Report on results of University of Surrey air and surface testing

Report Author – Professor Andrew Kemp, Head of the BICSc Scientific Advisory Board

Abstract

Bacterial cultures, counts and air particle samples were taken from multiple busy classrooms in the Surrey University Veterinary centre. One room was used as a control with no changes made from the normal routine cleaning regimes, disinfectants or cleaning materials. All the other rooms tested in the study continued with the standard cleaning regimes and materials, with changes made using either air or surface cleaning technologies. The treatment consisted of two new technologies, firstly a persistent disinfectant, and secondly an air cleansing system. Prior to the changes, rooms were tested to give base readings after routine standard cleaning, and before the start of the working day. Rooms were tested again after 4 weeks and after 10 weeks. Live Colony Forming Unit (CFU) counts were obtained using a hyper accurate Bacteria Specific Rapid Metabolic Assay (BSRMA) test [1.2], in addition, swabs were taken for culture using blood agar (used for species identification). Air particle sampling (used for estimation of airborne bioburden) was performed at the same time.

Pre treatment samples showed predominantly Staphylococcus Aureus and E coli colonies on all tested surfaces. Post treatment all rooms showed a significant reduction in CFU counts, whilst the control room remained statistically the same at all sample periods. In all treated rooms surface live bacterial counts were reduced to less than one CFU per cm^2. The reductions were so dramatic, that no samples from the treated rooms were able to provide cultures on any plates for species identification. In rooms treated with both new technology's, particle counts showed a significant reduction in counts for particle sizes that would include bacteria, fungi and viral units.

Background

On the 23rd January 2024, a group of colleagues from industry, and the Surrey University facilities management department met to discuss the potential to run a study using University real estate and personnel, to determine if the use of robotic aids, and changes to cleaning materials and disinfectant regimes, would make any difference to surface and air bioburden. The results would hope to identify ways to reduce potential cross infection/ transmission of disease between students and tutors. In addition, it was also to answer the question "can robotic aids release cleaning staff time to more thoroughly clean more important surfaces?"

The study design included multiple companies bringing their equipment into the University at 6-week intervals (standard ½ term for students), ensuring similar levels of room use over the year. University cleaning staff were trained in the use of equipment and safety with any changes in chemical disinfectants. Two companies with novel new surface and air cleaning technologies, were also engaged to provide products into separate areas that would not be affected by the other changes during test periods.

As the WHO are currently evaluating the potential use of CO^2 levels as a determining factor of safety of indoor air quality, it was suggested that with the addition of Volatile Organic Compound and CO^2 testing may help them to deliver their new recommendations for standards of indoor air quality. As the Global Centre for Indoor Air Quality testing is also based at Surrey University, it was decide that they would be engaged to test for any changes in Volatile Organic Compounds (VOC's) including CO^2 in the air. Professor Khumar and his team organised and conducted all VOC testing.

AK Medical Ltd, was engaged to undertake both the surface sampling and air particle testing.

Unfortunately, due to changes in senior staff, maternity leave and the recommendations of an independent consultant who wasn't aware of the study parameters, testing of the robotic aids, new cleaning equipment, and disinfectant changes, were not considered scientifically sound. This report then concentrates only on the data provided by the two new technologies that were kept separate from the main study.

In addition, the senior assessor for the British Institute of Cleaning Science undertook a cleaning audit of the rooms in the study, the results of which will be reported separately.

Introduction to the new technologies

Technology 1 – Advanced Photocatalytic Oxidation (APO)

This product is primarily used for active reduction in live microbial activity in the air. It filters the air, whilst also producing and circulating an hydroxyl radical (free radical) anti-microbial aerosol. Before the introduction of this patented technology, for free radicals to effectively kill microbes in the air and on surfaces, the concentration used would have to be above the safe maximum exposure levels (MEL's). This would mean that either significant Personal Protective Equipment (PPE) needed to be worn in the rooms during treatment, or the room would need to be vacated. The manufacturers of the new APO products used in the study, have discovered a method of reducing the concentration to well below safe MEL's, whilst maintaining therapeutic value. This is achieved by reducing the concentration of free radicals, then passing it over titanium dioxide in the presence of UVc light.

There was at the time of testing some, as yet unpublished evidence, that this technology has the secondary effect of reducing live microbial levels on surfaces.

Technology 2 – Photocatalytic solution (PS)

This surface treatment uses similar Photocatalytic technology to the APO product, in that it uses a form of free radical as its active antimicrobial. As a persistent surface treatment, it is applied every 3 to 6 months to clean surfaces, and remains in place until worn away through frictional forces, i.e use. Like any persistent antimicrobial technology, the reapplication schedule is based on the perceived levels of use of the

surfaces and may change from surface to surface. At the time of testing, a test is being developed that will show the presence of sufficient antimicrobial to remain therapeutic.

With both technologies, manufacturers recommend that routine standard cleaning is recommended to be continued.

Study design/ methodology

This study is limited to the two technologies described above, bacterial counts and cultures only, no viruses or fungi were able to be counted. Whilst not exact, it is possible to extrapolate the bacterial count results with equivalent increases and decreases of both viral units and fungi[3]. Highly accurate particle counts are an acceptable method of determining that increases or reductions in particles of certain sizes, would lead to the conclusion that these equate to increases or reductions in bacterial species, viral units and fungi in the air [4].

The study was blinded to all staff except the cleaning supervisors, who were instructed not to intervene in any cleaning within the rooms to be tested.

Rooms of equivalent size with similar footfall, sharing the same ventilation system, were selected. One room was used as the control, a second room was treated with the two new disinfecting technologies already described. Room three had APO only and room four had PS only. The rooms were in use for the entire 10-week period. The normal surface cleaning regime was continued in both rooms by the same cleaning operatives, using identical disinfecting/ decontaminating chemicals and equipment.

Environmental samples were taken using sterile Dacron swabs, dampened with "Aespetol". In all rooms, two samples were taken from areas of 20cm^2 on flat tabletop surfaces made of similar materials, allowing for maximum potential to gain comparator results. Whilst standard testing requires samples to be taken from only 10cm^2 evidence has shown that on surfaces where BSRMA shows live CFU counts are low, culture rarely shows any result [4,5,6]. There is therefore a much better chance of getting a result from the larger sample area which is in fact 4 times the size of a standard sample area. Blood agar plate cultures were used for bacterial species identification [6].

In all rooms, surface and air samples were taken at two sites as far apart as possible. The first samples were taken between 6.30am and 7am in all rooms. These times are after the standard cleaning has taken place, and before the rooms began their normal daily routine work. Up to 15 people use the rooms at any one time, whilst normal study classes and meetings took place. The second and third set of samples were taken at the same sites and at the same time of day, 4 weeks and 10 weeks after treatment. An average was calculated between the two sets of samples to give an overall appreciation of air and surface bioburden within the room [4].

In the rooms with the PS disinfecting technology, the surfaces were treated by spraying the solution onto the surfaces, they were then allowed to dry fully. The APO's were placed at the back of the rooms away from the entry doors, and activated at level three, with a notice saying, "do not turn off".

Air sampling was done using a multi particle sampler unit known as a Met One analyser. This unit can determine 6 different particle sizes in any one sample. One litre of air is sucked into the unit over 1 min. Particles are measured in their respective size groups, and a digital read out is taken of each particle size. Pathogen sizes are shown at Annex A.

Results/ data

Testing did not in fact take place in these rooms at the pre-determined 6 week intervals as originally planned. The test intervals were, pre-treatment, 4 weeks post treatment, and 10 weeks post treatment.

The tables below show the averaged results of air sampling by particulate size, the BSRMA results CFU per cm^2, and the result of any cultures. From air particle and BSRMA testing, there were no individual sample results of note, all were within statistical relevance of the partner tests.

Table 1 shows the BSRMA results from samples in all rooms prior to any intervention.

Pre 1st				
intervention				
05/04/2023				
Vets building				
	Control	APO	PS	APO + PS
Rm No	03VSM	01VSM	07VSM	08VSM
0.1 to 0.5 $Micm^3$	5,788	4,286	5,218	4,242
0.5 to 0.7	2,928	1,865	2,248	2,259
0.7 to 1	1,847	992	1,637	1,326
1 to 2	612	631	603	557
2 to 5	5	77	6	19
5 to 10	3	18	3	4
BSRMA	48,549	31,662	42,569	37,898
Culture	SA + Ecoli	SA + Ecoli	SA + Ecoli	SA + Ecoli

Table 2 shows the results after 4 weeks.

4 weeks				
post				
03/05/2024				
Vets building				
	Control	APO	PS	APO + PS
Rm No	03VSM	01VSM	07VSM	08VSM
0.1 to 0.5 Micm^3	3,030	1,124	932	671
0.5 to 0.7	2,496	463	137	128
0.7 to 1	1,310	290	189	118
1 to 2	405	166	106	80
2 to 5	5	36	6	9
5 to 10	2	18	4	8
BSRMA	38,352	5,629	2,975	2,526
Culture	SA + Ecoli	NCG	NCG	NCG

Table 3 shows the results after 10 weeks.

10 weeks				
post				
14/06/2024				
Vets building				
	Control	APO	PS	APO + PS
Rm No	03VSM	01VSM	07VSM	08VSM
0.1 to 0.5 Micm^3	3,083	1,353	1,849	794
0.5 to 0.7	1,517	298	182	139
0.7 to 1	1,004	108	147	124
1 to 2	353	44	198	173
2 to 5	6	56	11	27
5 to 10	3	16	4	9
BSRMA	37,189	4,065	2,403	1,222
Culture	SA + Ecoli	NCG	NCG	NCG

The tables above clearly show a significant reduction in CFU counts per cm^2 in all the treated rooms, as well as a reduction in air particle counts in the size ranges of interest to this study (see Annex A).

There was no statistical difference in air counts of VOC's or CO^2 between any of the rooms, including the control room.

Conclusion

Although this was originally set up to be a large scale study over 18 months and multiple companies, due to the unforeseen changes made during the course of testing this is now a small-scale study. However, the results are so compelling, there can be no doubt that the combination of these two new technologies significantly reduce the live CFU counts on surfaces and in the air to a degree that would certainly reduce risk of cross infection in an indoor environment.

As the only measurable differences between the study rooms were the interventions undertaken with both the APO and PS technologies, it is reasonable to conclude that these interventions were responsible for the changes.

Although there was a measurable difference in surface counts using the BSRMA tests, as there were no cultures grown in either of the three treated rooms after treatment, it is impossible to know for certain if there is a real difference in potential for cross contamination from either surfaces or air.

As such, it is the authors view that the most effective way to use the technologies is by combining them. It is of course possible that due to the "Holism" or "Entourage theory" [8] that the individual product efficacy is increased by the combined use with the other product.

As a result of this study, it is now the opinion of the authors, that there is a clear relationship between air and surface contamination in both directions.

Further research

It is clear there is more research required if we are to determine if robotics will either increase efficacy of cleaning or simply reduce the number of hours cleaning staff are required to clean areas within buildings, such as floors. It is also still unclear as to how much effect the reduction in live CFU surface counts will have on student/ tutor sickness.

This research study was funded entirely by the BICSc and the CSSA, with products and services provided for free by the relevant parties. At the time of publication there are no conflicts of interest.

Additional note

As previously described, during the course of the study, an external consultant not involved in the study recommended a change of disinfectant. Although the University knew that there was to be no such changes in study rooms, due to a change in senior management the changes were allowed. The results were dramatic, with a significant increase in bacterial counts and a few bacterial species changes of concern. The FM department were informed of the concerns, and changed back. This did not affect the results above, but it was one of the reasons the study was no longer considered scientifically viable.

Annex A

Approximate particle sizes of pathogens of interest to the study

Species	Microm^3		
SA	0.52	Staph Aureus	
Psu	0.55 to 0.7	Pseudomonas	
Sp	0.5 to 1.25	Streptococcus pneumoniae	
Kl	0.5 to 0.8	Klebsiella	
Hi	0.3 to 1	Haemophilus Influenzae	
Sh	0.4 to 0.6	Shigella	
EC	0.6 to 0.7	E-Coli	
Cp	3 to 4	Clostridium perfringens	
Ca	1.7	Campylobacter	
BC	3 to 4	Bacillus Cereus	
NCG		No culture growth	
	Below 0.5	? Virus	
	10 plus	Fungi	
CO2	1 Kg = 0.5458m3		
	1 microm is 10 to the 18th of a cubic meter		

References

1. Kemp A, Diggle M. How do we clean up this mess? American Journal of Biomedical Science and Research. Aug 2019. ISSN:2642-1747
2. Kemp A. A new era in bacterial detection in healthcare. Clinical Services Journal Vol 18 (8) 38-39 Oct 2018.
3. Murray PR, Baron EJ , Jorgensen JH , Landry ML , Pfaller MA, Kilian M 2007. Manual of clinical microbiology, 9th ed. ASM Press, Washington, DC.

4. Kemp A, Laird K, Diggle M. Cleaning and Disinfection Quality. Guidance standards for establishing and assessing cleaning and disinfection in UK Hospitals and other healthcare facilities. July 2017. https://www.qtechnologiesgroup.com/wp-content/uploads/2018/06/Healthcare-Environmental-Cleaning-guide-and-standards.pdf
5. Boone SA, Gerba CP. 2007. Significance of fomites in the spread of respiratory and enteric viral disease. Appl. Environ. Microbiol. 73:1687–1696.
6. Bollmann A, Lewis K, Epstein SS. 2007. Incubation of environmental samples in a diffusion chamber increases the diversity of recovered isolates. Appl Environ Microbiol 73:6386–6390.
7. Kemp A, Hodgkinson V, Bugg A. Prevention is better than cure. Clinical Services Journal Vol 16 (9) 61-63 Oct 2017.
8. Kemp A. Antimicrobial Efficacy and Lack of Resistance to Silane Quaternary Compounds. Pathology in Practice 1-6 April 2020.