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Innova NanoJet CDA Pro Air Scrubber

The Liverpool Biovalidation Laboratory

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Innova NanoJet Biovalidation Report March 2025

Introduction

This report relates to the Biovalidation of the Innova (the Client) NanoJet CDa Pro to the Liverpool Biovalidation Protocol modified (see the notes at each test report section) as per the Client's instructions at the laboratory of the NHS Health Innovation NWC at the Feedwater site, Moreton on Wirral. The Standard Protocol can be found at the end of this report or on the IAQS (Indoor Air Quality Society) website.

Methodology

The standardised method (the Protocol) for the biovalidation of air purifiers (a.k.a. air scrubbers) is developed for NHS Supply Chain. The Protocol determines the clearance rate of aerosolized *Micrococcus luteus* in a closed room-sized chamber achieved by the air scrubber under test. Aerosolization of the bacterium suspension is by venturi nebuliser. Air sampling is by a Coriolis air-to-liquid impinger. Collected samples are spiral plated on to agar plates. After incubation, colony development is quantified as the number of 'specific' colony-forming units using a dedicated image processor. Microbiology laboratory is accredited to ISO/IEC 17025:2017. Clearance rates are inferred from data represented by a first order exponential decay model.

Due to different working principle of the Innova NanoJet device to the conventional UVC-, HEPA- and Electrostatic-based air purifiers, modification based on the 'Protocol' has been conducted. The exceptions from the 'Protocol' are listed before each set of data.

Validation of the Innova NanoJet CDa Pro Air Scrubber to the Liverpool Biovalidation Protocol with 5-minute sprays

Innova NanoJet CDa Pro

Room Size	53	m^3
Ceiling Height	2.2	m
Spray Time	5	mins

T0 Bacteria Concentration 8.62×10^5 to 1.06×10^6 CFU/m^3

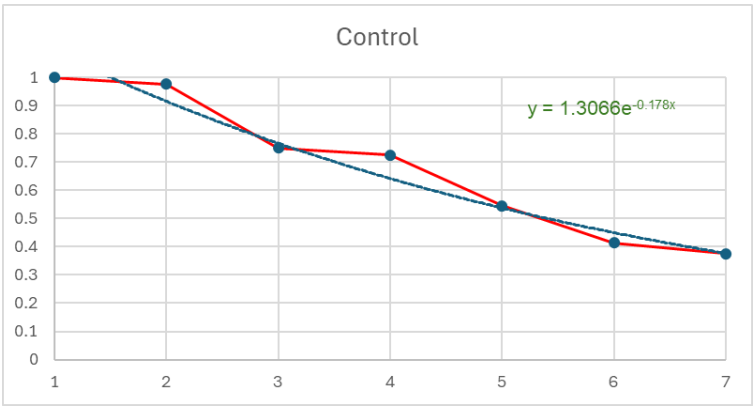
NanoJet configured to dispense horizontally

Room highly mixed with x4 fans set as per the Liverpool Protocol

26/07/2024

Control

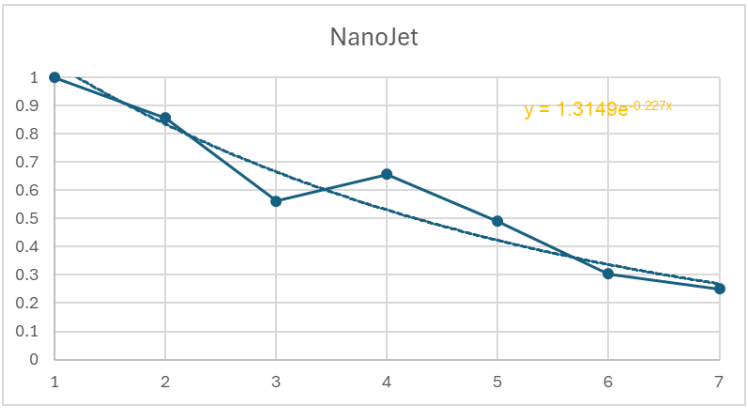
Time (mins)	Counts A	Counts B	Av. Counts	Norm.
Init (Zero)	56900	42300	56900	1.00
10	55600	55500	55550	0.98
20	39400	46000	42700	0.75
30	41600	40900	41250	0.72
40	29200	32800	31000	0.54
50	20500	26500	23500	0.41
60	23900	18900	21400	0.38



26/07/2024

n=1

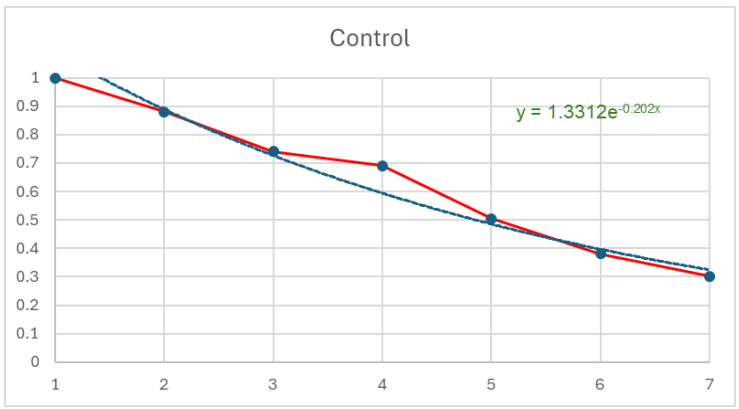
Time (mins)	Counts A	Counts B	Av. Counts	Norm.
Init (Zero)	61100	61100	61100	1.00
10	45300	59300	52300	0.86
20	30700	38000	34350	0.56
30	39400	40900	40150	0.66
40	30700	29200	29950	0.49
50	19300	17800	18550	0.30
60	15900	14800	15350	0.25



26/07/2024

Control

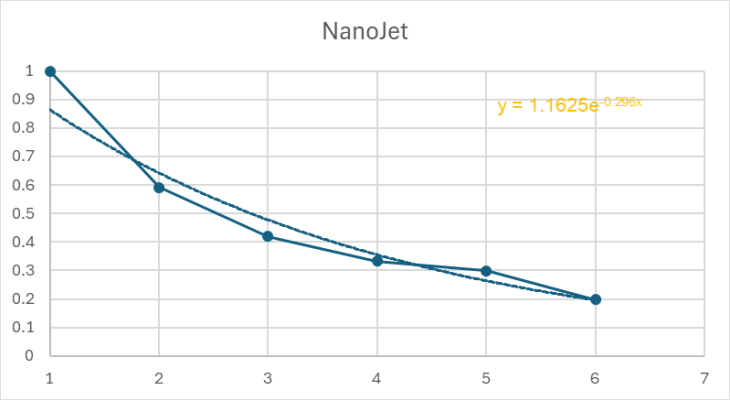
Time (mins)	Counts A	Counts B	Av. Counts	Norm.
Init (Zero)	62000	53300	57650	1.00
10	51100	50400	50750	0.88
20	37200	48200	42700	0.74
30	34300	45300	39800	0.69
40	32100	26100	29100	0.50
50	21200	22700	21950	0.38
60	15200	19700	17450	0.30



26/07/2024

n=2

Time (mins)	Counts A	Counts B	Av. Counts	Norm.
Init (Zero)	70400	70400	70400	1.00
10	44500	38700	41600	0.59
20	32100	27000	29550	0.42
30	26100	20800	23450	0.33
40	20800	21200	21000	0.30
50	11600	16300	13950	0.20



Summary Results

A and k determined from the runs *viz* $y = Ae^{kt}$

For illustration, parameters evaluated at Clearances [%] of 63.3, 90 & 99

Note: a Clearance of 63.3% corresponds to an equivalent x1 Air-Change-per-Hour (ACH) or 53m^3.

Run	Type	A (Scaling Constant)	k (Time Constant)	Residual [fractional]	Clearance [%]	Time [slot]	Time [mins]
#1	Control	1.3066	-0.178	0.37	63.3	7.09	60.88
				0.10	90	14.44	134.38
				0.01	99	27.37	263.74
	NanoJet	1.3149	-0.227	0.37	63.3	5.59	45.86
				0.10	90	11.35	103.50
				0.01	99	21.49	204.93
#2	Control	1.3312	-0.202	0.37	63.3	6.34	53.38
				0.10	90	12.82	118.15
				0.01	99	24.21	232.14
	NanoJet	1.1625	-0.296	0.37	63.3	3.87	28.68
				0.10	90	8.29	72.88
				0.01	99	16.07	150.67

Time [mins] @ Clearance of x1 ACH (63.3%), x1 & x2 log10 reductions after application CDa Pro for 5 mins			
	63.3%	1 x log10	2 x log10
Mean Control	57.13	126.28	247.94
Mean NanoJet	37.27	176.38	177.8

Validation of the Innova NanoJet CDa Pro Air Scrubber to the Liverpool Biovalidation Protocol with 10-minute sprays at different directions

Innova NanoJet CDa Pro

Room Size	53	m^3
Ceiling Height	2.2	m
Spray Time	10	mins

T0 Bacteria Concentration 6.96×10^5 to 1.37×10^6 CFU/m^3

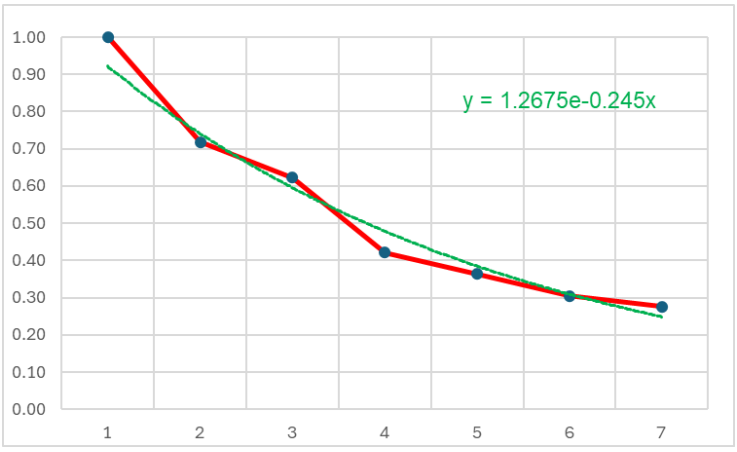
NanoJet configured to dispense horizontally towards different directions.

Room highly mixed with x4 fans set as per the Liverpool Protocol

21/11/2024

Control

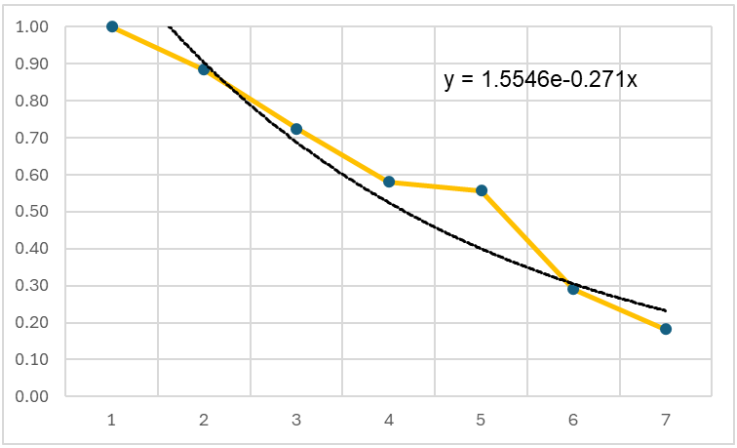
Time (mins)	Counts A	Counts B	Av. Counts	Norm.
Init (Zero)	49600	42300	45950	1.00
10	33013	33013	33013	0.72
20	29900	27300	28600	0.62
30	22000	16700	19350	0.42
40	15200	18200	16700	0.36
50	12500	15500	14000	0.30
60	12359	13004	12682	0.28



21/11/2024

n=1 NanoJet Vertica

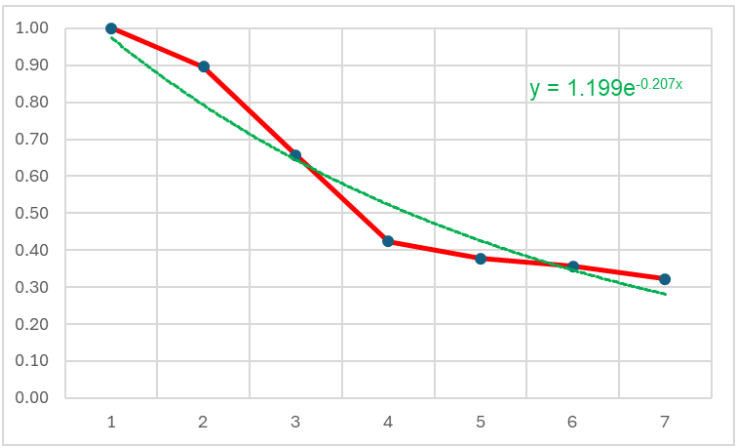
Time (mins)	Counts A	Counts B	Av. Counts	Norm.
Init (Zero)	88461	87843	88152	1.00
10	71696	84271	77984	0.88
20	55818	71942	63880	0.72
30	50136	52323	51230	0.58
40	48953	49272	49113	0.56
50	26120	25205	25663	0.29
60	15978	16086	16032	0.18



21/11/2024

Control

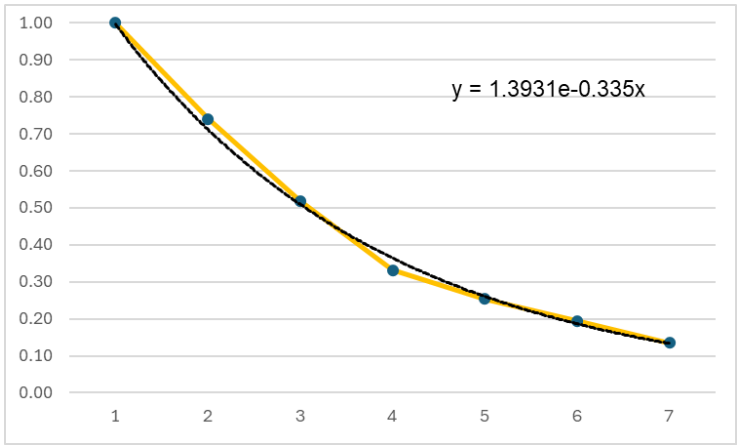
Time (mins)	Counts A	Counts B	Av. Counts	Norm.
Init (Zero)	46000	58400	52200	1.00
10	43100	50400	46750	0.90
20	33600	35000	34300	0.66
30	23100	21200	22150	0.42
40	19300	20100	19700	0.38
50	17119	20100	18610	0.36
60	16001	17603	16802	0.32



21/11/2024

n=2 NanoJet Vertica

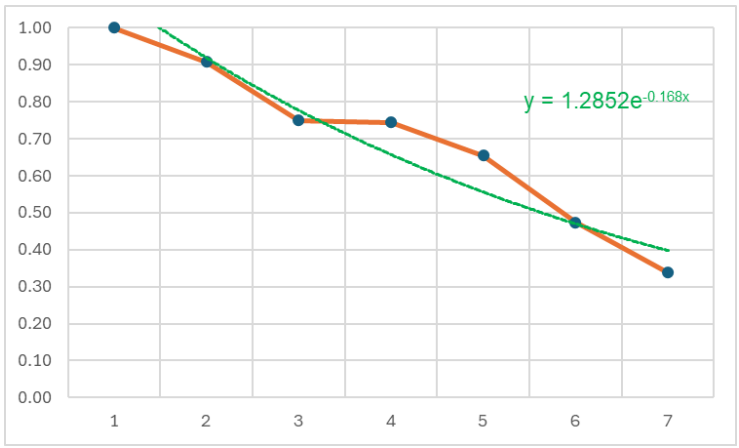
Time (mins)	Counts A	Counts B	Av. Counts	Norm.
Init (Zero)	54671	54910	54791	1.00
10	36411	44770	40591	0.74
20	28137	28776	28457	0.52
30	19842	16530	18186	0.33
40	13796	14022	13909	0.25
50	8990	12309	10650	0.19
60	6760	8100	7430	0.14



22/11/2024

Control

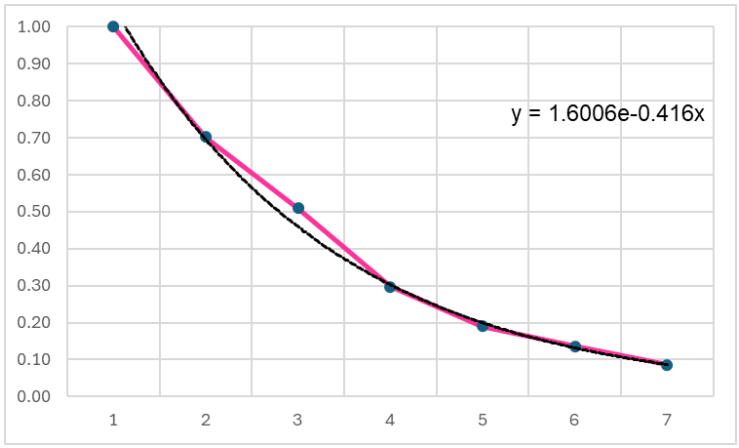
Time (mins)	Counts A	Counts B	Av. Counts	Norm.
Init (Zero)	85400	90700	88050	1.00
10	80009	79991	80000	0.91
20	63500	68500	66000	0.75
30	65400	65600	65500	0.74
40	58700	56508	57604	0.65
50	39000	44500	41750	0.47
60	25500	34003	29752	0.34



22/11/2024

n=3 NanoJet Horizontal

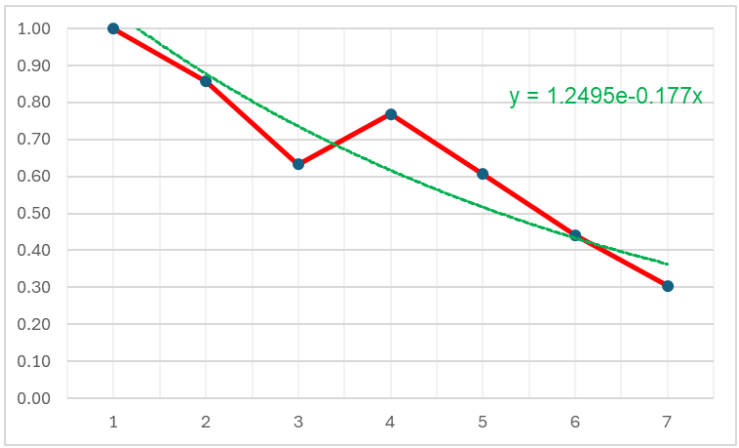
Time (mins)	Counts A	Counts B	Av. Counts	Norm.
Init (Zero)	48739	49496	49118	1.00
10	33194	35850	34522	0.70
20	24713	25292	25003	0.51
30	14703	14513	14608	0.30
40	8822	9835	9329	0.19
50	5359	7963	6661	0.14
60	3754	4657	4206	0.09



22/11/2024

Control

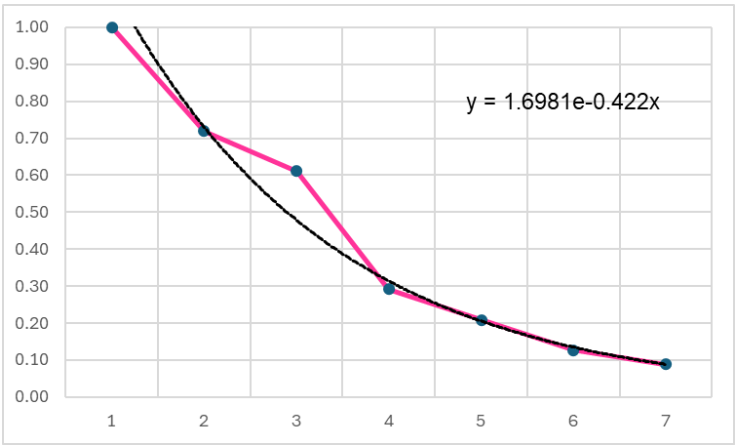
Time (mins)	Counts A	Counts B	Av. Counts	Norm.
Init (Zero)	79171	101106	90139	1.00
10	84792	69742	77267	0.86
20	49509	64587	57048	0.63
30	66800	71782	69291	0.77
40	59250	50166	54708	0.61
50	40194	39283	39739	0.44
60	23050	31780	27415	0.30



22/11/2024

n=4 NanoJet Horizontal

Time (mins)	Counts A	Counts B	Av. Counts	Norm.
Init (Zero)	50621	46951	48786	1.00
10	27159	43043	35101	0.72
20	29713	29898	29806	0.61
30	15469	12999	14234	0.29
40	9996	10313	10155	0.21
50	5715	6664	6190	0.13
60	4310	4336	4323	0.09



Summary Results

A and k determined from the runs *viz* $y = Ae^{kt}$

For illustration, parameters evaluated at Clearances [%] of 63.3, 90 & 99

Note: a Clearance of 63.3% corresponds to an equivalent x1 Air-Change-per-Hour (ACH) or 53m^3.

Run	Type	A (Scaling Constant)	k (Time Constant)	Residual [fractional]	Clearance [%]	Time [slot]	Time [mins]
#1	Control	1.2675	-0.245	0.37	63.3	5.03	40.26
				0.10	90	10.37	93.66
				0.01	99	19.76	187.64
	NanoJet Vertical	1.5546	-0.271	0.37	63.3	5.30	42.97
				0.10	90	10.12	91.25
				0.01	99	18.62	176.21
#2	Control	1.199	-0.207	0.37	63.3	5.68	46.80
				0.10	90	12.00	110.00
				0.01	99	23.12	221.24
	NanoJet Vertical	1.3931	-0.335	0.37	63.3	3.96	29.58
				0.10	90	7.86	68.63
				0.01	99	14.74	137.36
#3	Control	1.2852	-0.168	0.37	63.3	7.41	64.12
				0.10	90	15.20	141.99
				0.01	99	28.91	279.05
	NanoJet Horizontal	1.6006	-0.416	0.37	63.3	3.52	25.21
				0.10	90	6.67	56.66
				0.01	99	12.20	112.01
#4	Control	1.2495	-0.177	0.37	63.3	6.88	58.76
				0.10	90	14.27	132.67
				0.01	99	27.28	262.76
	NanoJet Horizontal	1.6981	-0.422	0.37	63.3	3.61	26.11
				0.10	90	6.71	57.11
				0.01	99	12.17	111.67

Time [mins] @ Clearance of x1 ACH (63.3%), x1 & x2 log10 reductions after application CDa Pro for 10 mins			
	63.3%	1 x log10	2 x log10
Mean Control	52.49	126.28	247.94
Mean NanoJet Vertical	36.28	79.94	156.79
Mean NanoJet Horizontal	25.66	56.89	111.84

Validation of the Innova NanoJet CDa Pro Air Scrubber to the Liverpool Biovalidation Protocol with Different Concentrations of Bacteria

Innova NanoJet CDa Pro

Room Size 53 m^3

Ceiling Height 2.2 m

Sampling Direct air-to-TSA agar 90cm plates

- MicroBio MB-1 sampler
- Sample volume: 50L (50l) in 30s
- Colony counting as CFU: manual

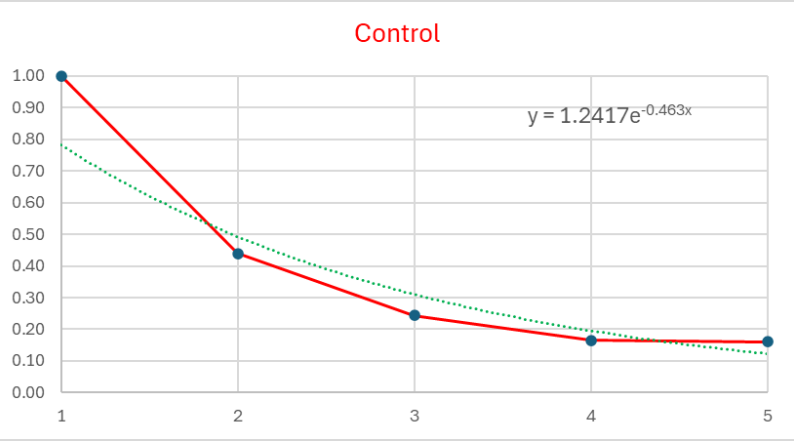
***Luteus* inoculation** 1000µl at 10-3 dilution of Standard Concentration in MRD

T0 Bacteria Concentration 3200 to 4200 CFU/m^3

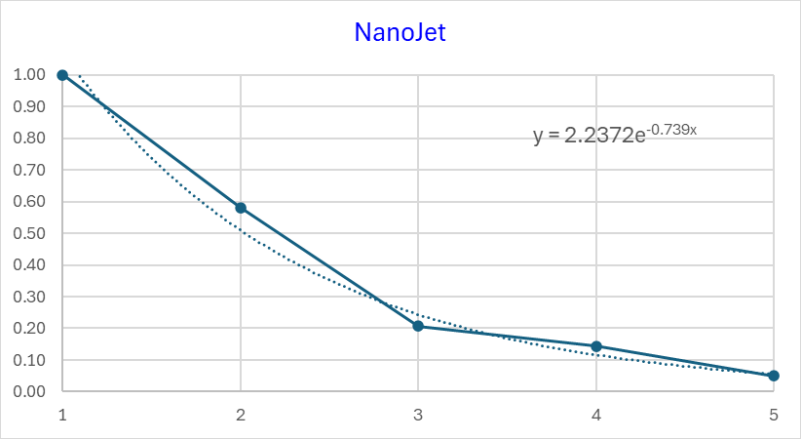
NanoJet configured to dispense horizontally towards the sampler.

Room highly mixed with x4 fans set as per the Liverpool Protocol

24/12/2024			
Control	**Time (mins)**	**Counts**	**Norm.**
	Init (Zero)	205	1.00
	10	90	0.44
	20	50	0.24
	30	34	0.17
	40	33	0.16



24/12/2024			
n=1	**Time (mins)**	**Counts**	**Norm.**
	Init (Zero)	160	1.00
	10	93	0.58
	20	33	0.21
	30	23	0.14
	40	8	0.05



Summary Results

A and k determined from the runs *viz* $y = Ae^{kt}$

For illustration, parameters evaluated at Clearances [%] of 63.3, 90 & 99

Note: a Clearance of 63.3% corresponds to an equivalent x1 Air-Change-per-Hour (ACH) or 53m^3.

Run	Type	A (Scaling Constant)	k (Time Constant)	Residual [fractional]	Clearance [%]	Time [slot]	Time [mins]
#1	Control	1.2417	-0.463	0.37	63.3	2.61	16.15
				0.10	90	5.44	44.41
				0.01	99	10.41	94.14
	NanoJet	2.2372	-0.739	0.37	63.3	2.44	14.35
				0.10	90	4.21	32.05
				0.01	99	7.32	63.21

Validation of precipitated bacteria with the Innova NanoJet CDa Pro Air Scrubber to the modified Liverpool Biovalidation Protocol

Innova NanoJet CDa Pro

Room Size	53	m^3
Ceiling Height	2.2	m

Sampling

Impact samples were made using the MicroBio Impact Sampler:

- Flow rate: 100 litres/min
- Sampling time 30s

Agar plates were TSA (tryptic soy agar)

- Incubated at 30C for 48 hours
- Manual reading

  Specific to identifiable *luteus* cfu's

  Discarded if interfering fungal or 'non-specific' bacterial contamination

Trial Run

30 minutes
Impact sampling at [0,10, 20, 30] minutes (*viz* x4 samples)
Passive settle plates [0-10, 10-20, 20-30] (*viz* x3 samples)

T0 Bacteria Concentration 2400 to 3100 CFU/m^3

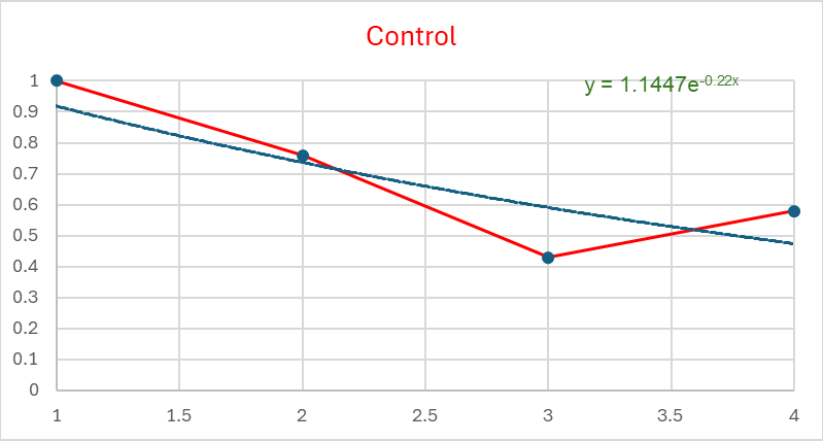
Trials were run as pairs of 'Controls' and '10 minute NanoJet treatments'

Fallow time of 2 hours between repeat runs

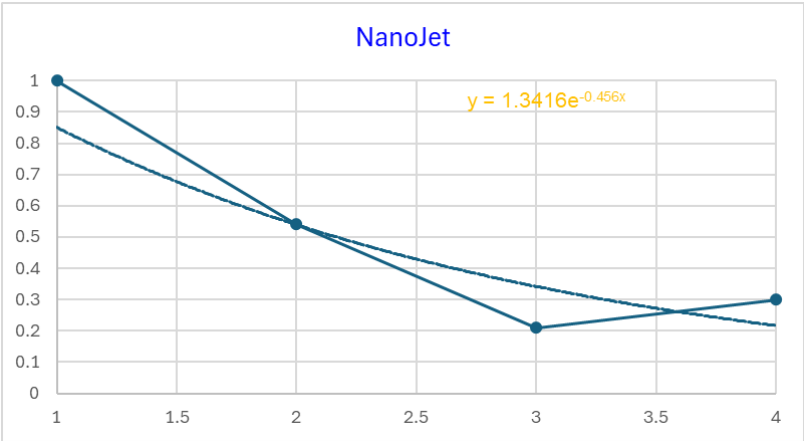
NanoJet configured to dispense horizontally towards the sampler.

Room highly mixed with x4 fans set as per the Liverpool Protocol

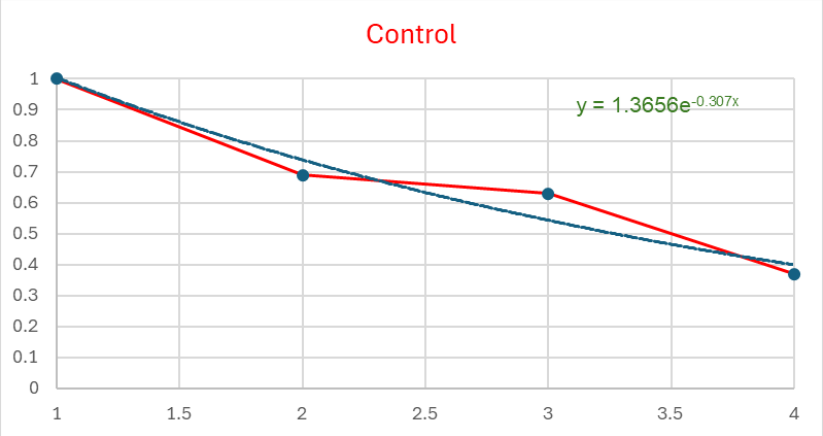
11/03/2025			
Control	**Time (mins)**	**Counts**	**Norm.**
	Init (Zero)	144	1.00
	10	110	0.76
	20	62	0.43
	30	83	0.58



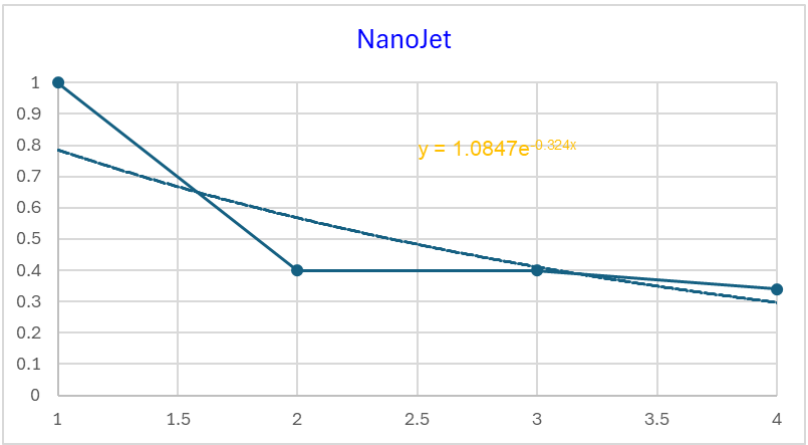
11/03/2025			
n=1	**Time (mins)**	**Counts**	**Norm.**
	Init (Zero)	154	1.00
	10	83	0.54
	20	32	0.21
	30	46	0.30



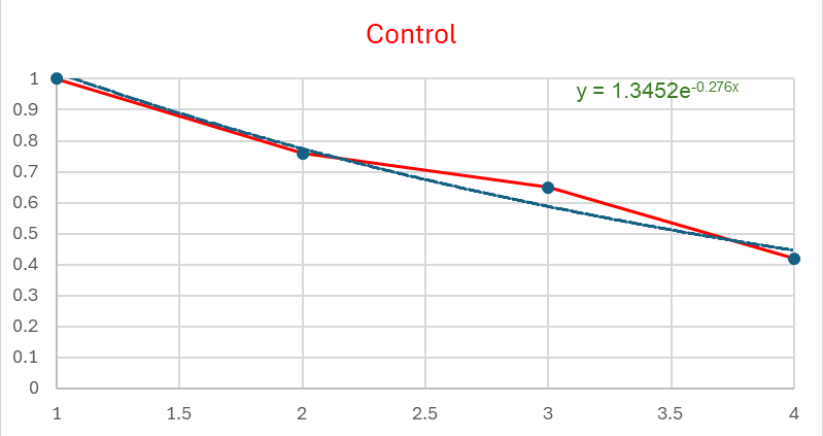
11/03/2025			
Control	Time (mins)	Counts	Norm.
	Init (Zero)	147	1.00
	10	101	0.69
	20	93	0.63
	30	54	0.37



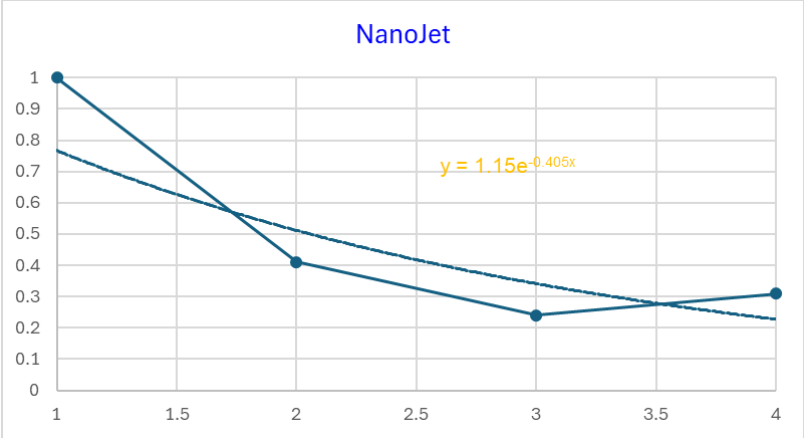
11/03/2025			
n=2	Time (mins)	Counts	Norm.
	Init (Zero)	139	1.00
	10	56	0.40
	20	56	0.40
	30	47	0.34



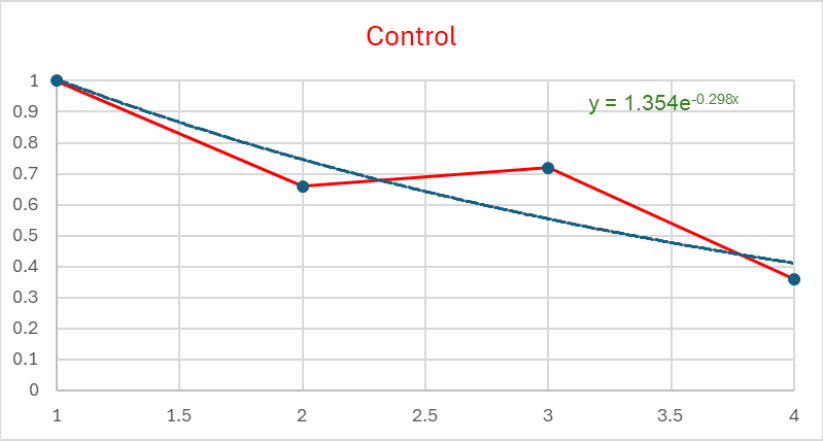
11/03/2025			
Control	**Time (mins)**	**Counts**	**Norm.**
	Init (Zero)	139	1.00
	10	105	0.76
	20	90	0.65
	30	59	0.42



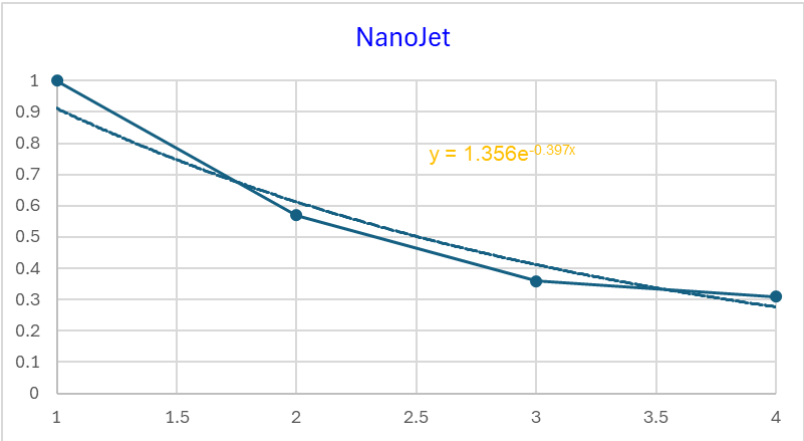
11/03/2025			
n=4	**Time (mins)**	**Counts**	**Norm.**
	Init (Zero)	127	1.00
	10	52	0.41
	20	31	0.24
	30	39	0.31



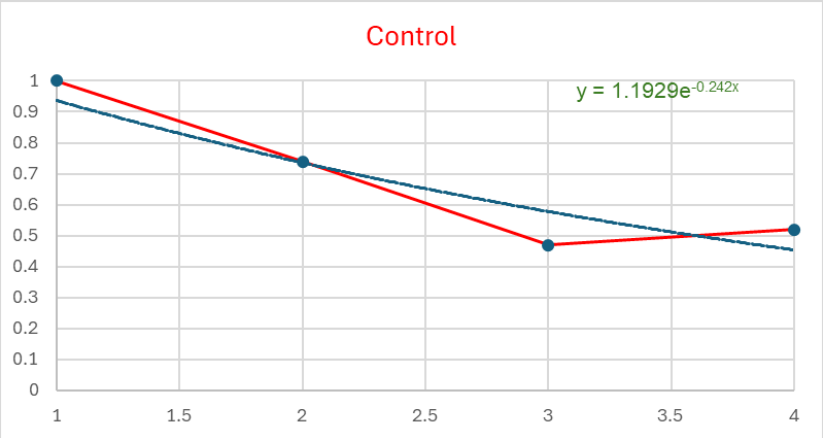
11/03/2025			
Control	**Time (mins)**	**Counts**	**Norm.**
	Init (Zero)	137	1.00
	10	90	0.66
	20	99	0.72
	30	49	0.36



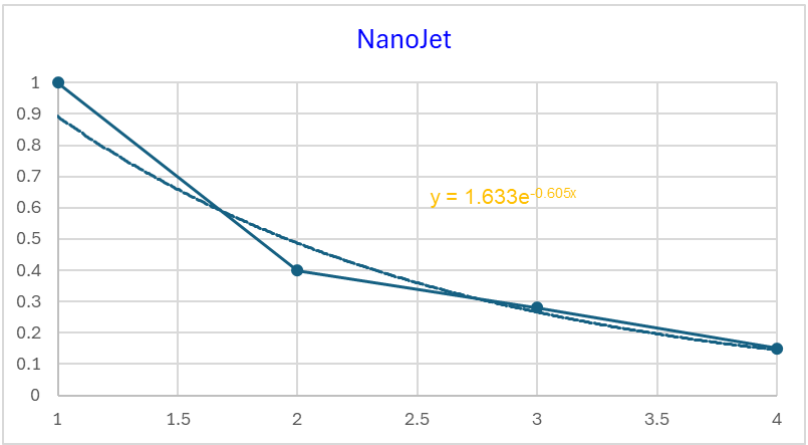
11/03/2025			
n=5	**Time (mins)**	**Counts**	**Norm.**
	Init (Zero)	121	1.00
	10	69	0.57
	20	43	0.36
	30	37	0.31



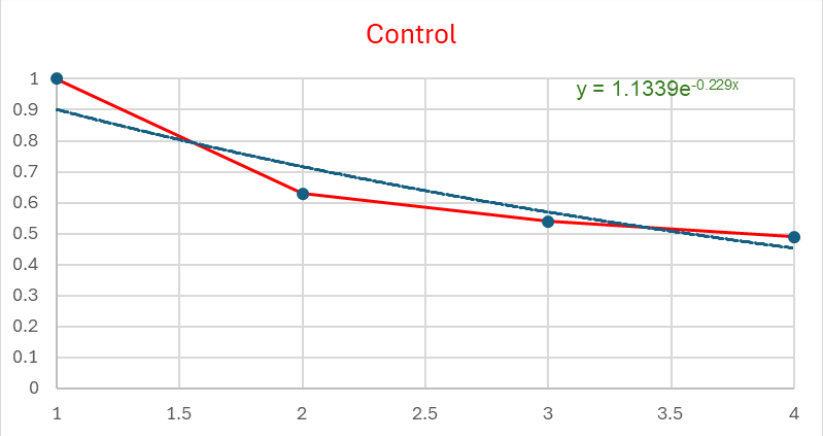
11/03/2025			
Control	**Time (mins)**	**Counts**	**Norm.**
	Init (Zero)	141	1.00
	10	105	0.74
	20	66	0.47
	30	73	0.52



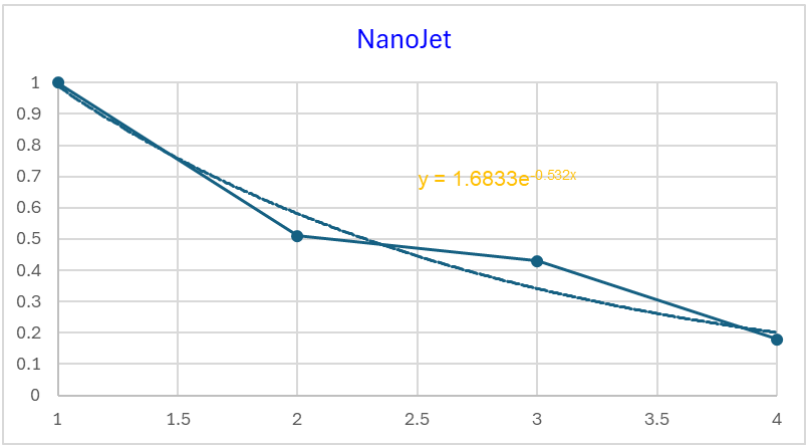
11/03/2025			
n=7	**Time (mins)**	**Counts**	**Norm.**
	Init (Zero)	155	1.00
	10	62	0.4
	20	44	0.28
	30	25	0.15



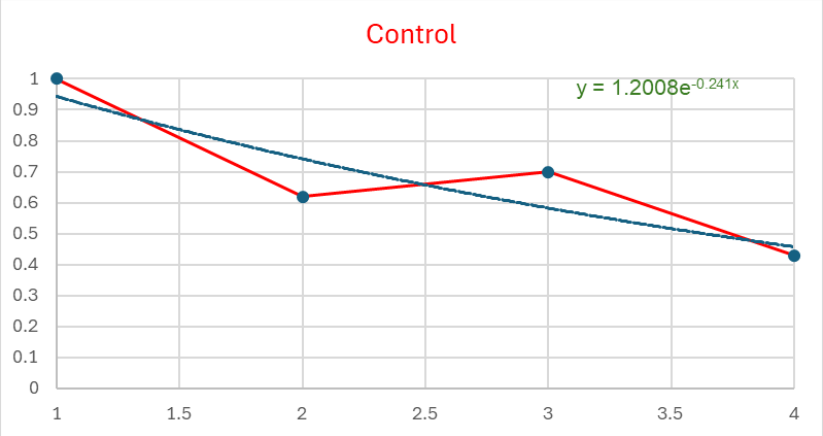
11/03/2025			
Control	**Time (mins)**	**Counts**	**Norm.**
	Init (Zero)	146	1.00
	10	92	0.63
	20	79	0.54
	30	71	0.49



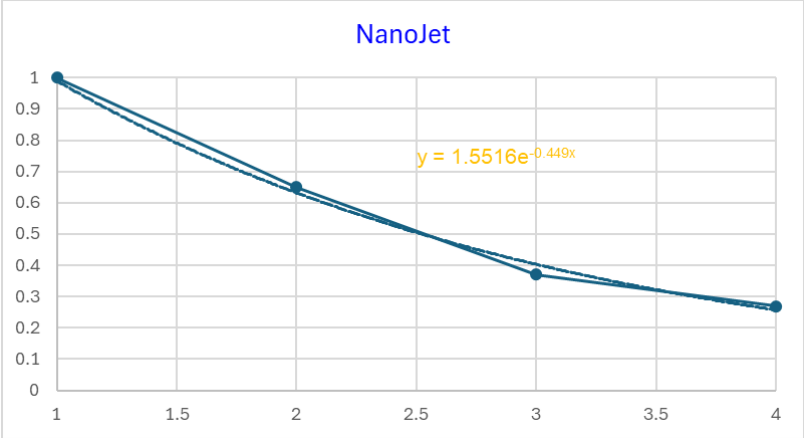
11/03/2025			
n=8	**Time (mins)**	**Counts**	**Norm.**
	Init (Zero)	125	1.00
	10	64	0.51
	20	54	0.43
	30	23	0.18



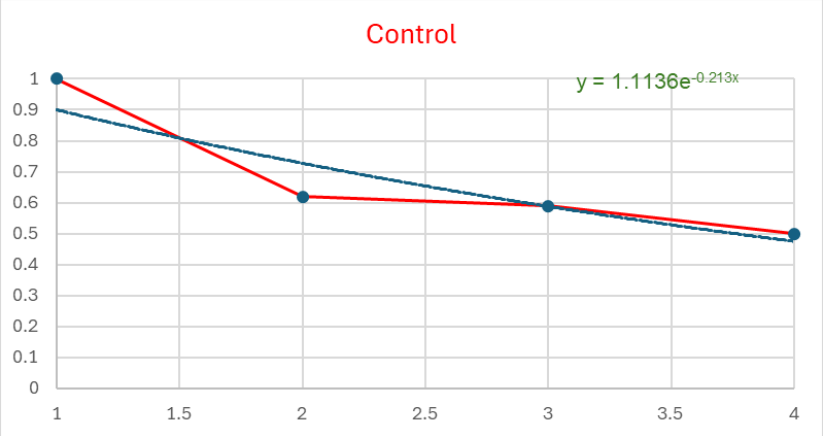
11/03/2025			
Control	**Time (mins)**	**Counts**	**Norm.**
	Init (Zero)	138	1.00
	10	86	0.62
	20	96	0.70
	30	60	0.43



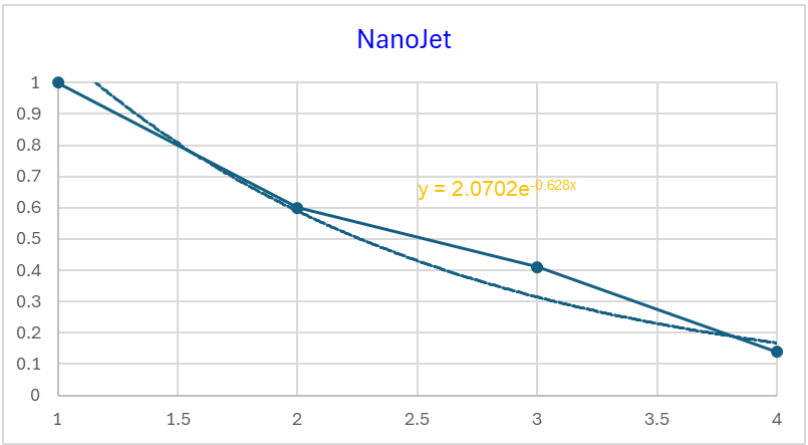
11/03/2025			
n=9	**Time (mins)**	**Counts**	**Norm.**
	Init (Zero)	124	1.00
	10	80	0.65
	20	46	0.37
	30	33	0.27



11/03/2025			
Control	**Time (mins)**	**Counts**	**Norm.**
	Init (Zero)	145	1.00
	10	90	0.62
	20	85	0.59
	30	73	0.50



11/03/2025			
n=10	**Time (mins)**	**Counts**	**Norm.**
	Init (Zero)	134	1.00
	10	81	0.60
	20	55	0.41
	30	19	0.14



Summary Results

A and k determined from the runs *viz* $y = Ae^{kt}$

For illustration, parameters evaluated at Clearances [%] of 63.3, 90 & 99

Note: a Clearance of 63.3% corresponds to an equivalent x1 Air-Change-per-Hour (ACH) or 53m^3.

Run	Type	A (Scaling Constant)	k (Time Constant)	Residual [fractional]	Clearance [%]	Time [slot]	Time [mins]
#1	Control	1.1447	-0.22	0.37	63.3	5.13	41.34
				0.10	90	11.08	100.81
				0.01	99	21.55	205.47
	NanoJet	1.3416	-0.456	0.37	63.3	2.82	18.25
				0.10	90	5.69	46.94
				0.01	99	10.74	97.43
#2	Control	1.3656	-0.307	0.37	63.3	4.25	32.54
				0.10	90	8.52	75.15
				0.01	99	16.02	150.16
	NanoJet	1.0847	-0.324	0.37	63.3	3.32	23.20
				0.10	90	7.36	63.58
				0.01	99	14.46	134.64
#4	Control	1.3452	-0.276	0.37	63.3	4.68	36.77
				0.10	90	9.42	84.17
				0.01	99	17.76	167.60
	NanoJet	1.15	-0.405	0.37	63.3	2.80	18.00
				0.10	90	6.03	50.30
				0.01	99	11.72	107.16
#5	Control	1.354	-0.298	0.37	63.3	4.35	33.53
				0.10	90	8.74	77.44
				0.01	99	16.47	154.71
	NanoJet	1.356	-0.397	0.37	63.3	3.27	22.72
				0.10	90	6.57	55.67
				0.01	99	12.37	113.67
#7	Control	1.1929	-0.242	0.37	63.3	4.84	38.37
				0.10	90	10.24	92.44
				0.01	99	19.76	187.59
	NanoJet	1.633	-0.605	0.37	63.3	2.45	14.54
				0.10	90	4.62	36.17
				0.01	99	8.42	74.22
#8	Control	1.1339	-0.229	0.37	63.3	4.89	38.90
				0.10	90	10.60	96.04
				0.01	99	20.66	196.59
	NanoJet	1.633	-0.532	0.37	63.3	2.85	18.48
				0.10	90	5.31	43.07
				0.01	99	9.64	86.35
#9	Control	1.2008	-0.241	0.37	63.3	4.88	38.85
				0.10	90	10.31	93.14
				0.01	99	19.87	188.68
	NanoJet	1.5516	-0.449	0.37	63.3	3.19	21.93
				0.10	90	6.11	51.07

				0.01	99	11.23	102.35

#10	Control	1.1136	-0.213	0.37	63.3	5.17	41.73
				0.10	90	11.32	103.15
				0.01	99	22.13	211.26
	NanoJet	2.0702	-0.628	0.37	63.3	2.74	17.42
				0.10	90	4.83	38.25
				0.01	99	8.49	74.92

Time [mins] @ Clearance of x1 ACH (63.3%), x1 & x2 log10 reductions after application CDa Pro for 10 mins			
	63.3%	1 x log10	2 x log10
Mean Control	37.75	90.29	182.75
Mean NanoJet	19.32	48.13	98.84
Median Control	38.61	92.79	188.13
Median NanoJet	18.36	48.62	99.89

Validation of the Innova NanoJet CDa Pro Air Scrubber Augmented with Hypochlorous Acid (HClO) to the Liverpool Biovalidation Protocol

Innova NanoJet CDa Pro

Room Size	53	m^3
Ceiling Height	2.2	m
Spray Time	10	mins
HClO Concentration	50	ppm

As guided by Innova NanoJet Technologies, mixing 500ml of commercial HClO (150ppm) with 1000ml of distilled water.

T0 Bacteria Concentration 6.25×10^5 to 1.11×10^6 CFU/m^3

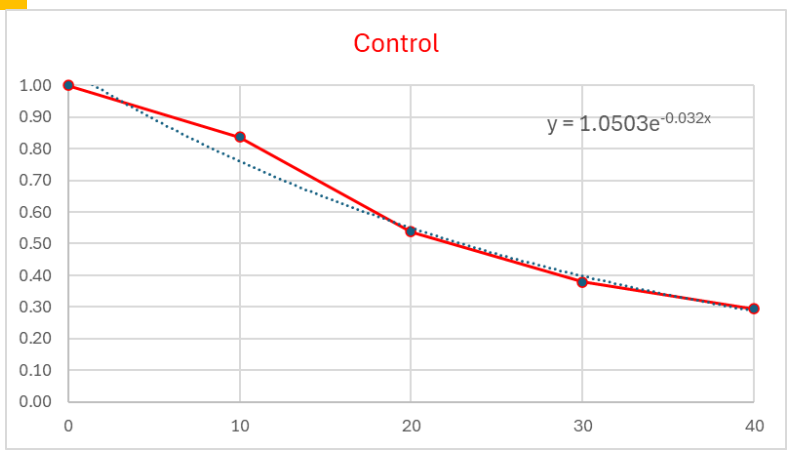
NanoJet configured to dispense horizontally towards different directions.

Room highly mixed with x4 fans set as per the Liverpool Protocol

24/01/2025

Control

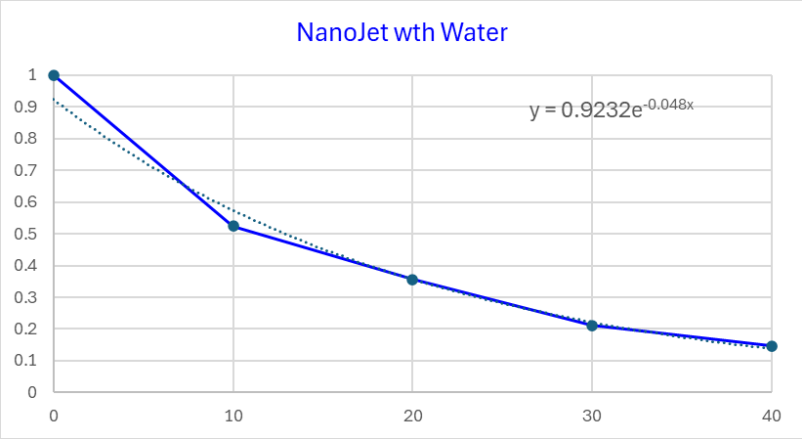
Time (mins)	Counts A	Counts B	Av. Counts	Norm.
Init (Zero)	65000	40100	52550	1.00
10	50003	38000	44002	0.84
20	27700	28800	28250	0.54
30	19300	20500	19900	0.38
40	17400	13600	15500	0.29



24/01/2025

n=1 With only water

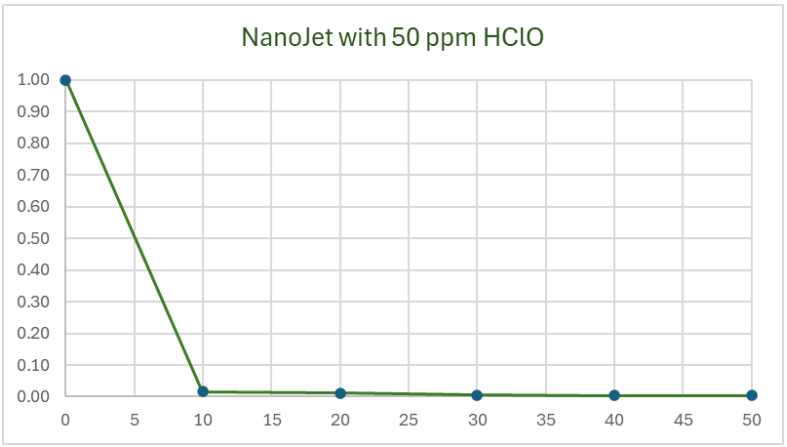
Time (mins)	Counts A	Counts B	Av. Counts	Norm.
Init (Zero)	80300	65700	73000	1.00
10	40100	36500	38300	0.52
20	24200	27700	25950	0.36
30	19700	11200	15450	0.21
40	8000	13300	10650	0.15



24/01/2025

n=1 With 50ppm HClO

Time (mins)	Counts A	Counts B	Av. Counts	Norm.
Init (Zero)	40900	41600	41250	1.000
10	660	620	640	0.016
20	500	500	500	0.012
30	220	220	220	0.005
40	180	180	180	0.004



Summary Results

A and k determined from the runs *viz* $y = Ae^{kt}$

For illustration, parameters evaluated at Clearances [%] of 63.3, 90 & 99

Note: a Clearance of 63.3% corresponds to an equivalent x1 Air-Change-per-Hour (ACH) or 53m^3.

Due to dramatic reduction of the count in NanoJet with HClO, exponential curve not fitted to HClO run.

Run	Type	A (Scaling Constant)	k (Time Constant)	Residual [fractional]	Clearance [%]	Time [slot]	Time [mins]
#1	Control	1.0503	-0.032	0.37	63.3	2.61	16.15
				0.10	90	5.44	44.41
				0.01	99	10.41	94.14
	NanoJet	0.9232	-0.048	0.37	63.3	2.44	14.35
				0.10	90	4.21	32.05
				0.01	99	7.32	63.21
	NanoJet			0.37	63.3		<10
	+ 50ppm			0.10	90		<10
	HClO			0.01	99		<30