Marine red sea algae in combatting indoor respiratory infections: A catch and kill exposure reduction strategy.

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KEYWORDS: Carrageenan; Ventilation; Covid-19

INTRODUCTION: Our study researched and developed a catch and kill technology for airborne particles in centralized ventilation systems. As the air we breathe is the most difficult to manage, physically removing viral pathogens is deemed the most effective (REHVA,2020). The main principle was to present an exposure reduction strategy to combat indoor respiratory infections for enveloped viruses such as SARS-CoV-2 and influenza. The technology needed to be sustainable and based on bio-economic principles. Energy consumption and carbon footprint as important criteria. Crucial was that we employed sources derived from a natural source. In contradiction to traditional filtration technologies who are made in heavily industrialized processes and are adding to an ever-growing landfill. We believe a natural product is a viable and more long-term strategy helping in the paradigm shift that is happening for ventilation practices.

METHODS: Three main questions need to be addressed for this study: (i) A biological compound as a killing agent that is derived from a natural source (ii) develop a system that is retrofit on modern-day ventilation systems and shows a catch and kill capacity without an air pressure drop (that would result in higher energy usage) (iii) develop a matrix (or sieve) that holds the biological compound and that renewal of the antiviral capability can be guaranteed without waste products or replacements of parts (limiting our carbon footprint). After much research, a test procedure was developed by which the capture of phages from the airflow through a treated filter, placed in the ventilation tube, could be measured and the antiviral activity of our biological compound could be experimentally demonstrated.

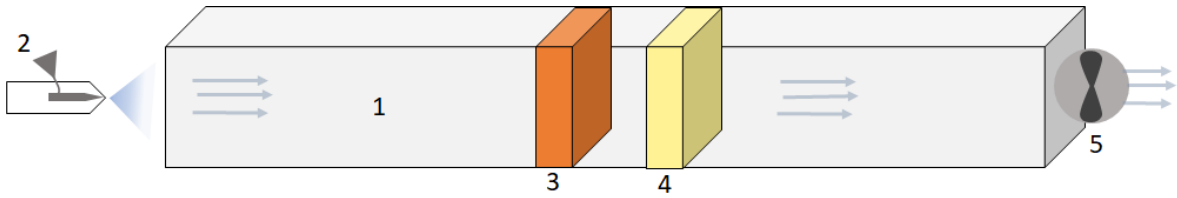

Figure 1. AVECOM testing results: Scheme of the lab-scale Sea-Aeration system with implementation of Proxy 1.

A first small-scale lab test setup would strengthen our first insights and would be later replaced by a large-scale testing unit with an AHU (Air Handling Unit) to mimic a real-life ventilation system. In the lab and large-scale testing, we used the MS2 phage proxy to determine the catching and killing capacity of our setup. The use of MS2 bacteriophage specifically as a viral representative is also recognized by EPA (Environmental Protection Agency). Based on its morphological characteristics EPA considers MS2 an appropriate viral representative for water filtration and purification testing.

RESULTS AND DISCUSSION: For our biological compound, we found a solution in high-molecular-weight polysaccharides (Ginsberg et al.,1947). Research indicates sulphated polysaccharides (carrageenan) are selective inhibitors of several enveloped and non-enveloped viruses and act predominantly by inhibiting the binding or internalization of the virus into the host cells. These promising antiviral agents against respiratory viruses were also suggested by the WHO in the fight against the global pandemic (WHO, 2020; Periera, L. 2018; Gaikwad, etal., 2020).

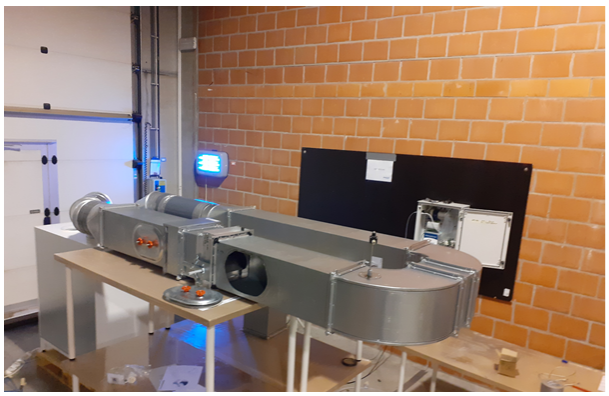

Figure 2: AVECOM test setup: Large scale test with AHU unit in place

This is a natural source, cheaply available, non-toxic in nature, safe and biodegradable and in many instances biocompatible, it also Generally Recognized As Safe (GRAS) by the USFDA (Carthew 2002). Tests with the independent REGA institute in Leuven showed our solution had antiviral activity against certain coronaviruses with EC50 values in the range of 20 -100 µg/ml (starting from solutions of 2 g carrageenan/L or 5 g carrageenan/L). By adding another product (P) to the antiviral compound we were able to retain phages on the matrix, so a combination of dehydration and the action of the antiviral product resulted in the killing of the proxy. With the help of a digital twin and the cooperation of the University of Genova, we could further optimize the matrix system and determine catching capabilities. Further focusing on efficient positioning, engineering and automatization of the renewal process.

CONCLUSION: Our main achievements, based on the experiments with the lab-scale and the large-scale ventilation systems showed that an optimized positioning of the virus catcher in the ventilation tube did not cause an important obstruction of airflow. At an airflow velocity of 1.5 m/s, we can conclude that the pressure drop is 15,4 Pascal. A substantial higher efficiency than other traditional filtration techniques results in a pressure loss ranging from 400 – 7000 Pascal. Experimental demonstration and also results from the digital twin showed a high phage-capturing capacity of our filter, pre-treated with the biological compound-based formulation from up to 92 % phage capturing, and 99% particle mass capturing. We demonstrated a fast die-off of captured phages on the filters, treated with a mixture of our biologica1 compound with a log 3 PFU decrease due to virucidal capacities.

Filter		Log PFU*** decrease	
Thickness (mm)	Time between treatment and test	Rel. Capt. Cap.*	Antiviral effect of product P**
XX	15 min	1.3	3.0
XX	15 min	2.6	1.3
XX	7 days	1.1	3.5

*Relative capturing capacity: Log difference between the main filter and Proxy 1
**Log difference between PFU on main filter, treated only with compound 1 , and PFU on main filter, treated with compound 1 and antiviral product
*** Plaque Forming Units

Table 1. AVECOM Testing results: Die-off of captured phages.

REFERENCES:

REHVA, REHVA COVID-19 guidance document: How to operate HVAC and other building service systems to prevent the spread of the coronavirus (SARS-CoV-2) disease (COVID-19) in workplaces; November 17, 2020

Ginsberg RH, Goebel WF, Horsfall FL. 1947. Inhibition of mumps virus multiplication by a polysaccharide. Proc Soc Exp Biol Med. 66:99–100.

WHO; 2020. Can sulphated polysaccharides from seaweed provide prophylactic and/or therapeutic solution to COVID-19 pandemic?;retrieved from https://search.bvsalud.org/global-literature-on-novel-coronavirus-2019-ncov/resource/en/covidwho-705697; January 2021.

Periera, L. 2018. Therapeutic and Nutritional Uses of Algae. A Science publisher's book. CRC Press. pg: 895.

Nagle, V.; Gaikwad, M.; Pawar, Y.; Dasgupta, S. Marine Red Alga Porphyridium sp. as a Source of Sulfated Polysaccharides (SPs) for Combating Against COVID-19. Preprints 2020, 2020040168

Carthew, P. 2002. Safety of carrageenan in foods. Environmental Health Perspectives. 110(4): A176-A176.

ACKNOWLEDGEMENTS:

TakeAir Inc.: Jo Pannecoucke, Founding Father, Owner
Take Air Labs: Ghent Oost-Vlaanderen, Belgium
Avecom: Ghent Oost-Vlaanderen, Belgium
Bronkhorst High-Tech B.V.: Ruurlo, The Netherlands
University of Genova: Wolf Dynamics, Genova, Italy