

# Oxygen cage decontamination using photocatalytic oxidation.

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## Introduction

Oxygen cages provide a controlled environment designed to regulate temperature, humidity, carbon dioxide and oxygen levels. These conditions can be useful in caring for the critically ill or injured patient. However, oxygen cages may constitute a serious source of infection by viruses, bacteria and dermatophytes for subsequent patients. Particularly, the disinfection of the air handling section is difficult because most internal surfaces and parts cannot be reached with fluid surface disinfectants. Gaseous disinfection is cumbersome, introduces toxic risks, may be corrosive, and not effective against all types of micro-organisms.

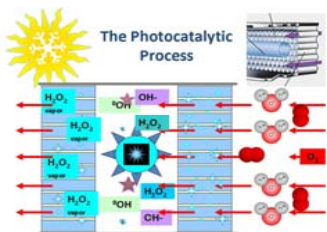


Figure 1

We evaluated the decontaminating effect of in-chamber photocatalytic oxidation which activates air molecules producing superoxides and hydro-peroxides amongst others (Fig. 1). This treatment is easy to apply, non-toxic, leaving no residues, non-corrosive, non-humid and highly cost-effective.

## Materials and Methods

Two different modified PlasLab oxygen cages (PlasLabs Inc, Lansing, MI, USA) were used for evaluation of bacterial surface contamination. After use of the oxygen cage for at least 4 hours, bacterial surface contamination was evaluated by sampling 8 locations with Rodac Petri dishes (bioTrading, Mijdrecht, the Netherlands) (Fig. 3: series 1, blue bar). The sampling locations were the inside access door (1), back side (2), left side (3), right side (4), ceiling (5), and bottom (6) of the patient compartment; inside (7) and inside access door (8) of the sodalime compartment.

Subsequently, the oxygen cage was cleaned and disinfected according to a standardised in-house protocol with cleaning and disinfectant solutions. The 8 locations were again sampled directly adjacent to the previous sampling site (Fig. 3: series 2, purple bar).

A stainless steel air handler (designed by Clean Air Concept, Ede, the Netherlands) fitted with an electrical fan and a photocatalytic oxidation cell (RCI DuctwoRx 9 inch; EcoQuest International, Greeneville, TN, USA) was placed for 12h in the chamber which ran in standard mode (Fig. 2). Remaining contamination was evaluated (Fig. 3: series 3, yellow bar).

Contamination was defined as the number of colonies that were counted on the dishes after 48h incubation at 37°C.

## Acknowledgments

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## Statistical analysis

Results were not normally distributed. A Mann-Whitney U test was used in all locations and in all series to compare the two different cages. From the 27 tests, all but two tests showed no significant difference, leading to the conclusion that the two cages reacted in a similar manner.

Next, a Wilcoxon signed-ranks test was used to compare the different series.

$P < 0.05$  was considered significant. Analysis was conducted with the use of SPSS 18.0.

## Results

The mean and standard deviation ( $n=21$ ) of the total and per location (1 to 8) are summarised in figure 3. Identical letters indicate a non-significant difference between series of one location; different letters represent a significant difference.

All locations had a significant difference between series 2 and 3 (Total, location 2, 3 and 6 with a  $P < 0.001$ ; location 4 and 5 with  $P < 0.01$ ).

The in-house cleaning and disinfectant protocol did not reduce bacterial surface contamination; on the contrary, bacterial growth was significantly increased for the total, location 6 and 8. All other locations, with exception of location 1, show similar but non-significant trends.



Figure 2

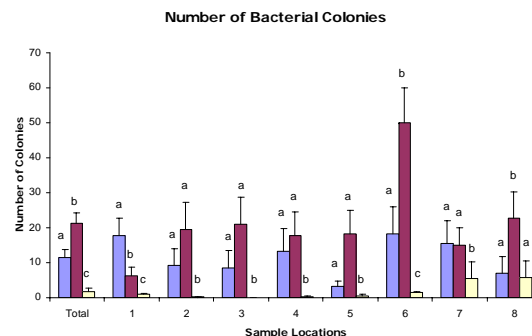


Figure 3

## Discussion

Photocatalytic oxidation experimentally inactivates several airborne species of bacteria and fungi (Fan et al 2002, Li and Wang 2003, Grinshpun et al 2007). In previous experiments we demonstrated that this also holds true for bacteria on surfaces. Even viruses and spores might be sensitive to this oxidative effect (Li and Wang 2003, Becker 2004). Based on these studies, we were interested if it could reduce the bacterial contamination level in our oxygen cages.

The bacterial counts of series 3 indicate a decontaminating effect of the photocatalytic oxidation cell. This is of particular interest for the internal parts of the air handling section that cannot be reached with fluid disinfectants.

Although the two locations in the sodalime compartment had a significant reduction in bacterial growth between series 2 and 3, the mean number of bacteria was higher than in other locations. Looking at the results this can be ascribed to two samples (one in each location) that had a very high bacterial count ( $>100$ ). All other counts were zero or almost zero which suggests some incidental cause. Excluding these samples gives similar results as in the other locations, suggesting that the oxidation process has a similar effect on more distant locations.

Much to our own surprise the standardised, in-house cleaning protocol (series 2) resulted in increased bacterial counts in almost all sample locations. The repeated use of the same cleaning attributes and data collection by different people might play a role. Based on our suspicions, we have made adjustments to our in-house cleaning protocol. This result reminded us to remain critical towards in-house protocols and to scrutinize their appropriateness on a regular basis.

## Conclusion

Photocatalytic oxidation is an excellent method to reduce bacterial surface contamination especially in areas of the oxygen cage that cannot be treated with conventional cleaning and disinfectant protocols.

## References

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