Environmental disinfection: Bucket and mop to robots and rays.

A look at environmental decontamination and potential lessons from other sectors.

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Bucket and Mops or Spray and Wipe
Manual cleaning and disinfection
The use of any disinfectant requires the following:

- Each and every surface must have a layer of solution applied.
- Solution must remain and not dry or evaporate for the required contact time.
- Must have efficacy against the pathogens being targeted.
- Solution remain fresh and non contaminated
- Cloths remain clean and non contaminated.
Manual cleaning and disinfection
(Other applications)

- Pharmaceutical.
- Biotech
- Medical device
- Healthcare (infection Control)
- Defence (bio terrorism)
- Food production and food processing
Limitations of manual cleaning and disinfection (lessons from healthcare)

Failure to comply with any of the previous can have disastrous consequences.

In one study reported in the international journals Acinetobacter was inadvertently spread throughout a ward when the manufacturer’s instructions for use of a disinfectant were not strictly followed. Hard water!

In another study designed to test two approved sporicidal products not only did the products fail to eliminate the contamination they actually spread it to other surfaces. In fact in testing they performed no better than water.

Limitations of cleaning and disinfection

- MRSA, GNR and VRE were cultured from 30%, 10% and 5% of sites, respectively, after terminal cleaning in one room.\(^1\)
- It took an average 2.8 disinfections to eradicate VRE from a room.\(^2\)
- *C. difficile* can persist even after cleaning with bleach.\(^3\)-\(^5\)
- Hospital pathogens can be transferred from apparently “cleaned” rooms to HCW hands.\(^6\)

Any manual disinfection is only as good as the person or persons applying the disinfectant.

Required controls difficult to monitor

Impossible to validate.

Failures are common

BUT

Its cheap (until something goes wrong)
Chemical fogging

Fogging or aerosolisation

A liquid disinfectant is nebulised or aerosolised into droplets and sprayed into the room.

It does offer advantages over manual disinfection as it attempts to automate the delivery of the disinfectant.

However droplets are relatively large and will be pulled down by gravity affecting distribution.

HVAC must be disabled.
ASP Glosair – Tyvek pouched BIs*

* BIs = *Geobacillus stearothermophilus* biological indicators.

93% of 6-log BIs grew.
64% of 4-log BIs grew.

Fu et al. *J Hosp Infect* in press.
ASP Glosair – BIs* removed from Tyvek pouches

* BIs = *Geobacillus stearothermophilus* biological indicators.

86% of 6-log BIs grew.
64% of 4-log BIs grew.

Fu et al. J Hosp Infect in press.
Inside cupboard

Two ASP Glosair units running three back-to-back cycles

Back of drawer, open 10 cm

Under washer / disinfector

6-log BI: killed

6-log BI: grew

Chemical fogging

Fogging is essentially a wet process.

Additional issues with material compatibility.

Undersides or occluded surfaces outside of direct line of sight.

Residues.
Chemical fogging

Conclusion

• Relatively cheap (depending on system purchased)
• Some what automated.
• Distribution of fog is an issue
• Repeatability is a problem making validation difficult if not impossible.
• Chemical residues.
Gas and vapour phase

Gas or vapour phase decontamination technologies offer a number of advantages.

Full 3D or homogenous distribution

Can be fully automated.

Excellent and will proven efficacy
Formaldehyde

Excellent distribution.

Proven efficacy.

Full 3D or homogenous distribution

Cheap
Formaldehyde

Leakage

Difficult to validate

Residues

Permeates everywhere

Class 1 carcinogenic.

Humidity control critical

There is a growing movement away from the use of Formaldehyde in Europe and the US with a European wide ban under discussion.
Chlorine Dioxide

Excellent distribution.

Well established proven efficacy.

Full 3D or homogenous distribution

Good penetrative ability
Chlorine Dioxide

Requires a minimum temperature of 24 degrees and a humidity of 75%.

While it is a true gas uses steam (a vapour) to raise humidity. Efficacy is only as good as the steam distribution.

Residues (potential white powder which much be removed)

Permeates well.. (too well)

Material Compatibility
Chlorine Dioxide  (lessons from defence)

- Noted material compatibility issues
- Internal and external corrosion on a computer
- Powered residues inside the computer (acidic)
- Failure of one computer monitor
Chlorine Dioxide

Also reported hard drive failure and component failure
Chlorine Dioxide

Report Conclusions

“As discussed in previous reports, ClO2 gas can cause severe corrosion on several types of structural materials and discoloration of wiring insulation. Hydrogen peroxide (H2O2), therefore, can be considered the more compatible fumigant of the two.”

“Results from the 750 ppmv ClO2 fumigation suggest that 750 ppmv was more damaging to Category 4 materials than the 3000 ppmv ClO2 fumigation. Although both fumigation concentrations resulted in severe physical damage to the computers by promoting rusting and corrosion,”
Conclusions

Relatively cheap

True gas with excellent distribution but efficacy is dependent on humidity which is introduced as vapour. Efficacy is dependant on vapour distribution but no forced distribution of vapour?

Permeability : Pro and a con.

Material compatibility.
Vapour Technologies

Hydrogen Peroxide as a Vapour
Not to be confused with Hydrogen peroxide fogging.

30 to 35% of high purity Hydrogen peroxide flash evaporated to generate a vapour. This vapour is injected into rooms or enclosures.

Forced distribution

Well established efficacy
No residues
Some penetrative ability
Excellent material compatibility
Vapour Technologies

Hydrogen Peroxide as a Vapour

Two types of this technology. Condensing and non-condensing.

Non-Condensing requires low humidity and tight humidity control throughout the cycle.

Condensing does not require humidity control. Operating window between 35% and 75% RH and between 15 degrees and 35 degrees temperature.

Penetrative ability does not match Chlorine Dioxide or Formaldehyde but does not require air tight enclosures.
Vapour Technologies

Hydrogen Peroxide as a Vapour

“All Category 2 and 3 materials demonstrated sufficient compatibility with H2O2 vapour.”

“In this study, all Category 2 and 3 materials proved to be resistant to H2O2 exposure under all conditions tested.”
Vapour Technologies

Hydrogen Peroxide as a Vapour

As it is a vapour and not a true gas it does not have the same distribution ability as Chlorine Dioxide or Formaldehyde but with specially designed distribution systems and the aid of fans full homogenous distribution is achieved.

Although vapour does have some penetrative ability it lags behind in comparison to Chlorine Dioxide or Formaldehyde.

Only suitable for use of dry surfaces.
UV:

The technology:

- Mobile UV unit
- Emits high dose of UVC (115W).
- UVC is short range UV (254nm) called “germicidal UV”.
- UVC breaks the molecular bonds within nucleic acids, producing thymine dimers hence destroying microorganisms, rendering them harmless or prohibiting their growth and reproduction.
- The system controls the dose of UV according to room topology to ensure an even dose.
UV system:

Microbiological efficacy:

- 2-3 log reduction in MRSA and C. diff and 3-4 log reduction in VRE at the spore killing dose, but only 1 log reduction in C. diff at lower reflective dose\(^1\).
- Complete eradication of organisms from surfaces not achieved\(^1,2\).
- Efficacy greater closer to the unit and in direct line of site\(^1\).
- 1-3 log reduction in bacterial spores depending on room location and no complete eradication of contaminant\(^2\).

2- Rutala, SHEA, 2010.
UV system:

Conclusion:

Its fast and easy to operate

Expensive to buy and run

Shadows

Variable efficacy
Other applications

Decontamination of BSC’s

Decontamination of IVC’s

Multi use applications, cage wash, heat sensitive items.

Room decontamination.

Building decontamination.

Decontamination chambers.
The importance of validation or cycle verification.

One of the major benefits of automated decontamination solutions over manual solutions is the ability to verify or validate the effectiveness of cycles.

It provides a guarantee that the environmental contaminants have been eliminated...

This provides confidence not only to you but to the regulators and customers.

The method of validation is important, has cycle development been performed? In the case of transfer solutions have worst case loads been identified and allowed for.
The validation and verification challenge.

The identification of an appropriate “challenge” for cycle verification and validation is critical to ensure the successful implementation of any decontamination solution.

There is currently some debate over what constitutes an appropriate challenge but to date a 6 log sporicidal reduction remains the gold standard.

Is a 6-log sporicidal challenge too high?

A number of studies have looked at decontamination solutions that have demonstrated an ability to inactivate a 4 log sporicidal challenge but yet fail to eliminate environmental pathogens.

It is also known that many pathogens including common animal pathogens prove to be a tougher challenge for decontamination solutions than bacterial spores. Indeed is anything there is some concern that a 6 log sporicidal reduction is not a tough enough Challenge.
Choosing the correct solution for you

The selection of the correct disinfection \ sterilisation technology is important and depends on the customer requirements.

The various factors include, efficacy, penetrative ability, safety, leakage, mobile, variety of applications, etc.

All must be balanced to ensure the best solution for you.

Do you need a water soluble highly penetrative solution ?
Is your facility air tight, can you evacuate surrounding areas ?
Do you want to decontaminate an IVC while the room is in use ?
Do you want to decontaminate a BSC while the room is in use ?

Do you require large area (e.g. entire facility) decon ? If so do you want to purchase multiple pieces of capital equipment or would a decontamination service be more suitable ?

Can you validate the process ?

Can you verify results ?
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Questions and comments?

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