	Continuous	See Appendix D
Chlordane	5 ug/m³	0.0003	Continuous	Reference 27
Ozone	100 ug/m³	0.05	Continuous	Reference 28
Radon gas	100 Bq/m C3(EEC)**		Annual Average	Reference 42 and 43

*This level is not considered a health risk but is a surrogate for human comfort (odor). See Section 6.1.3 and Appendix D.
**EEC = Equilibrium Equivalent Concentration

Covid-19 and Ventilation

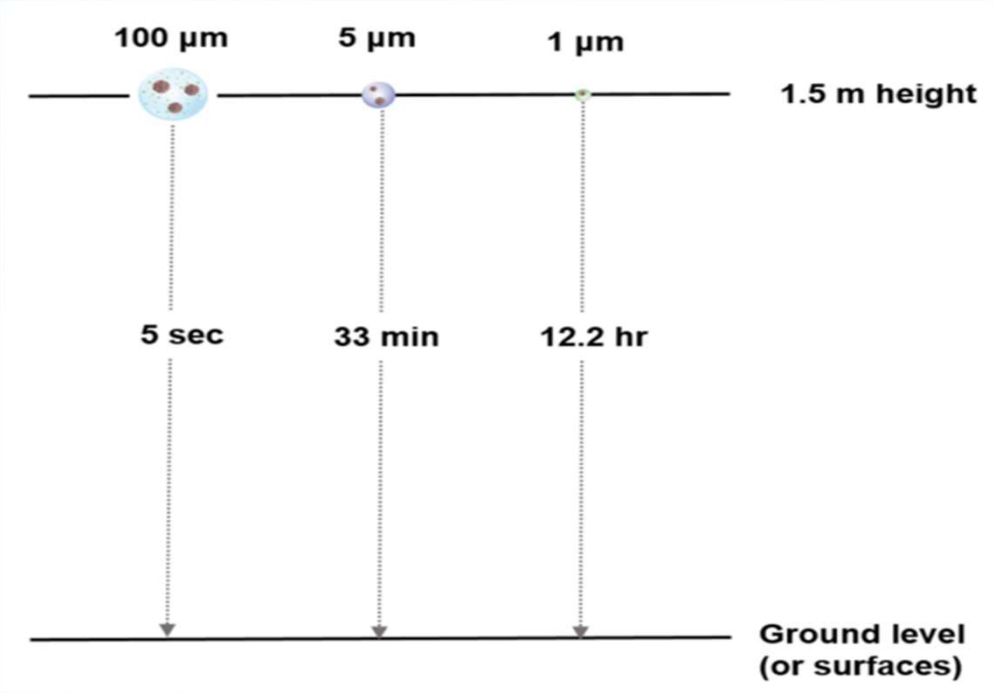


Reference: https://www.science.org/doi/10.1126/science.abd9149

Illustration of exhaled particles by an infected person (a) Aerosols, (b) Droplets.

Aerosols <5um & 5-10um. Can travel longer distance & time. Stay suspended in air.

Droplet > 10um. Such larger particles fall down nearby, can't travel as heavier. Can't be inhaled but can contaminate surface.



* Upon analysis of SARS-CoV-2 particles by electron microscopy, different researchers have had varying results, but the diameter of the virus has been found to range between 50 nm to 140 nm.

* Ref:

https://www.science.org/doi/10.1126/science.abd9149
https://www.news-medical.net/health/The-Size-of-SARS-CoV-2-Compared-to-Other-Things.aspx

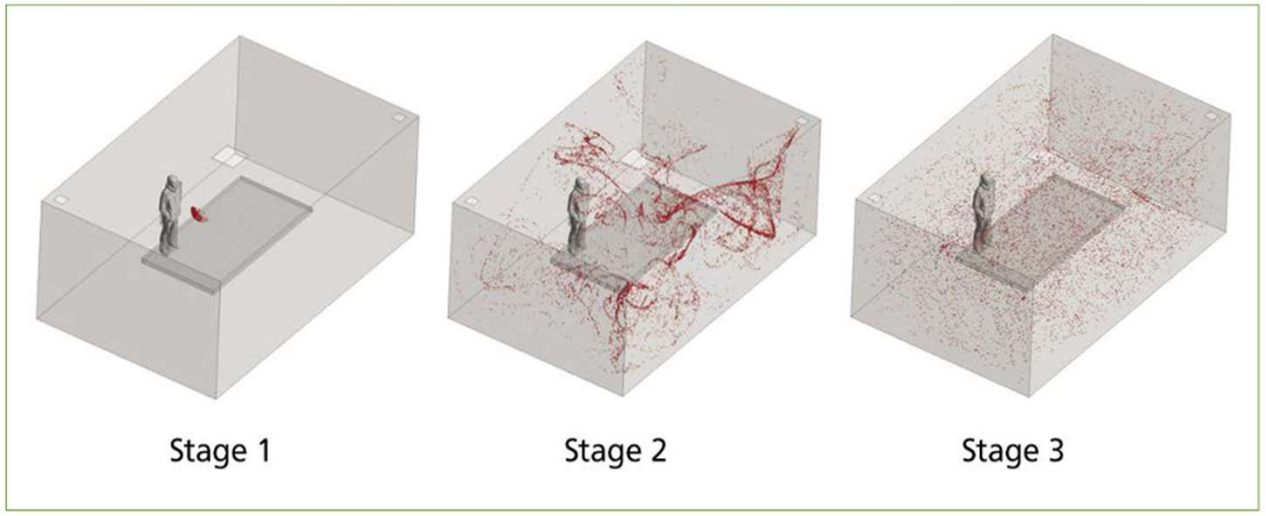
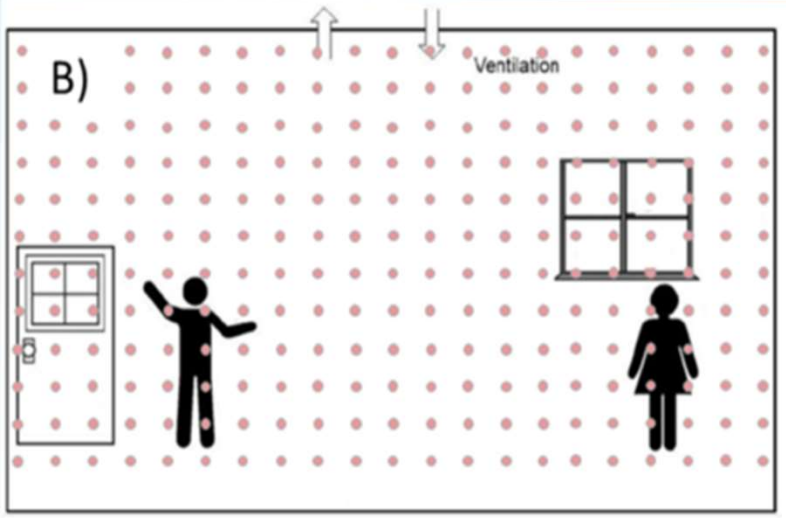
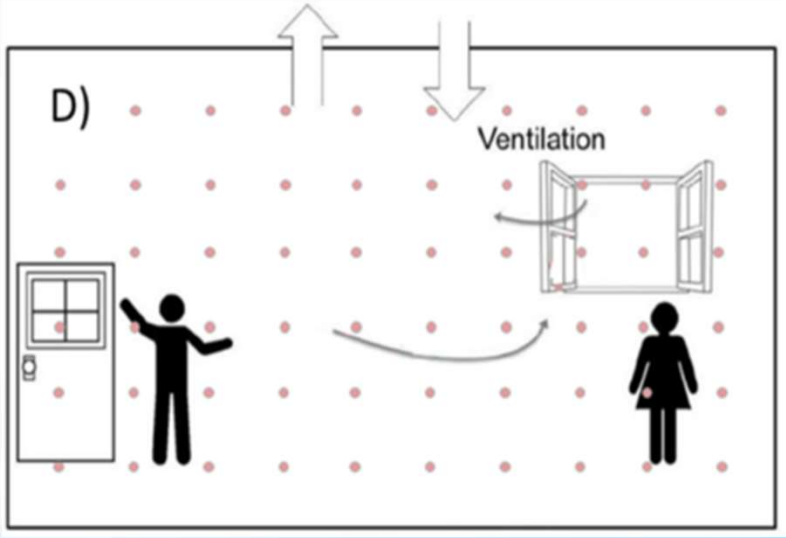


Figure 4. Stages of aerosol dispersion





* Note after some time the overall area becomes densely populated with particles = higher risk of exposure.

* With improved ventilation, we reduce the time period for which the virus particle would spend in the same enclosure.

Summary of COV-2?

* Covid is extremely tiny. Diameter in Nano meters.

* Small particles linger in the air for long periods of time, this increases contact time with virus.

* Best way to reduce contact time spent in the virus infected space is to replace the particle laden air with “clean air”

Metrics for clean air

* What does monitoring air quality look like?
* Not just CO2
  * VOC
  * PM
  * Humidity

Element	Air Quality Range							Unit
	A	B	C	D	E	F	G	
CO_2	400-500	501-600	601-800	801-1200	1201-1800	1801-1999	>2000	ppm
PM1.0	0	1-3	4-8	9-13	14-18	19-24	>25	µg/m3
PM2.5	0-2	3-4	5-8	9-13	14-18	19-24	>25	µg/m3
PM10	0-4	5-10	11-15	16-20	21-30	31-44	>45	µg/m3
VOC	0-50	51-150	151-250	251-300	301-350	351-450	451-500	Index

Metrics for clean air-co2

* CO2 measured in parts per million (ppm)
* Ministry of education requires us to maintain 1200ppm or lower on average.
* The maximum peak concentration for any teaching day should not exceed 3000ppm.
* Generally aiming for 800ppm or lower is desired.

Metrics for clean air-VOC

* Volatile organic compounds (VOC) are compounds that easily become vapors or gases.
* Occur from a myriad of products, including carpet adhesives, paint, cleaning products and furniture.
* Common types of VOC's:
  * benzene, acetone, ethylene glycol, formaldehyde, methylene chloride, perchloroethylene, toluene, xylene, and 1,3-butadiene

Metrics for clean air-PM

* Particulate matter (PM) is everything in the air that is not a gas. (dust, pollen, mould etc)
* Due to the small size of many of the particles that form PM some of these toxins may enter the bloodstream and be transported around the body.
* Commonly grouped as PM10,PM2.5 and PM1 (micrometers in diameter)

Score for clean air

Element	Air Quality Range							Unit
	A	B	C	D	E	F	G	
CO_2	400-500	501-600	601-800	801-1200	1201-1800	1801-1999	>2000	ppm
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PM2.5	0-2	3-4	5-8	9-13	14-18	19-24	>25	µg/m3
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VOC	0-50	51-150	151-250	251-300	301-350	351-450	451-500	Index

Ventilation

Natural and Mechanical

Natural Ventilation

Mainly achieved by opening windows to allow for cross ventilation.

Could become uncomfortable for occupants due to drafts, sun rays, temperature, rain, outdoor noise, dirt-dust.

Calm wind may not bring effective cross ventilation.

Window layout may not be suitable to provide sufficient natural ventilation.

Energy used to heat/cool air gets lost.

Mechanical Ventilation

* Use of fans to supply filtered fresh air or recirculate filtered air.
* Mechanical ventilation metrics like air change per hour, air volume delivered per floor area etc. as prescribed by NZS4303.
* Has its limitations e.g. spatial or acoustic constraints for increasing ventilation rates, aesthetic and cost.

What if we can't increase ventilation rates ?

Indoor Air Cleaning

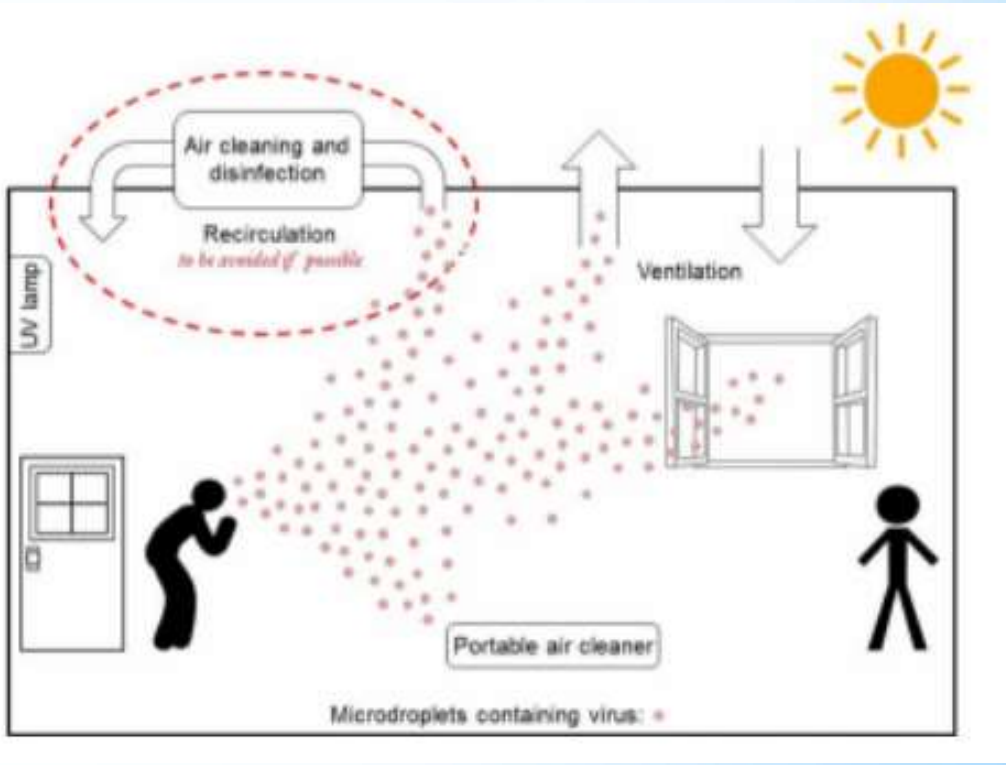
* If we can't deliver and/or increase existing fresh air supply consider cleaning the air available instead.

* Clean air using best and safe available indoor air cleaning technologies.

* **Does not reduce CO2**

so can't replace

min outdoor air intake.



Indoor Air Cleaning

* **Use short-wave ultraviolet light (UV-C light) to inactivate airborne pathogens and microorganisms like mold, bacteria and viruses.**
* Plasma cleaners-Air that passes through the device is briefly switched to the energetic state of non-thermal (NT) plasma which positively charges the molecules to neutralise the viruses and bacteria
* Be aware that some devices can cause/ introduce Ozone- reputable manufactures eliminate this. ASHRAE prohibits use of Ozone emitting devices.

Indoor Air Cleaning

Filter media traps air-born particles that get entrained with the air.

G4

F7

F9

HEPA

Some filters require in depth changing process as the bacteria/ virus still remains active within the media.

Clean Air Delivery Rate (CADR)

- The amount of clean air supplied to an area (l/s).
- Can be achieved by more fresh air (ventilation) or by cleaning the air with filters, UV, Air purifiers, etc.
- Eg. If a filter removes 80% of a virus and has an airflow of 1,000l/s the CADR is 800l/s.

* 5. For example, if the floor area of a room measures 4 metres x 5 metres, the floor is 4×5=20 square metres. If the ceiling is 3 metres high, the room volume is 20 x 3=60 cubic metres. If an air cleaner has a CADR of 300 cubic metres per hour, it will give 300/60=5 extra air changes per hour. This is in addition to the air changes that the ventilation system makes, which is usually at least 1-2 air changes per hour, so this room now has 6-7 air changes per hour, which is good. A room twice this size could have two air cleaners. If CADR is stated in cubic metres per hour, make sure your room volume is also measured in cubic metres. If CADR is stated in cubic feet per hour, either convert it to cubic metres per hour, or measure the relevant room volume in cubic feet.

* As per Otago University Health professor
* The CADR number should be two to four times the volume of the relevant room.

Thank You

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