A new milestone for BioRemediation:

A regenerative design for the indoor air with the help of Ammonia Oxidising Bacteria.

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Introduction

As recent as 1987, the Biosphere 2 experiments in Oracle (Arizona, USA) conducted by NASA showed that biofiltration with plants is a very promising technology to help solve widespread global problems caused by air pollution. As the realistic and logistical implementation of such a plant-based system reaches the impractical very quickly, a 21st century solution is presented by TakeAirLabs (TAL).

By looking at plants and mimicking their ecological processes we developed a system derived from biofiltration with plants, a system that is add-on and can be retrofitted to any indoor environment.

As filtration will reduce the bad organism from its system, we can also achieve this on a microbial level by limiting the space for bad organism to settle on (this is called competitive exclusion). Instead of using the plants (or nature in general) in its totality we use the microbial characteristics and the benefits they produce towards a healthy human environment. By defining the microbial benefits of nature, we can now introduce these in the most separated and sealed off habitat created by humans: the built environment (BE). By assessing and tending to the smallest matter, we become masters of the microbial landscape and we can produce the most favorable indoor space for human habitation.

The scope of application for this technology is immense as most buildings today have a centralized HVAC system in which dispersion of the beneficial natural organism can happen in a direct and practical manner. The capital investment to be made is also substantially smaller as most HVAC systems are already in place and operational. As such the BioRemediation of indoor spaces can be widely applied and start a substantial improvement for our indoor climates. Additionally, this application reduces the need for outside ventilation, which translates in reduced energy use and thus smaller carbon footprint of existing HVAC systems. The technology itself is built with clean-tech principles and favors a circular use.

We have achieved the ultimate goal! The path that lays ahead of us shows tremendous opportunities in using the microbial world to further enhance our world and make it more resilient.

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What is a regenerative design?

we treat the air for the whole building and come closer to an indoor climate with a regenerative design. This design of the indoor air is restorative for the air quality and revitalizes the health of the inhabitant. During the internal air-exchange processes and after the air is circulated, we disperse our air and health improving organisms with our patented BioRemediation process.

With TakeAir and TAL the science behind BioRemediation of Indoor spaces started in 2016. Building a hardware system that can disperse living organisms so they survive dispersion but also that droplet size can travel in air streams. The development of our Biodisperser system was completed in early 2017. What follows is a successful cooperation with the leading laboratory regarding microbial management, Avecom. The Ghent University spinoff run by Prof Willy Verstraete provided us with a living microbiome as one would find in nature. The microbiome consisted of ammonia-oxidizing bacteria (AOB), ammonia-oxidizing archaea (AOA) from the Archaea tree and several other beneficial organisms. This microbiome (a collection of bacteria working together) proved itself fitted to activate the principle of competitive exclusion and dominated the indoor spaces so other bad pathogens could not colonize it. It also paved the way for further research.

Today we have achieved a new milestone.

As the living microbiome was improving the microbial landscape of the BE, we now focus solely on AOB organisms that also have a suggested effect in improving the air quality by mitigating CO2 and PM2.5 levels. We found specific organisms within the AOB group that keeps the revitalizing design of our previous product and adds the restorative properties for the air quality. The following text concering the scientific background of our AOB organisms was provided by our lead R&D engineer on the project Dr. Ir. Sylwia Jezierska

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Ammonia Oxidising Bacteria.

Ammonia-oxidizing bacteria (AOB) transform ammonium to nitrite, an essential step in the complete mineralization (release of nutrients) of organic matter. Nitrification, microbial oxidation of ammonia to nitrate, is a central step of the global nitrogen cycle. Ammonia oxidizing bacteria plays a critical role in the global nitrogen cycle.

Ammonia oxidising bacteria: role in human wellbeing

Exposure to microbes is essential for immune system development and training. Microorganisms such as AOB's can reinforce barrier immunity and condition innate cells to promote immune cell responses against pathogens, meaning a stronger immune system! When underexposed to foreign substances, the immune system is not trained to react appropriately to harmful foreign substances incentives, which leads to disproportionate responses to self-tissues (auto-immune diseases) or external triggers that are otherwise harmless stimuli (atopic diseases such as eczema, asthma).

Several microorganisms were identified to positively modulate our immune system and improve allergy symptoms. The list of beneficial microorganisms includes ammonia oxidizing bacteria (AOB). AOB's have been detected in human skin microflora that contributed to the regulation of a human's body healthy biology.

However, it is believed that due to modern hygienic lifestyles the presence of these beneficial bacteria has drastically decreased in recent decades; together with other lifestyle-related changes associated. Dysregulated immunity and generalized inflammation can be observed due to these changes. Notably, reduced exposure to microbes, particularly early in life, as well as a loss of biodiversity within the human microbiome has been associated with atopy (problems with your immune system that makes you more likely to develop allergic diseases)

While nitrite produced by AOB's inhibits the growth of pathogenic bacteria (e.g. Staphylococcus), The combination of nitric and oxide is also an antioxidant that helps calm and soothe the skin. This action can help restore balance to the skin's ecosystem and contribute to the overall health.

Ammonia oxidising bacteria: role in air purification

Ammonia (NH_3), the primary alkaline gas in atmosphere, contributes to the formation of fine particulate matter (PM2.5, aerodynamic diameter less than or equal to 2.5 μm) as PM2.5 is a complex mixture of different inorganic and organic substances, PM2.5 is the main air pollutant in urban cities which can decrease visibility, modify radiation balance of the Earth, reduce lung function, and increase pulmonary disease.

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Ammonia is produced during organic waste decomposition and is often a by-product of wastewater treatment technologies and waste handling facilities. Ammonia is also the most abundant reduced form of reactive nitrogen in the atmosphere. Its deposition can reduce the biodiversity and disturb the global biogeochemical cycling of nitrogen. Thus, ammonia plays an important role in air quality, human wellbeing, and ecosystem health.

Therefore, increasing the concentration of ammonia oxidizing bacteria in air has a great potential in controlling ammonia emissions and concentrations, which consequently would effectively reduce PM2.5 pollution.

Our selected AOB is a non-pathogenic bacterium generally found in highest numbers in all habitats in which there is abundance of ammonia. It is widely studied chemolithoautotrophic ammonia oxidizing bacterium that catalyzes the aerobic oxidation of ammonia (NH3) to nitrite (NO2-) using carbon dioxide (CO2) as the preferred assimilative carbon source.

In short this means that our AOB bacterium catalyzes ammonia to nitrite using CO2! So next to combatting Pm 2.5 levels we are also mitigating CO2 levels for the built environment. An unprecedented amenity for the building's tenants, and unseen microbial improvement for the Indoor Air Quality.

Safety of our AOB

Our specific AOB is found everywhere there is life: lakes, rivers, soil, and (formerly) on our skin. There have never been any reports of illness or disease related to AOB's and they are literally incapable of causing an infection. Our organisms are upon the most extensively studied ammonia oxidizing bacterium in the world.

A 21st century TakeAir solution

Whether it is human skin or air, significant decreases in community diversity are a hallmark of a disease state.

With the Biospheric Air treatments developed by TakeAirLabs we build a systemic solution to indoor environmental quality called Biospheric Ventilation. By looking at the indoor environment as an Indoor Biosphere we can connect the technology of the building with its microbial landscape. But also reconnect with the people who live in it and contribute to a better environment in which the building stands.

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This system strengthens the diversity by introducing favourable organisms into the building. Previous tests with AOB and AOA delivered positive results, continuing research has shown the AOB show the most promise to continue.

Benefits of AOB's in a nutshell:

- Supports immune system responses
- Protects us from invasive pathogens
- Safeguards balanced skin microflora
- Improves aesthetics of your skin by reducing the appearance of wrinkles
- Purifies the air by decreasing formation of PM2.5
- Increases microbial biodiversity in environment
- Decontaminates water, air, and soil by removing toxic ammonia
- AOB bacterium catalyzes ammonia to nitrite using CO2

Bibliography is available on request.

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