Alfa Laval
Kathabar case study

Impact of liquid desiccant dehumidification technology on environmental microbial contamination present in outside air supplied to a surgical suite

Hospital — OR suite liquid desiccant dehumidification system

Abstract

This study has been designed to understand the effect of liquid desiccant dehumidification technology on environmental bacteria and fungi present within the outside air supplied to a Class A surgical suite. Environmental parameters of the surgical suite, temperature and relative humidity, were also assessed during the study.

Introduction

In August 2014, an Alfa Laval Kathabar dehumidification system was entered into an eighteen (18) month study with a regional hospital.

The study design encompassed a baseline sampling regimen followed by monthly sampling throughout the study duration.

The Hospital contracted to have an Alfa Laval Kathabar SP 240 packaged dehumidification unit installed to replace an aging HVAC (heating, ven tilating and air conditioning) system. The supply air system provided 100% outside air (2,200 cubic feet per minute) to the surgical suite with a single air pass.

The Alfa Laval Kathabar liquid desiccant dehumidification system employed LiCl solution to both temper and dehumidify the surgical suite environment. Humidification was also provided.

The solution uniformly sprayed within the conditioning unit in a downward fashion and contacted the moving air which passed concurrently upward. Moisture from the air was removed by the desiccant solution and condensed in the unit reservoir before being transferred to the companion regenerator. The collected moisture was then released from the desiccant before being transferred back to the conditioning unit.

It should be noted that the LiCl solution is extremely germicidal to viable microorganisms, including those pathogens associated with Healthcare associated infections[1].

Methods

Environmental swab samples were collected from pre-selected locations within the surgical suite and HVAC areas as indicated:

Sample 1- OR supply air diffuser #1
Sample 2- OR supply air diffuser #2
Sample 3- OR return air grille #2
Sample 4- OR return air grille #1
Sample 5- Cystoscopic Room supply air diffuser
Sample 6- Cystoscopic Room return air grille
Sample 7- Recovery Room supply air diffuser
Sample 8- Entry supply air diffuser
Sample 9- New-Kathabar Air Inlet
Sample 10- New-Kathabar Sump
Sample 11- New-Kathabar Air Outlet
Sample 12- Final Filter Upstream
Sample 13- Final Filter Downstream

Surface samples were collected by donning sterile gloves and swabbing the selected area of 1” x 1” with a sterile swab. After swabbing, each swab was placed back in its original container, sealed and labeled. All samples were transported to an independent certified environmental laboratory for culturing and analysis.

Swab sample procedure


Donned sterile gloves


Swab replacement


Swab removal


Sample method; roll over surface


Sealed swab

Lab procedure

Each swab sample was immersed in a sterile test tube containing 10 ml of sterile distilled water upon arrival at the laboratory. The test tube sample was kept at room temperature for 10 minutes and then placed in a rotary shaker (3.81 throw, 220 rpm) for one (1) minute. The resulting suspension or dilution was then inoculated (0.1 ml aliquots) on a 2% malt extract agar (MEA- for saprotrophic fungal growth) and a trypticase soy agar (TSA- for environmental bacteria growth), presenting estimates of the total number of viable propagules per milliliter of suspension. Inoculated laboratory controls were then incubated. The samples were immediately incubated at 25° +/-1°C.

Macroscopic, microscopic and quantitative morphology results were documented every 24 hours following incubation. Organisms were identified to a species level. Incubation was then terminated after seven days of observation depending on what species were present in the sample. The surface swab sample results were presented in total colony forming units per square inch (CFU/inch^2).

A “No Growth Promoted” (NG) sample designation denoted no viable microbiological growth identified using the above listed sample preparation and analysis protocols. An “Over Loaded” sample designation denoted an over growth of viable microbiological matter and numerical identification was not possible.

Results

The study demonstrated the impact that liquid desiccant dehumidification technology has on a Class A surgical suite at a regional medical center located in Delhi, NY.

Baseline swab sampling prior to the installation of the said technology showed the presence of microbial contamination, bacteria and fungi, within the existing HVAC system as well as within the OR and support area, Chart ‘A1 to A6’. The qualitative and quantitative results are depicted in Chart ‘B’ for the outside air supplied to the Alfa Laval system and ‘Chart B1 through B6’ for the OR and support area.

Upon installation of the liquid desiccant dehumidification system ongoing swab sampling demonstrated the presence of bacteria and fungi on surfaces at the outside air inlet to the Alfa Laval system and the absence of said contamination on surfaces at the supply air discharge to the OR. Also exhibited was the lack of bacteria and fungi counts within the OR and support area.

The demonstration of microbial control at the outside air inlet to the Kathabar system and within the Class A surgical suite and surrounding support area with the application of liquid desiccant dehumidification technology substantiates the germicidal properties of the Alfa Laval Kathabar technology as well as maintaining the required set points for environmental control of RH and temperature, Chart ‘C’ through Chart ‘E’.

Conclusion

The purpose of this study was to examine the performance of a fully operational liquid desiccant dehumidification system, as well as understanding the germicidal impact the said system may have on microbial contamination that is laden in outside air supplied for conditioning the OR and supporting area environment.

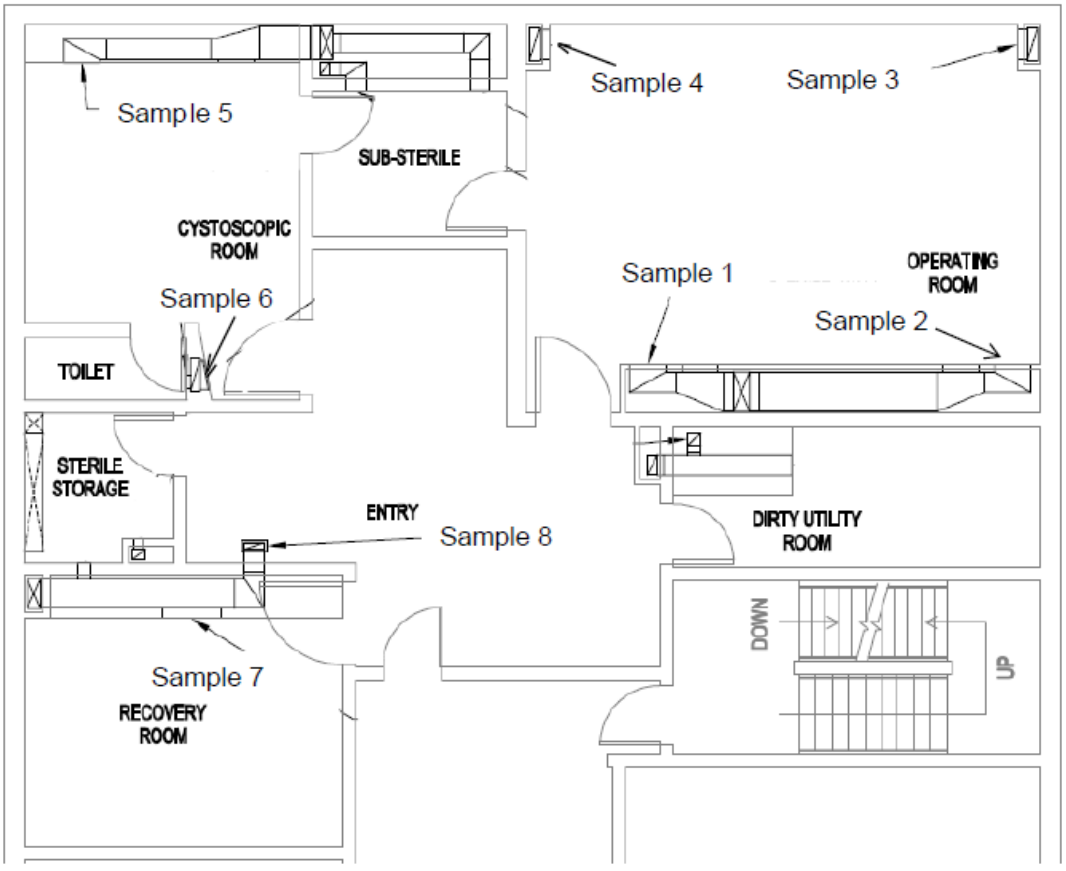
The Alfa Laval Kathabar SP 240 liquid desiccant dehumidification system demonstrated the removal of viable bacteria and fungi from surfaces at the supply air to the OR and support area. The microorganisms present in the pre-treated air are exhibited in Appendix 1, 'Microorganism Matrix'. Many of these organisms have been recognized as pathogens linked with Healthcare associated infections, where this study has proved that Alfa Laval Kathabar dehumidification systems in this setting provided HVAC germicidal protection.

Therefore, this technology when applied to the Healthcare environment is helpful in the control of infection throughout the critical space and aid in providing best possible patient outcomes.

Infection data provided by the Infection Control staff are found in 'Chart F through H'.

The results are found within the body of this report.

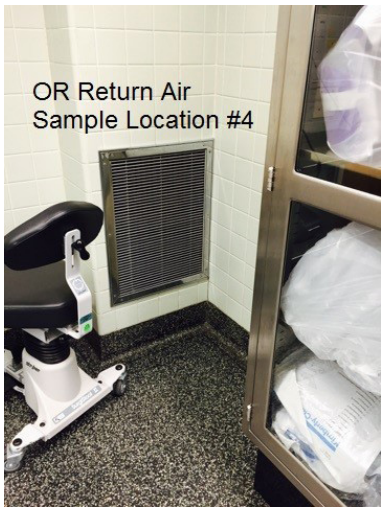
Sample location



Sample 1- OR supply air diffuser #1
Sample 2- OR supply air diffuser #2
Sample 3- OR return air grille #2
Sample 4- OR return air grille #1
Sample 5- Cystoscopic Room supply air diffuser
Sample 6- Cystoscopic Room return air grille
Sample 7- Recovery Room supply air diffuser
Sample 8- Entry supply air diffuser

OR Supply Air Diffusers

OR Return Air Grilles

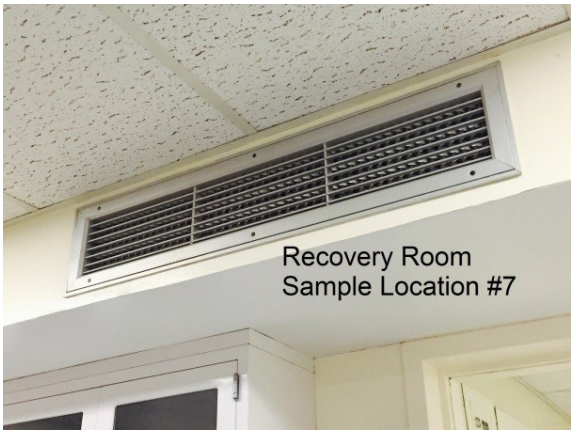


OR Return Air Grilles

Cystoscopic Room

Cystoscopic Room

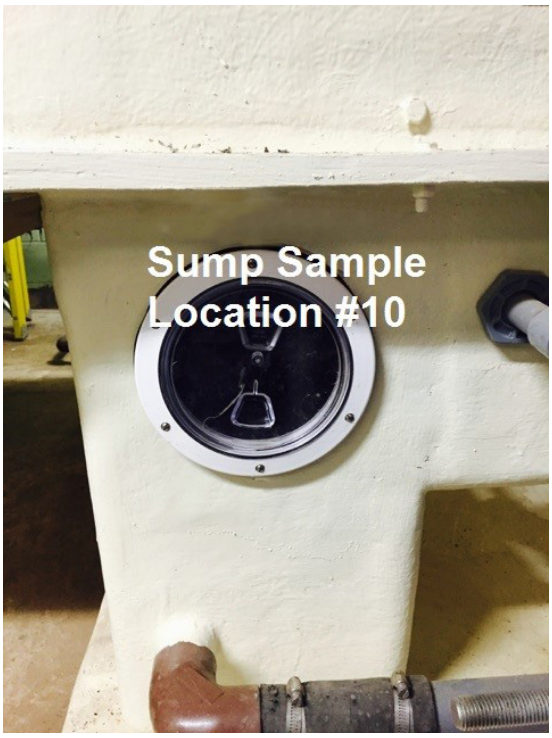
Recovery Room



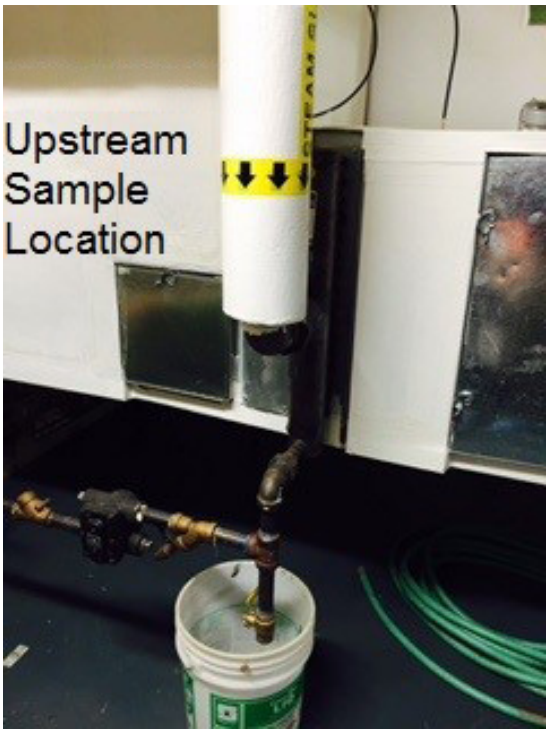
Entry Room

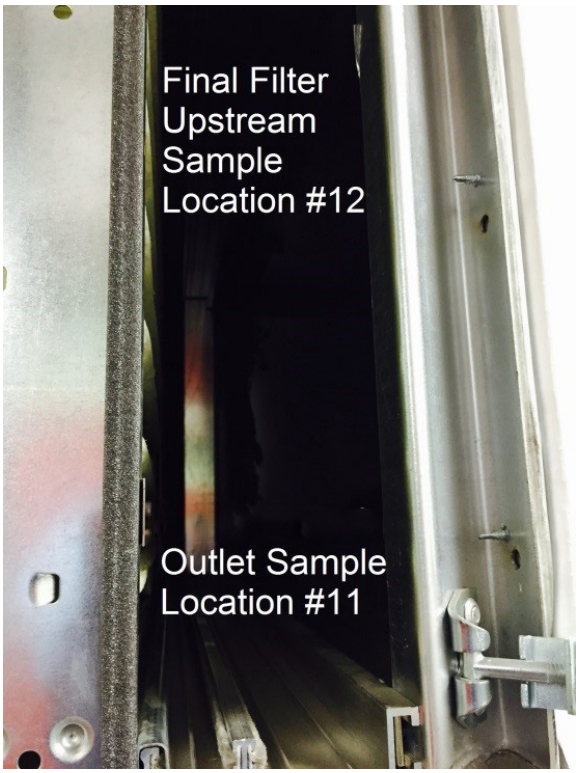
KATHABAR SP 240 Unit


Final Filter
Housing
Downstream


Sump Sample
Location #10


Upstream
Sample Location #9

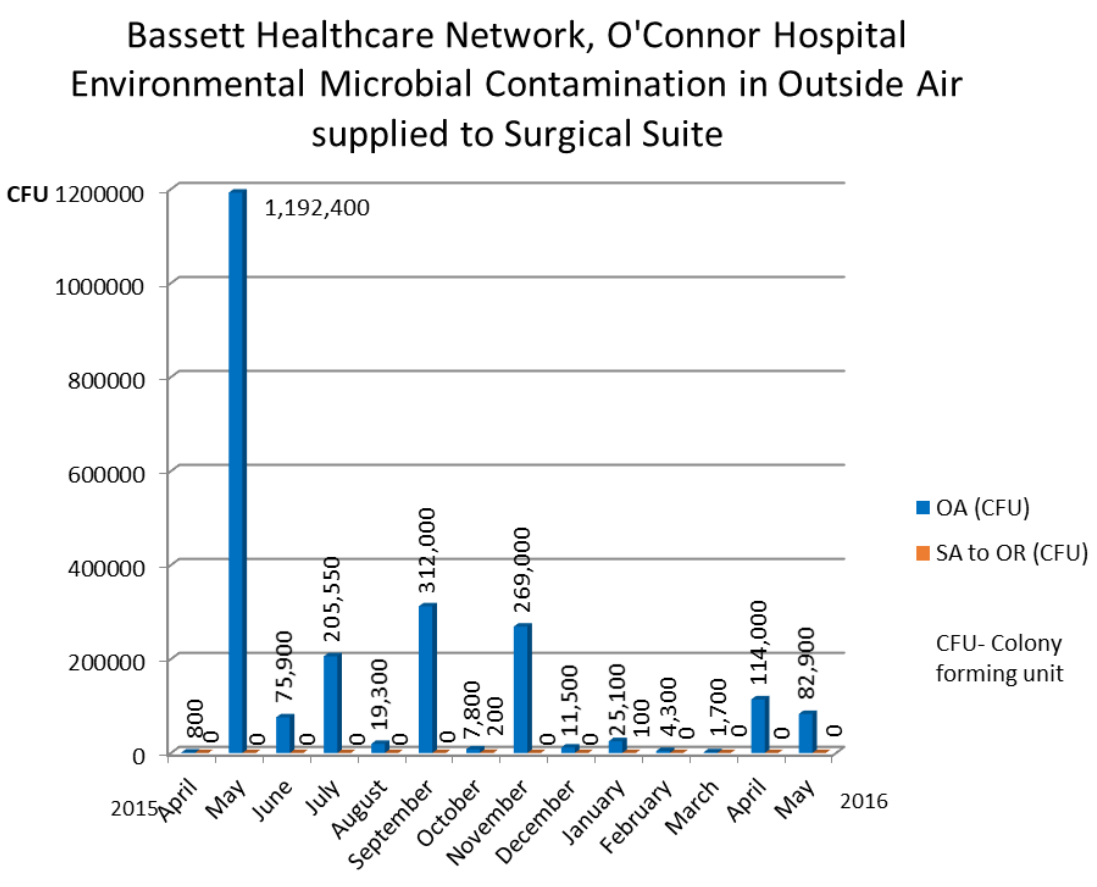

Upstream
Sample
Location


Final Filter
Upstream
Sample
Location #12
Outlet Sample
Location #11


Final Filter Downstream
Sample Location #13

Appendix 1

Chart 'A'
Sampling OA and SA to OR — Post Alfa Laval Pure Air installation



Sampling-
Post Alfa Laval Kathabar installation

Chart 'B1':
OR Supply Air Diffuser #1

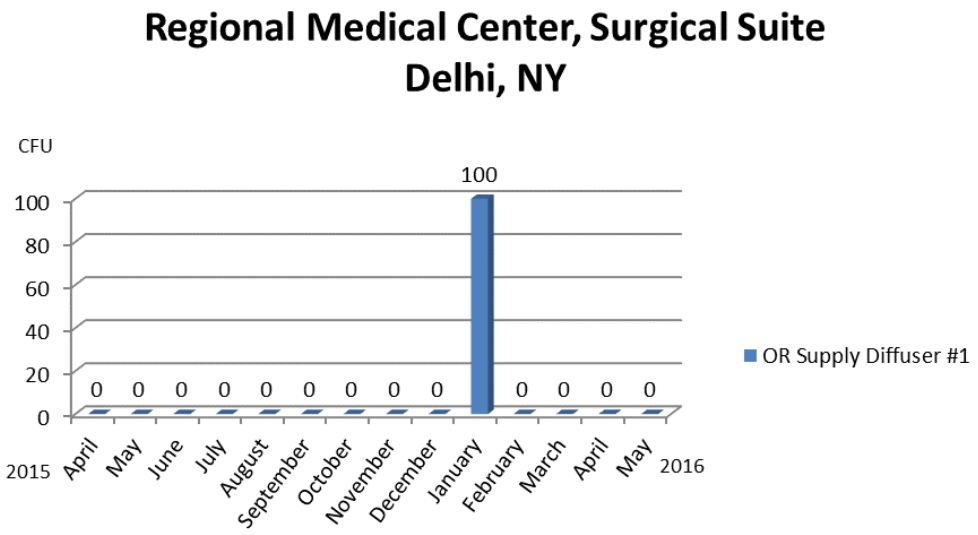


Chart 'B2':
OR Supply Air Diffuser #2

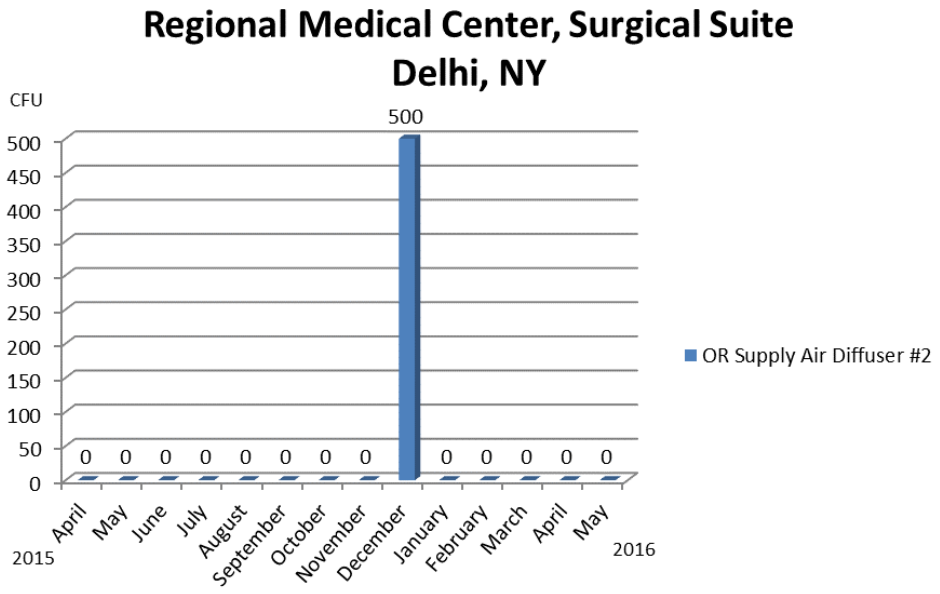


Chart 'B3':
OR Return Air Grille #1

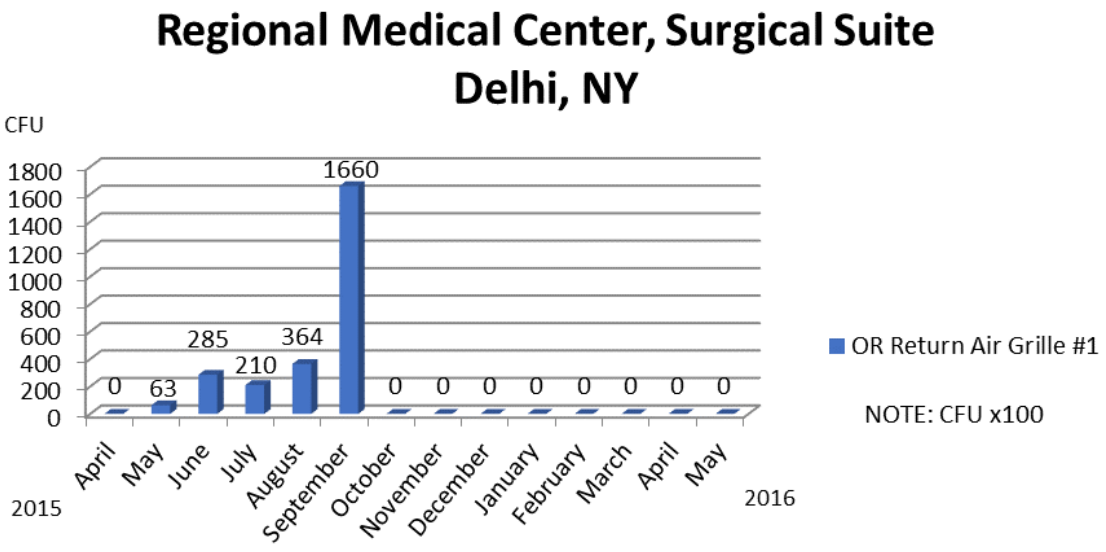


Chart 'B4':
OR Return Air Grille #2

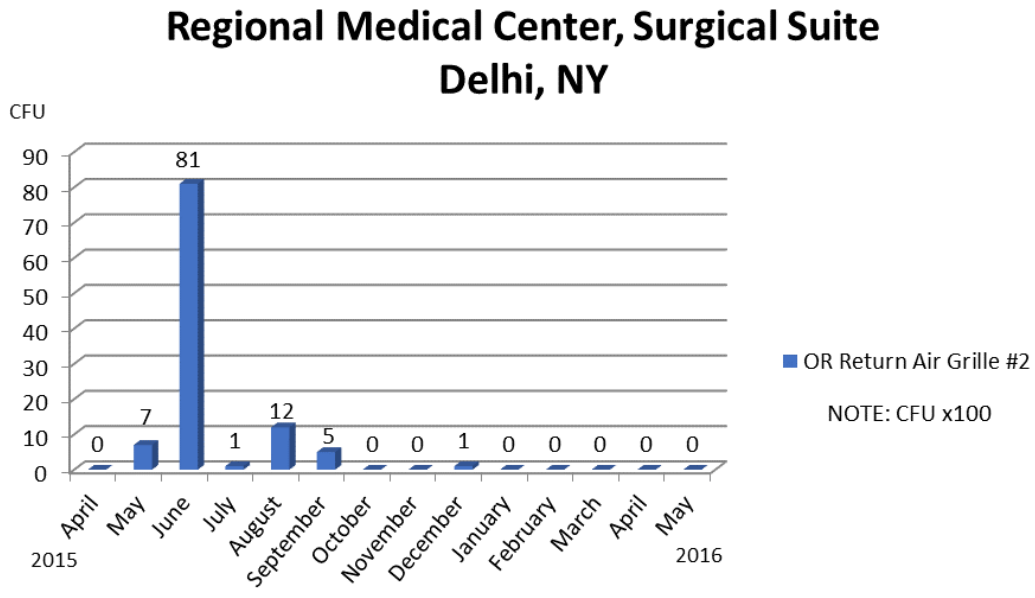


Chart 'B5':
Cystoscopy Supply Air Diffuser

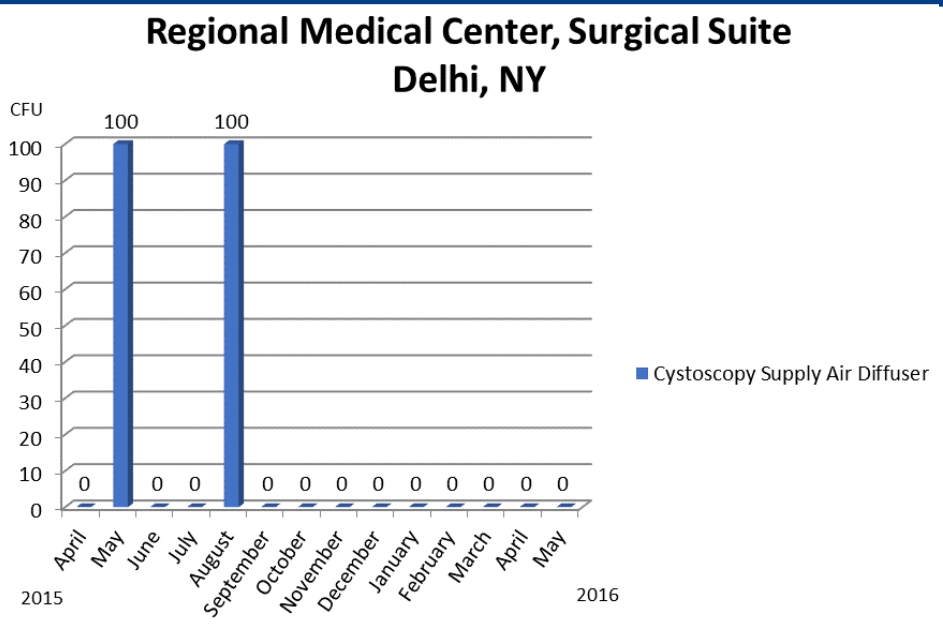


Chart 'B6':
Cystoscopy Return Air Grille

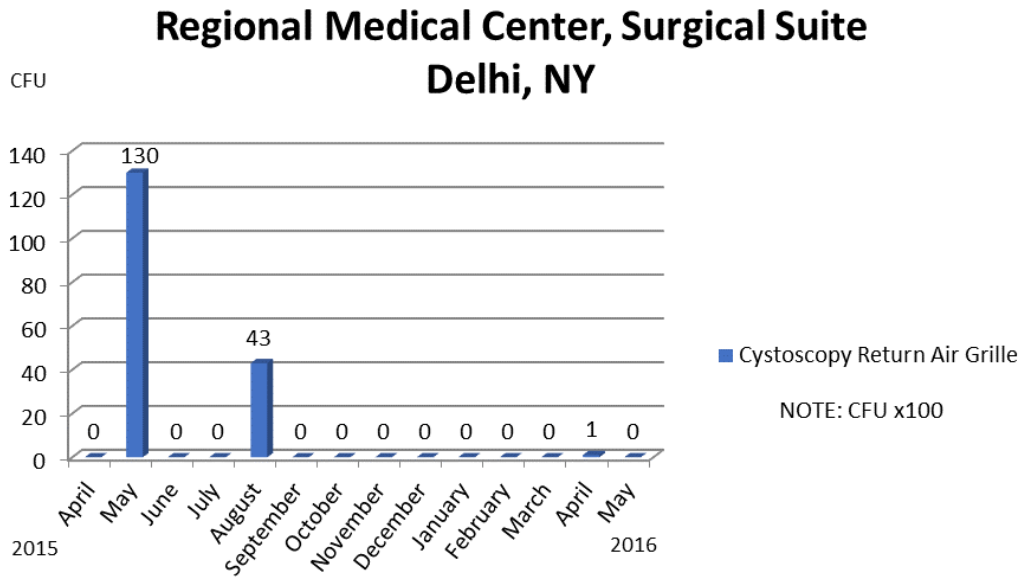


Chart 'C'

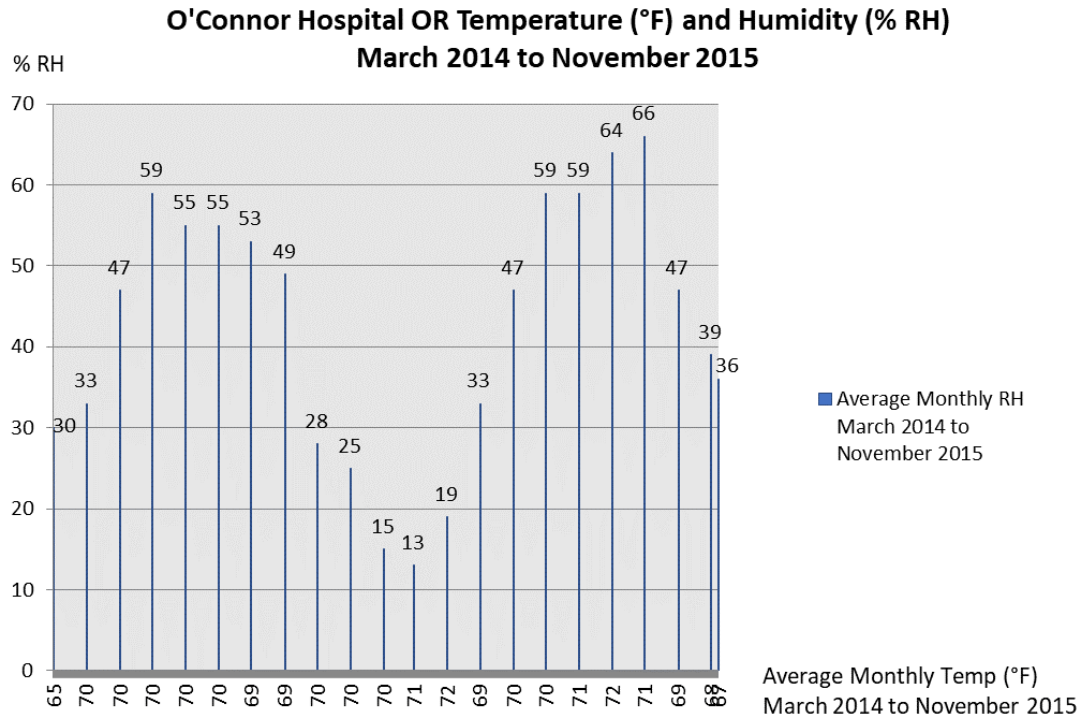

O'Connor Hospital OR Temperature (°F) and Humidity (% RH)
March 2014 to November 2015
% RH
70
60
50
40
30
20
10
0
30
33
47
59
55
55
53
49
28
25
15
13
19
33
47
59
59
64
66
47
39
36
65
70
70
70
70
70
69
69
70
70
70
71
72
69
70
70
71
72
71
69
68
67
Average Monthly RH
March 2014 to
November 2015
Average Monthly Temp (°F)
March 2014 to November 2015

Chart 'D'

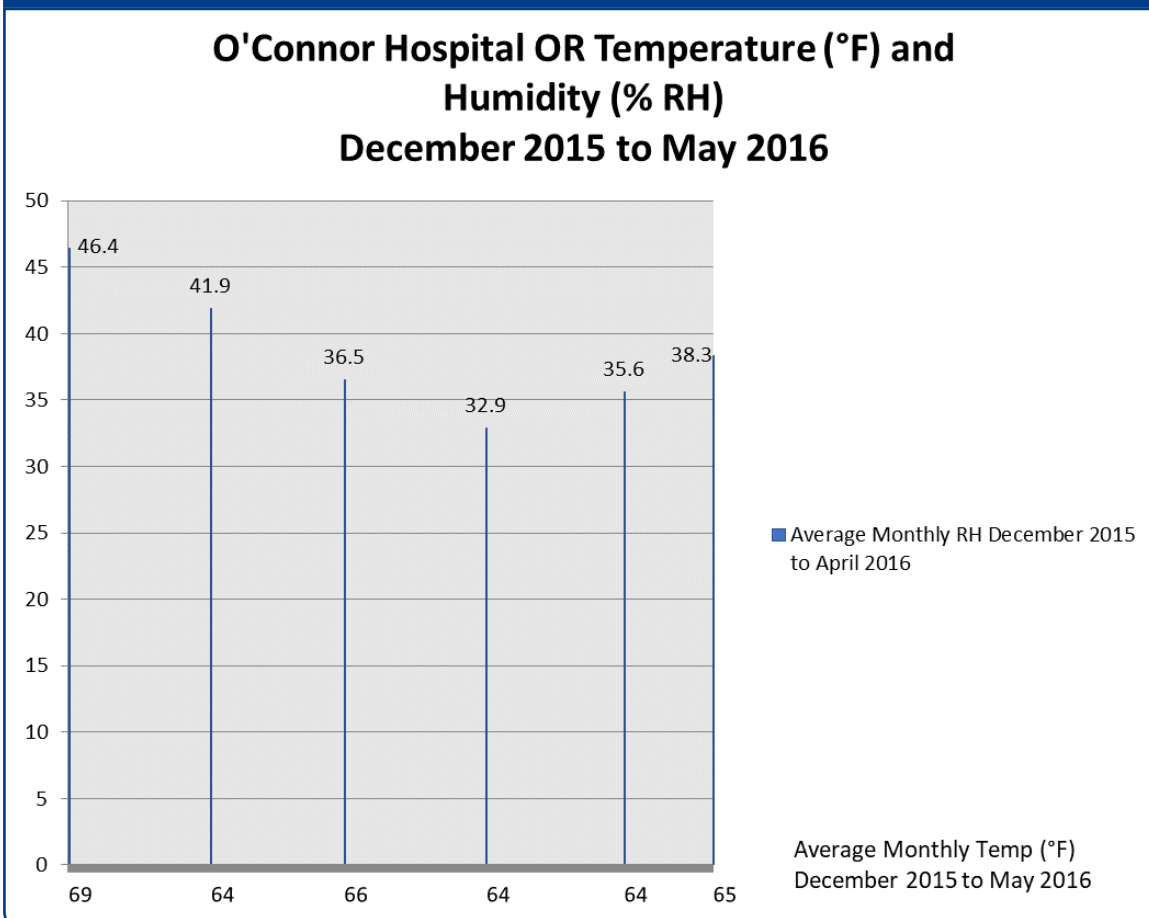
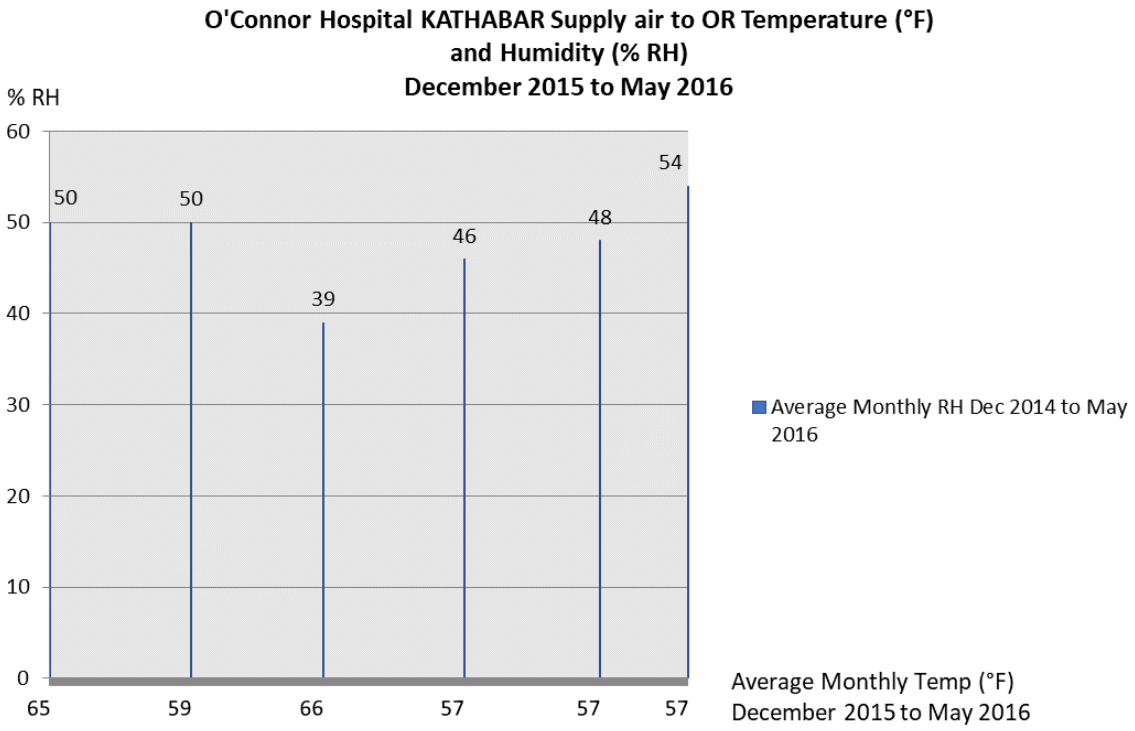

O'Connor Hospital OR Temperature (°F) and Humidity (% RH)
December 2015 to May 2016
50
45
40
35
30
25
20
15
10
5
0
46.4
41.9
36.5
32.9
35.6
38.3
69
64
66
64
64
65
Average Monthly RH December 2015 to April 2016
Average Monthly Temp (°F) December 2015 to May 2016

Chart 'E'


O'Connor Hospital KATHABAR Supply air to OR Temperature (°F)
and Humidity (% RH)
December 2015 to May 2016
% RH
60
50
40
30
20
10
0
50
50
39
46
48
54
65
59
66
57
57
57
Average Monthly RH Dec 2014 to May 2016
Average Monthly Temp (°F)
December 2015 to May 2016

Infection data provided by infection control department

Chart 'F':
Pre - Alfa Laval Kathabar installation

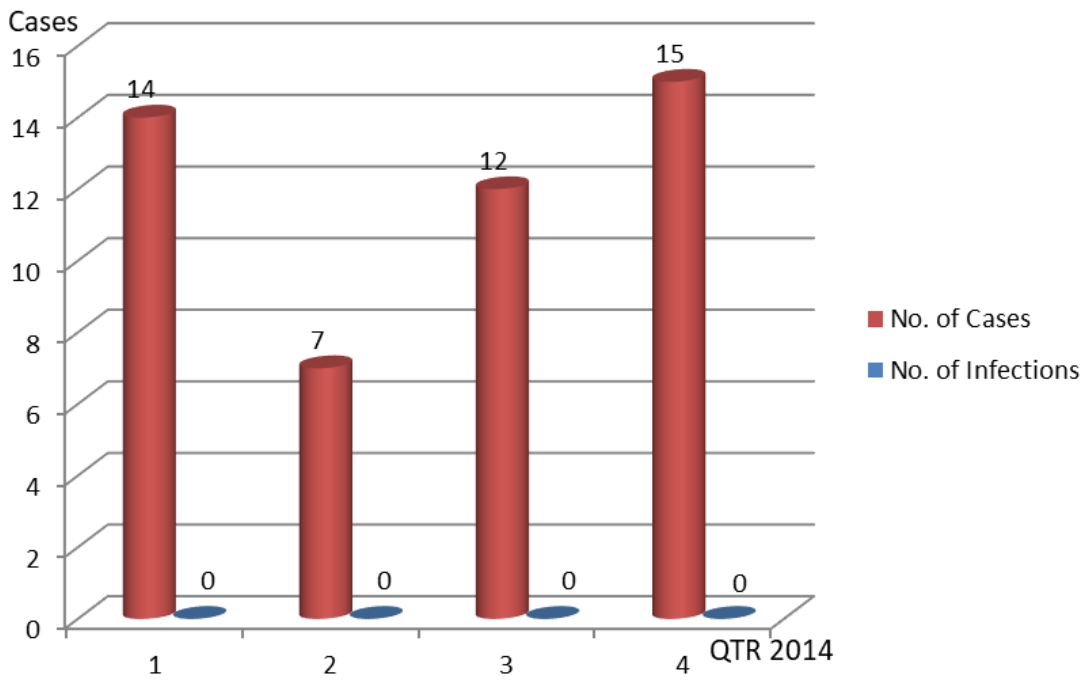


Chart 'G':
Post - Alfa Laval Kathabar installation

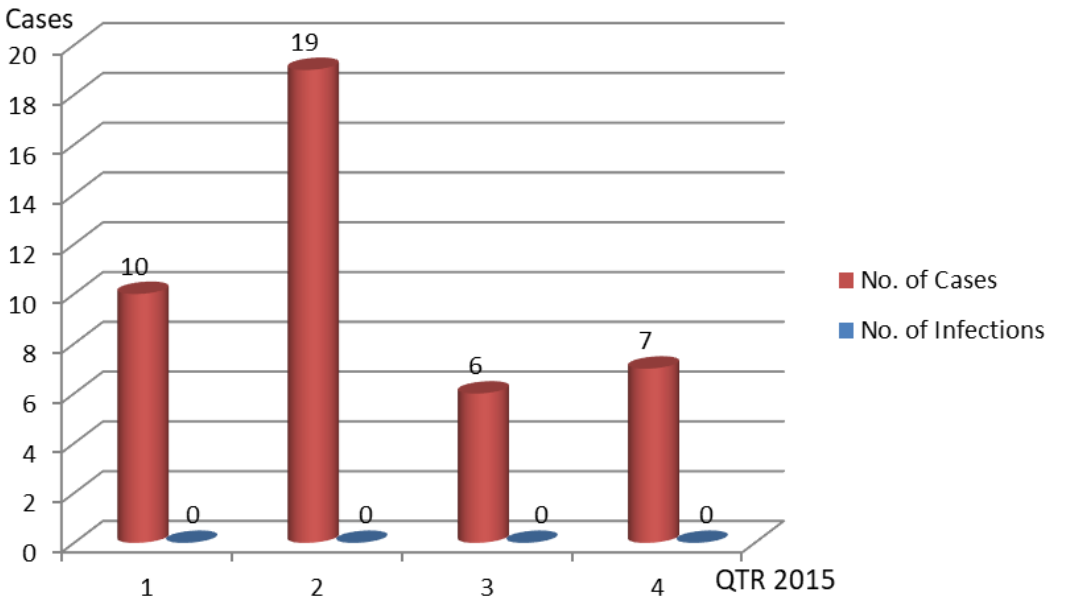
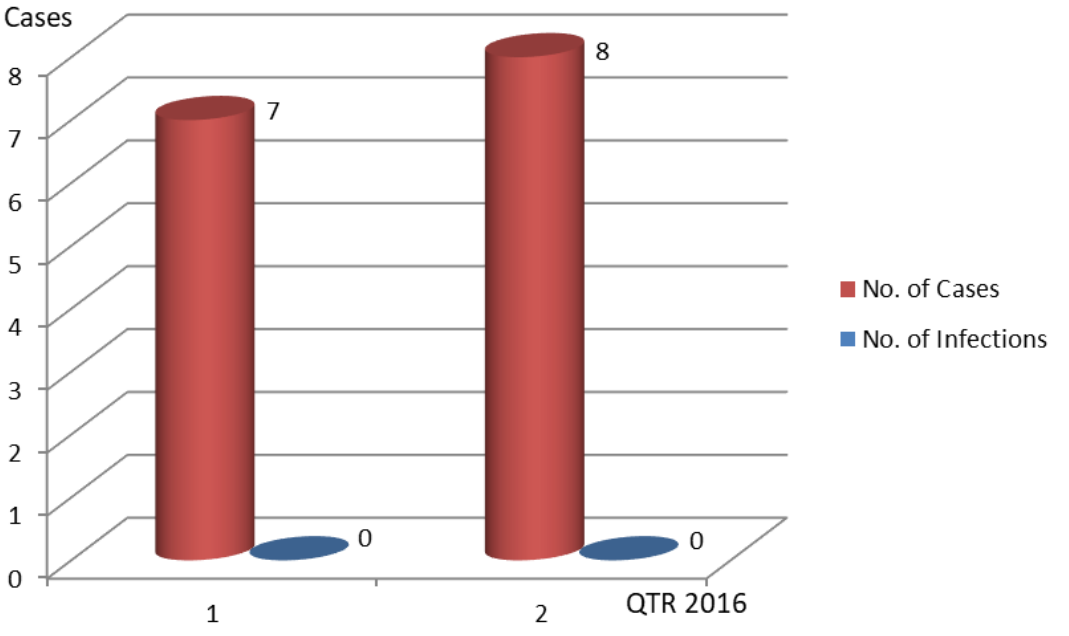


Chart 'H':
Post - Alfa Laval Kathabar installation



Hospital OR environmental sampling summary baseline
Pre - Alfa Laval Kathabar installation

Date	Location	Microorganism	CFU
9/26/2014	OR Supply #2	*Cladisporium sp.*	200
		Stachybotrys chartarum	200
	OR Return #1	*Sporothrix sp.*	100
	OR Return #2	*Aspergillus ustus*	100
	Old KATH Coil Dn	*Staphylococcus sp.*	6,000
10/31/2014	OR Supply #1	*Cladisporium sp.*	2,000
	OR Supply #2	*Cladisporium sp.*	9,000
	OR Return #2	*Chaetomium sp.*	1,500
		Cladisporium sp.	100
		Non-sporulating fungi	100
	OR Return #1	*Chaetomium sp.*	1,000
		Non-sporulating fungi	100
	Cyst. Supply	*Cladisporium sp.*	4,100
	Recovery Supply	*Cladisporium sp.*	100
	Old KATH Coil Up	*Pseudomonas sp.*	102,000
		Aureobasidium sp.	50,000
		Non-sporulating fungi	3,000
		Yeast sp.	9,000
	HEPA Up	*Bacillus sp.*	32,000
	Old KATH Coil Up	*Epicoccum sp.*	1,000
		Non-sporulating fungi	1,000
		Yeast sp.	3,000
	Old KATH Dn	*Cladisporium sp.*	100

Hospital OR environmental sampling summary post baseline
Post - Alfa Laval Kathabar installation

1/23/2015	Cyst. Supply	*Staphylococcus sp.*	1,000
3/6/2015	Cyst. Supply	*Staphylococcus sp.*	200
	KATH Inlet	*Bacillus sp.*	200
	KATH Outlet	*Cladosporium sp.*	100
4/10/2015	OR Return #1	*Micrococcus sp.*	400
	KATH Inlet	*Bacillus sp.*	600
		Non-sporulating fungi	200
	Final Filter Dn	*Bacillus sp.*	200
5/15/2015	OR Return #2	*Chaetomium sp.*	700
	OR Return #1	*Chaetomium sp.*	100
		Non-sporulating fungi	200
		Penicillium sp.	6,000
	Cyst. Supply	*Cladisporium sp.*	100
	Cyst.- Return	*Bacillus sp.*	12,000
		Micrococcus sp.	1,000
	KATH Inlet	*Bacillus sp.*	960,000
		Pseudomonas sp.	230,000
		Alternaria sp.	100
		Cladisporium sp.	100
		Curvularia sp.	100
		Epicoccum sp.	100
		Fusarium sp.	2,000
5/29/2015	OR Return #2	*Micrococcus sp.*	8,000
		Chaetomium sp.	100
	OR Return #1	*Pseudomonas sp.*	21,000
		Chaetomium sp.	500
		Penicillium sp.	7,000
	KATH Inlet	*Bacillus sp.*	63,000
		Alternaria sp.	600
		Cladisporium sp.	2,000
		Fusarium sp.	6,500
		Penicillium sp.	300
		Yeast	3,500
7/28/2015	OR Return #2	*Chaetomium sp.*	100
	OR Return #1	*Bacillus sp.*	6,000
		Micrococcus sp.	15,000
	KATH Inlet	*Bacillus sp.*	200,000
		Alternaria sp.	1,100
		Fusarium sp.	2,500
		Non-sporulating fungi	250
		Penicillium sp.	100

Hospital OR environmental sampling summary post baseline
Post - Alfa Laval Kathabar installation continued

		Rhodotorula sp.	1,600
8/7/2015	OR Return #2	*Chaetomium sp.*	400
		Curvularia sp.	300
		Penicillium sp.	500
	OR Return #1	*Micrococcus sp.*	36,000
		Chaetomium sp.	400
	Cyst. Supply	*Cladisporium sp.*	100
	Cyst.- Return	*Pseudomonas sp.*	4,200
		Penicillium sp.	100
	KATH Inlet	*Bacillus sp.*	3,600
		Pseudomonas sp.	9,600
		Cladisporium sp.	400
		Fusarium sp.	4,000
		Mucor sp.	1,100
		Rhodotorula sp.	600
9/4/2015	OR Return #1	*Bacillus sp.*	100,000
		Micrococcus sp.	66,000
	KATH Inlet	*Acinetobacter sp.*	75,000
		Bacillus sp.	75,000
		Enterobacter sp.	75,000
		Pseudomonas sp.	75,000
		Mucor sp.	3,000
		Rhodotorula sp.	9,000
10/16/2015	KATH Inlet	*Bacillus sp.*	2,300
		Coag-negative Staphylococcus sp.	1,000
		Alternaria sp.	200
		Cladosporium sp.	1,500
		Curbularia sp.	500
		Epicoccum sp.	1,100
		Rhodotorula sp.	800
		Yeasts	400
12/11/2015	KATH Inlet	*Bacillus sp.*	100,000
		Pseudomonas sp.	100,000
		Alternaria sp.	500
		Aureobasidium sp.	18,000
		Cladosporium sp.	500
		Epicoccum sp.	4,000
		Rhodotorula sp.	28,000
		Trichoderma sp.	2,000
		Yeasts	16,000

Hospital OR environmental sampling summary post baseline
Post - Alfa Laval Kathabar installation continued

1/8/2016		*Bacillus sp.*	600
		Coag-negative Staphylococcus sp.	400
		Alternaria sp.	1,000
		Aureobasidium sp.	3,000
		Cladosporium sp.	1,000
		Epicoccum sp.	1,000
		Rhodotorula sp.	2,000
		Yeasts	16,000
2/26/2016	KATH Inlet	*Bacillus sp.*	200
		Pseudomonas sp.	1,200
		Aureobasidium sp.	1,400
		Non-sporulating colonies	500
		Rhodotorula sp.	400
		Yeasts	600
3/18/2016	KATH Inlet	*Bacillus sp.*	600
		Cladosporium sp.	200
		Epicoccum sp.	200
		Rhodotorula sp.	100
		Yeasts	600
4/22/2016	KATH Inlet	*Bacillus sp.*	96,000
		Alternaria sp.	900
		Aureobasidium sp.	9,000
		Cladosporium sp.	4,000
		Epicoccum sp.	1,100
		Penicillium sp.	1,000
		Yeasts	2,000
5/20/2016	KATH Inlet	*Bacillus sp.*	65,000
		Coag-negative Staphylococcus sp.	4,000
		Alternaria sp.	2,000
		Cladosporium sp.	1,500
		Epicoccum sp.	2,000
		Penicillium sp.	1,400
		Rhodotorula sp.	7,000

References

1. Connell, T., April 2014, State University of New York at Buffalo, Buffalo, NY, School of Medicine, 'Influence of Dehumidification Solutions on the Survival of Pathogenic Microorganisms Associated with Hospital Acquired Infections',

2. Beneke ES, Rogers AL. 1996. Medical Mycology and Human Mycoses. Belmont, CA: Star Publishing Co. 239p.

3. Brock TD, Madigan MT, Martinko JM, Parker J. 1994. Biology of Microorganisms. Englewood Cliffs, New Jersey: Prentice-Hall, Inc. 909p.

4. Carlson, N. (1998). University of Minnesota Environmental Health and Safety - Mycological Aspects of Indoor Environmental Quality

5. Croft WA, Jarvis BB, Yatawara CS. 1986. Airborne outbreak of trichothecene toxicosis. Atmos Environ 20:549-552.

6. Dearborn DG, Yike I, Sorenson WG, Miller MJ, Etzel RA. 1999. Overview of investigations into pulmonary hemorrhage among infants in Cleveland, Ohio. Environ Health Perspect 107:495-499.

7. Dillon HK, Heinsohn PA, Miller JD, editors. 1996. Field Guide for the Determination of Biological Contaminants in Environmental Samples. Fairfax, VA:AIHA Publications. 174p.

8. Domsch KH, et al. 1993. Compendium of Soil Fungi. Vol. 1. Eching, Germany: IHW-Verlag.

9. Flannigan B, Morey PR, 1996. Control of Moisture Problems Affedting Biological Indoor Air Quality. Ottawa: ISIAQ. 70p.

10. Gravesen S, Frisvad JC, Samson RA. 1994. Microrfungi. Copenhagen: Trykkeriet Viborg. 168p.

11. IARC (International Agency for Research on Cancer). 1993. Some naturally occurring substances: food items and constituents, heterccyclic aromatic amines and mycotoxins. Monograph 56. Lyon, France: International Agency for Research on Cancer.

12. Klaassen CD, Amdur MO, Doull J, editors. 1996. Casarett and Doull's Toxicology: The Basic Science of Poisons. 5th ed. New York: McGraw-Hill, Inc. 1111p.

13. Larone DH. 1995. Medically Important Fungi: A Guide to Identification. 3rd ed. Washington, D.C.: American Society for Microbiology. 274p.

14. Macher J, editor. 1999. Bioaerosols: Assesssment and Control. Cincinnati, OH: American Conference of Governmental Industrial Hygienists. 286p.

15. Portnoy J, Chapman J, Burge H, Muilenberg M, Solomon W. 1987. Epecoeeum allergy: skin reaction patterns and spoer/mycelium disparities recognized by IgG ans IgEELISA. Ann Allergy 59:39-43.

16. Reed CA, Kaplin B. 1996. S.O.S...HELP prevent E. coli 0157:H7...et al. J Am VetMed Assoc 209:1213.

17. Samsom RA, Flannigan B, Flannigan ME, Verhoeff AP, Adan OC, Hoeksrta ES, editors. 1994. Health Implications of Fungi in Indoor Environments. Amsterdam: Elsevier Science B.V. 602p.

18. St-Germain G, Summerbell R. 1996. Identifying Filamentous Fungi: A Clinical Laboratory Handbook. Belmont, CA: Star Publishing Co. 314p.

19. Tarlo SM, Fradkin A, Tobin RS. 1988. Skin testing wigh extracts of fungal shecies derived from the homes of allergy clinic patients in Toronto, Canada. Clin Allergy 18:45-52.

20. Wang CJ, Zabel RA. 1990. Identification Manual for Fungi from Utility Poles in the Eastern United States. Rockville, MD: American Type Culture Collection. 356p.

This is Alfa Laval

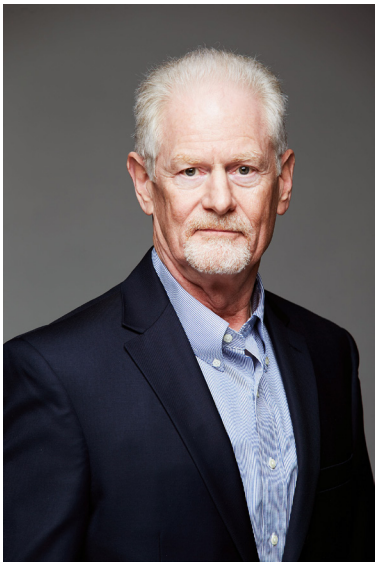
Alfa Laval is active in the areas of Energy, Food, Water and Marine, offering its expertise, products and service to a wide range of industries in some 100 countries. The company is committed to optimizing processes and creating responsible growth. We drive progress, always going the extra mile to support customers in achieving their business goals and sustainability targets.

Alfa Laval's innovative technologies are dedicated to purifying, refining and recycling material. They contribute to enhanced energy efficiency, improved heat recovery, responsible use of natural resources, better water treatment, and reduced emissions. Thereby not only accelerating success for our customers, but also for people and our planet. Making the world better, every day. It's all about ***Advancing better***™.

How to contact Alfa Laval

Up-to-date Alfa Laval contact details for all countries are always available on our website at www.alfalaval.com

Patrick Leach
Alfa Laval — Kathabar



Patrick Leach is as an authority on the role of HVAC (heating, ventilation and air conditioning) in healthcare and bio-defense. He has been involved in the design and implementation of clinical studies demonstrating the reduction of Healthcare Acquired Infections (HAIs) through application of Ultra Violet Germicidal Irradiation in Hospital HVAC systems. These published studies include Women and Children's Hospital of Buffalo, NY and Georgetown University Hospital in Washington, DC.

Mr. Leach has functioned as an invited consultant with government agencies including The White House Office of Science and Technology, the GSA and Department of Homeland Security.

He has designed and overseen microbial exposure testing in collaboration with the State University of New York at Buffalo, Buffalo, NY, School of Medicine. The resulting study demonstrated the efficacy on pathogens associated with HAIs through exposure to desiccant solutions.

Additionally, he has undertaken design and implementation of a study demonstrating the near sterilization of a controlled airstream containing aerosolized surrogate pathogens via liquid desiccant and ultraviolet germicidal irradiation technologies.

He is a member of ASHE (the American Society for Healthcare Engineering) and APIC (the Association for Professionals in Infection Control and Epidemiology.)

Contact: pat.leach@alfalaval.com

100001963 2006