

Area decontamination with hydrogen peroxide vapour (HPV) plus silver: The Hygienics Biosecurity BioGienie™ robot

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Summary

Hydrogen peroxide vapour with silver (HPV) decontamination may be considered for routine use in selected areas, and has particular value for the terminal decontamination of areas previously occupied by patients with particularly troublesome drug-resistant pathogens. Though toxicity of reactants for all HPV systems has been a particular concern, the BioGienie™ system offers an enhanced safety profile for operators and though the area must be sealed during treatment, the improved safety profile encourages and permits customer use thus increasing flexibility and reducing costs.

Using reference and wild strains of a wide range of 'problem pathogens' including methicillin-resistant *S aureus*, vancomycin-resistant enterococci, ESBL-producing coliforms, *Pseudomonas* spp, *Acinetobacter* spp, and *Clostridium difficile*, this system is proven to deliver reproducible killing of reference strains and clinical isolates dried with 10% serum onto hard surfaces to simulate heavy organic soil. With standard single-cycle treatment, a minimum 5 log₁₀ reduction of test preparations was achieved for all species tested, commonly with reductions up to and in excess of 7 Log₁₀.

With short turn-round times and a proven efficacy against key pathogens, and automated programming providing flexible treatment options for rooms of different size, effective HPV treatment with enhanced convenience and prompt return to use is now possible.

Background

Overwhelming concerns of hygiene standards and the prevention of healthcare-associated infections have escalated in recent years. Healthcare hygiene has never been under such close scrutiny, with intense pressure to maintain and enhance hygiene standards from regulators and public alike.

Despite knowledge of different cleaning regimens and their comparative efficacy, several problems remain. The increasing list of 'problem' pathogens such as MRSA, VRE, PVL, ESBL and *C difficile* makes compromise inevitable when selecting detergent and disinfectant products for routine and terminal cleaning.

COSHH safety and materials compatibility together with difficulties in cleaning a wide range of different furniture and equipment items, and the built environment create particular difficulties. Increasing cost and time pressures and environmental concerns severely limit the wider use of disposable fittings and furniture items.

Demands for minimal disruption with early return to use of areas that have been cleared for terminal cleaning create an inevitable conflict between hygiene standards and the prevention of healthcare-associated infection and the delivery of care that must continue to meet increasingly prescriptive government and purchaser/provider contract targets. Finding the correct balance is a challenge for healthcare professionals and managers alike.

HPV/silver decontamination is ideal for routine use in selected areas, particularly for the terminal decontamination of areas previously occupied by patients with particularly troublesome drug-resistant pathogens. Though toxicity of reactants for all HPV systems has been a particular concern, the present system offers an enhanced safety profile to permit customer use, to increase flexibility and to reduce costs.

With short turn-round times and a proven efficacy against key pathogens, and automated programming providing flexible treatment options for rooms of different size, effective HPV treatment with enhanced convenience and prompt return to use is now possible.

Hydrogen peroxide (HPV) vapour treatment

Hydrogen peroxide vapour (HPV) treatment has increased in popularity and is now central to the hygiene management of healthcare environments. Supporting compliance in the maintenance of hygiene standards, HPV offers enhanced terminal disinfection of the healthcare environment and of fixtures and fittings therein. Though no substitute for a good quality and effective cleaning regimen, HPV is rapidly becoming a *de facto* standard for environmental decontamination that delivers increased margins of safety.

In this study, we have examined using simulated 'in-use' conditions the efficacy of the Hygienics Biosecurity BioGienie™ HPV robot (Figure 1) against reference strains and clinical isolates of a range of common 'problem' pathogens.

<i>Staph aureus</i> / MRSA / PVL	<i>Escherichia coli</i>
Enterococci / VRE	<i>Klebsiella aerogenes</i> / ESBL
<i>Clostridium difficile</i>	<i>Enterobacter aerogenes</i>
<i>Listeria monocytogenes</i>	<i>Pseudomonas aeruginosa</i>
<i>Salmonella</i> spp	<i>Acinetobacter baumannii</i>
<i>Shigella</i> spp	<i>Serratia marcescens</i>

The Hygienics Biosecurity BioGienie™ HPV robot

The BioGienie™ HPV robot produces an aqueous aerosolised H₂O₂ and ionic silver mist from a multi-dose peroxide cassette that permits end-user operation with more rapid time to completion and enhanced safety profile.

Hyproxil™ is acid stabilised to prolong its shelf life and allow easy storage. Low peroxide concentrations (6%) in the recyclable and sealable cartridge make the BioGienie™ disinfectant dispersal system easy to use. 6% H₂O₂ makes road transport easy while in other systems H₂O₂ concentrations >8% are classified as dangerous goods demanding elaborate road transport safety conditions.

HPV aerosol is dispersed as a thermodynamic vapour. During the active phase, H₂O₂ concentrations increase due to an increase in water vapour pressure. After active dispersal, H₂O₂ concentrations decrease and without catalytic intervention during the contact time phase decomposition follows first order kinetics - the decline is dependent on the active H₂O₂ concentration only.

Due to the relatively slow decomposition of H₂O₂ at concentrations <15 ppm, a total operational time of 2 hours is recommended followed by a ventilation period of 15 minutes to reduce the peroxide concentration to below 1 ppm (1.4 mg m⁻³, LTEL 8 hours). The STEL for H₂O₂ is 2 ppm (2.8 mg m⁻³) (15 minutes exposure).

Test procedures

Overnight nutrient broth cultures were prepared for reference strains and clinical isolates. With counts ranging from 10⁶ – 10⁸ cfu ml⁻¹, test pieces were prepared by addition of 10% fresh horse serum to broths (to simulate a heavy organic load), from which 2 x 100µl aliquots were transferred to labelled sterile 3 x 1 inch glass slides. Final inoculum densities were not less than 10⁴ cfu and generally in excess of 10⁶ cfu per slide.

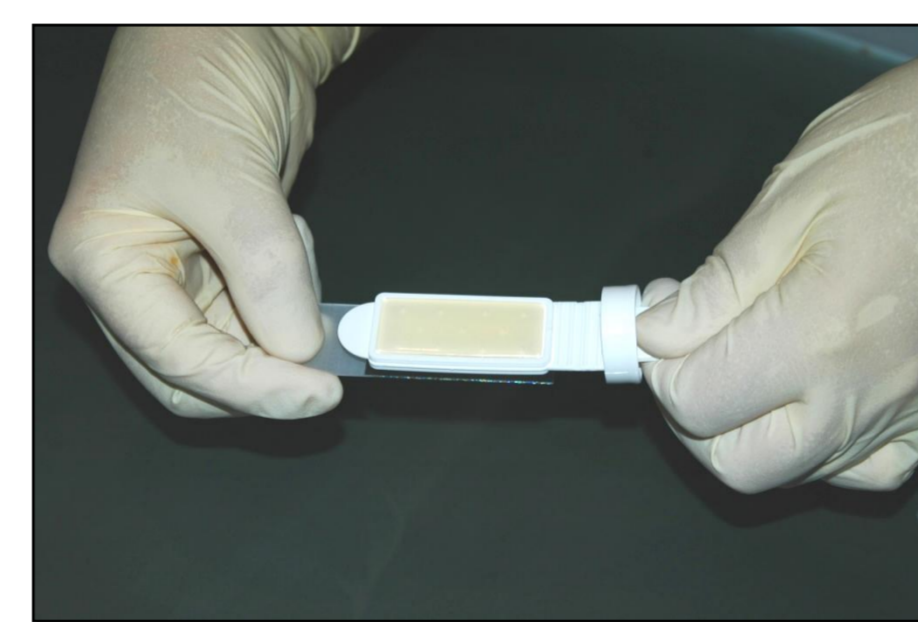
Inocula were spread using a sterile loop to give a uniform distribution. Test slides were allowed to dry in air then mounted for HPV treatment. All tests were performed in a dedicated test facility measuring 50 m³. The BioGienie™ HPV robot was positioned in an offset position towards one end of the room.

Inoculated test slides were mounted in triplicate on sample holders positioned in the four corners and at the mid-point of the side walls of the test suite to assess vapour distribution with sample points at the furthest point from, and behind, the unidirectional HPV vapour stream.

In triplicate, inoculated slides were positioned ~1m from the floor, with test slides held in horizontal, vertical and in inverted positions (Figure 2) to assess the spatial distribution of H₂O₂ vapour distribution and biocidal activity in 'hard to reach' positions. For each test run, a total of 54 replicate slides were exposed; control (unexposed) slides were left outside test room.

All tests were performed with a single exposure cycle comprising a total dose of 6 ml Hyproxil™ disinfectant per m³ delivered at a constant flow rate of 25 ml min⁻¹ (total dispersal time of 12 minutes). For uniformity, testing was performed under controlled temperature and relative humidity surveillance.

At the end of the HPV treatment cycle, test slides were sampled by impression culture on dip-slides comprising tryptone soya agar (Red Spot) (3M Diagnostics). Cultures were incubated for 2 – 5 days for comparison of pre-and post-exposure counts.

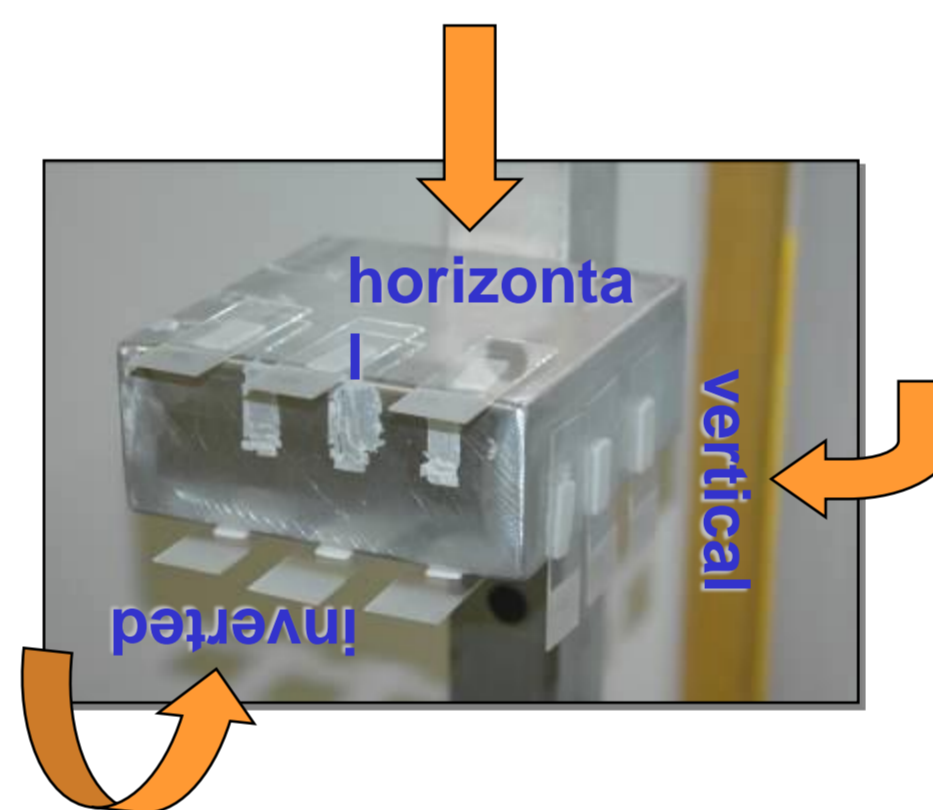


Sampling with dip-slides

For *C difficile*, prepared in Robertson's cooked meat medium, slides were recovered after treatment and wiped vigorously with moistened cotton swabs that were plated onto CCFA medium and incubated anaerobically for up to 5 days.



Fig 1 - BioGienie™ HPV robot

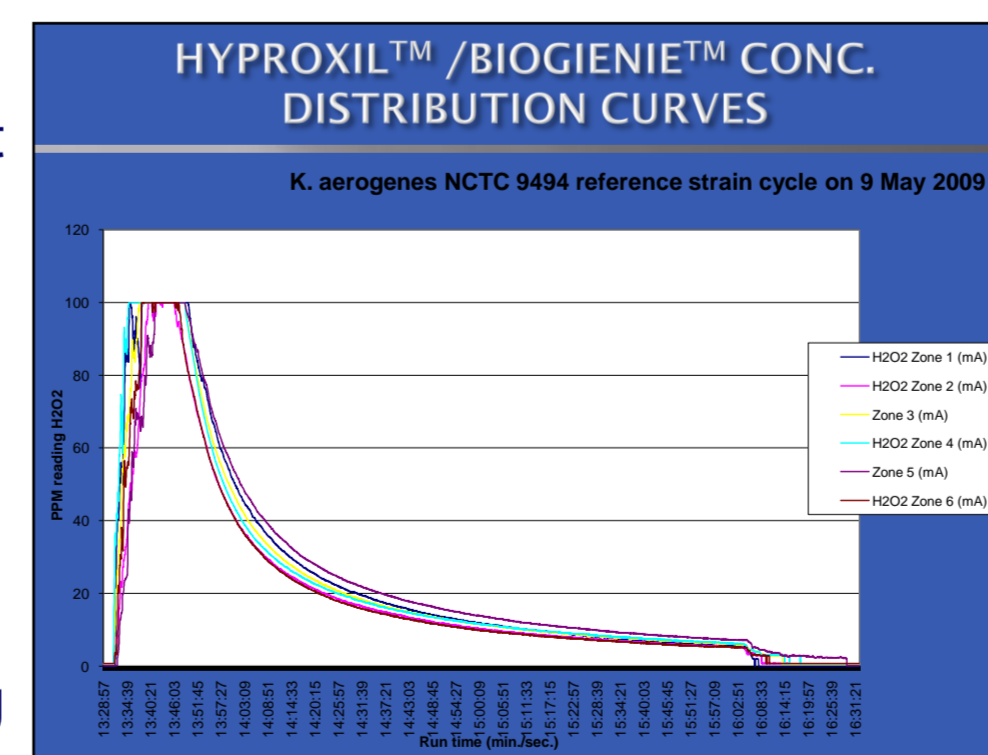


Results

Pre-calibrated Hyproxil™ electrochemical sensors were used to monitor H₂O₂ concentrations after the required contact time of 1 hour has been completed.

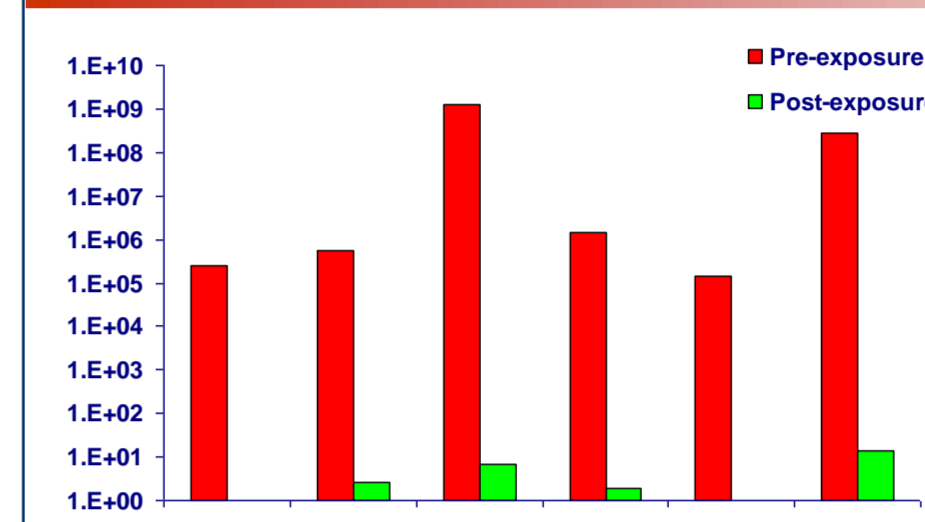
Hyproxil™ BioSens electrochemical peroxide sensors were used to accurately monitor peroxide concentrations in the 0-10 ppm range with a resolution of 100% (0.01 ppm).

H₂O₂ decomposition measurement shows the peroxide natural decay in a 50 m³ room without any intervention. The accuracy of homogenous dispersal can be seen in the similarity of peroxide concentration as sensed by 6 H₂O₂ sensors located uniformly throughout the test room. Sensing was done at each of six sampling points at a height of 2 metres above floor level. With ventilation intervention there is a rapid dilution to workplace acceptable exposure limits of below 2ppm.



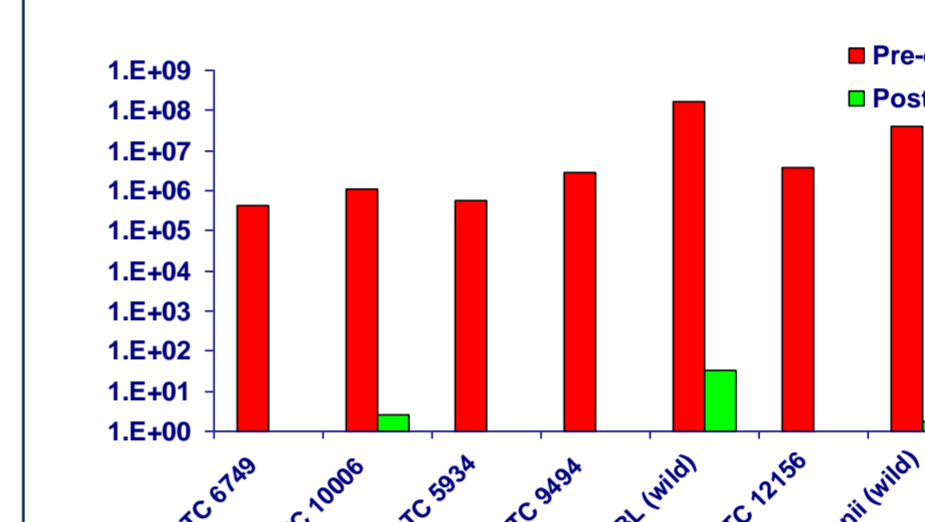
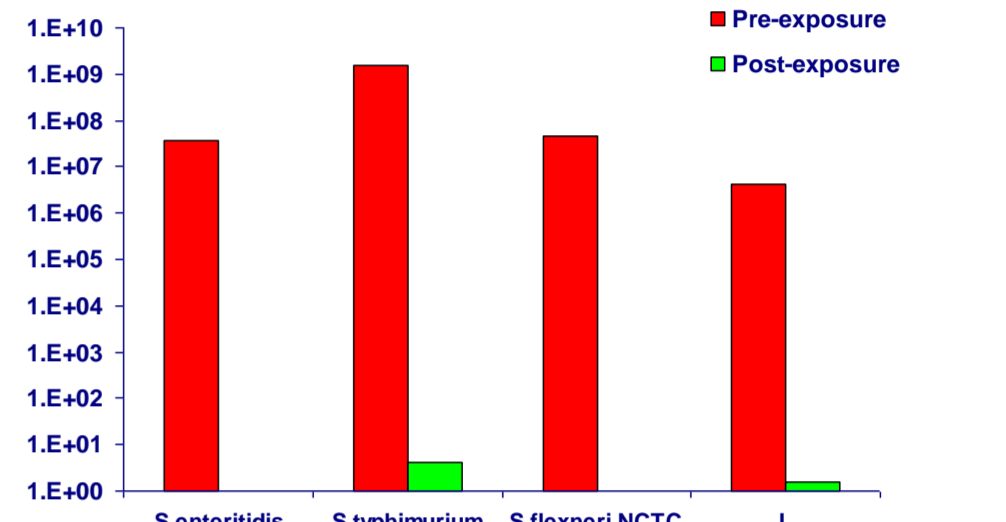
Using dip-slides for bacteriological sampling showed comprehensive killing of reference strains and clinical isolates of a range of potential pathogens. Despite the addition of 10% serum as an organic soil, HPV reduced all test strains to zero (<10 cfu) after single cycle treatment.

Results

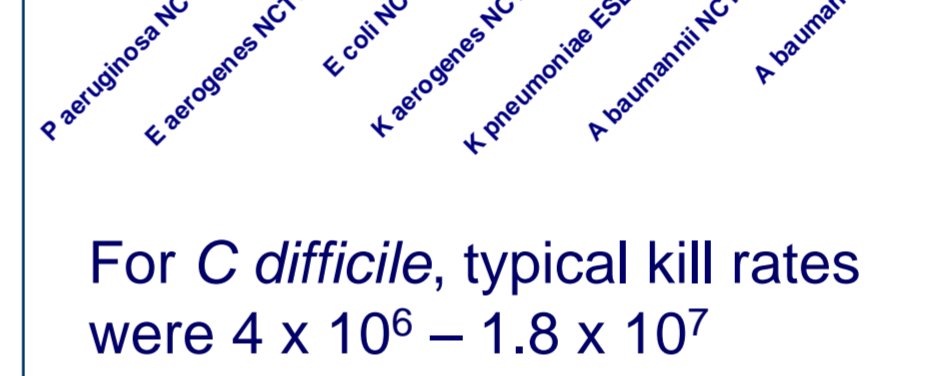


Gram positive pathogens including *S aureus* (MSSA, MRSA & PVL strains) and enterococci including VRE were susceptible to HPV. Typical kill rates were 1.5 x 10⁷ for *S aureus* and 1.2 x 10⁸ for *E faecalis*

The enteric and food hygiene pathogens *S enteritidis*, *S typhimurium*, *S flexneri* and *L monocytogenes* were each susceptible to HPV. Typical kill rates were 2.2 x 10⁸ (range 2.7 x 10⁶ - 4.5 x 10⁸).



For a range of Gram negative pathogens, typical kill rates were 8.0 x 10⁷ (range 6.5 x 10⁵ – 1.6 x 10⁸) with activity against ESBL strains.



For *C difficile*, typical kill rates were 4 x 10⁶ – 1.8 x 10⁷

Conclusions

The results demonstrate uniform bactericidal activity against a wide range of bacterial pathogens.

- Gram positive bacteria
- Gram negative bacteria
- *Clostridium difficile*
- Food pathogens
- Antibiotic resistant strains - MRSA, VRE, ESBL - are fully susceptible to HPV
- No resistance observed
- Good spatial distribution of HPV activity
- Simple programmable interface and cassette-pack reagents ensure maximum flexibility for owner/user operation
- Short treatment cycles (~2 hours) & fast turnaround time of not more than 2.5 hours with forced ventilation (3 hours without forced ventilation) for areas below 100 m³ reduce disruption and permit early return to use

The BioGienie™ HPV robot offers innovative programming features including:

- Simple pre-programme creation and a wide range of pre-set options
- Multiple user access control
- Full trackability and traceability in process cycles and material batches
- Engineering diagnostic screen
- Feedback sensors controlling all critical operational parameters
- Cartridge RFID technology for consumables control
- Variable flow rate, dosage and consecutive cycle input with reliable user friendly software
- Option of running up to five consecutive cycles at a range of practical dosage and flow rate variations.
- Remote control of the system via infrared or wireless communications



¹This work was done by Dr Murray Viljoen of Hygienics Biosecurity Ltd in collaboration with Ian Blenkarn of Blenkarn Environmental, an independent healthcare and environmental microbiology consultancy