# ALKA

cultivating air

## Project Summary


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GU68

# Product Introduction

**Indoor air pollution**

Pollutants found in the home are detrimental to our health and well-being.

| | |
|---|---|
| $CO_2$ | High levels of carbon dioxide indicate a lack of ventilation, and causes **loss of concentration** |
| VOC | Volatile Organic Compounds such as Formaldehyde and Benzene are **carinogens** |
| PM | Particulate Matter comes in various sizes, and causes **bronchial asthma** |

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**Current Market**

Air Purification devices are currently made using plastic.

Filtration materials such as HEPA filters are treated as contaminated waste after their useful life is over

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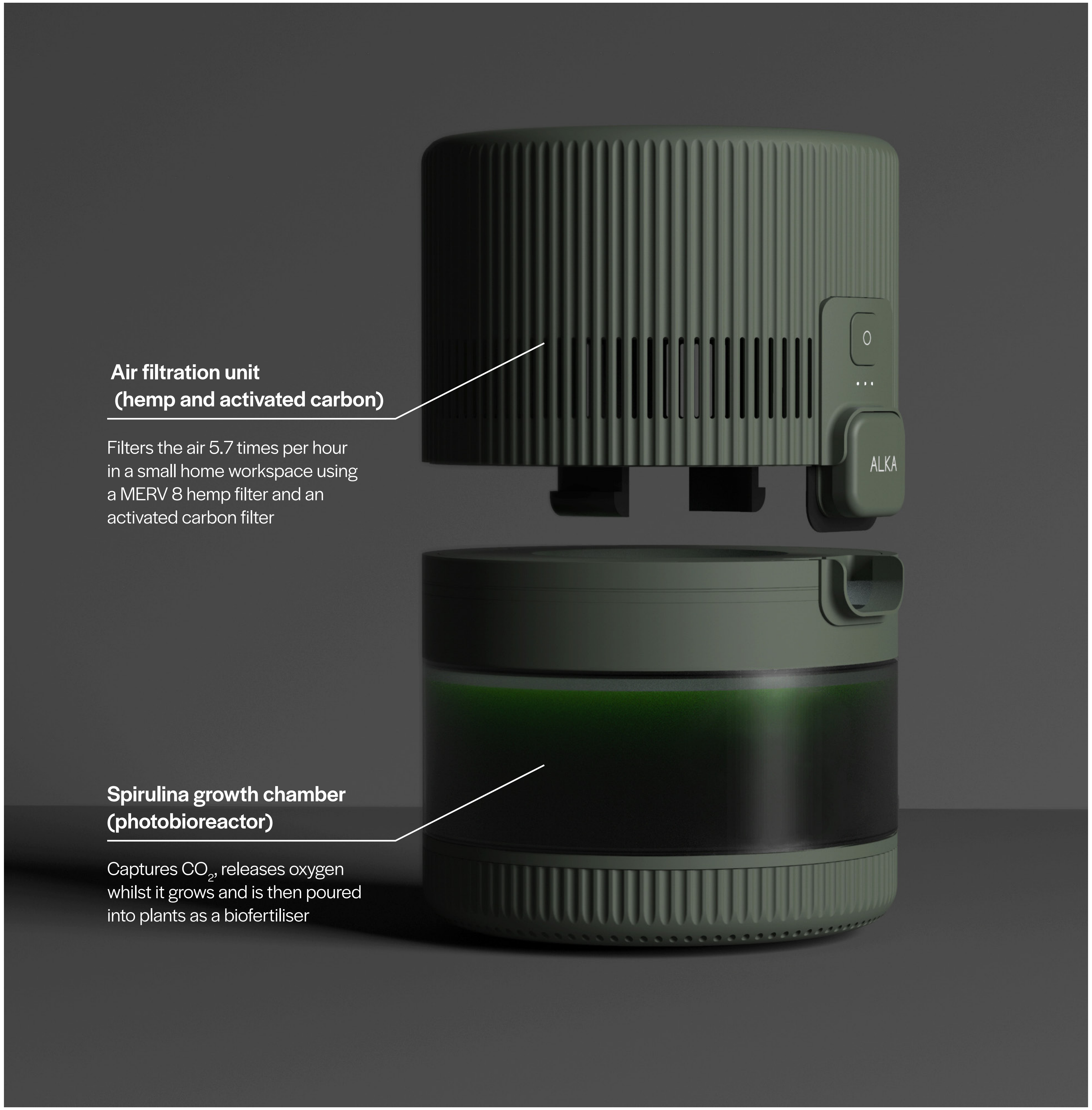
ALKA is an air cultivation device, that uses microalgae (Spirulina) and two levels of natural filtration (Hemp and Activated Carbon) to clean indoor air.

The device has been designed to live and work alongside homeplants in order to maintain a healthy environment in the home.



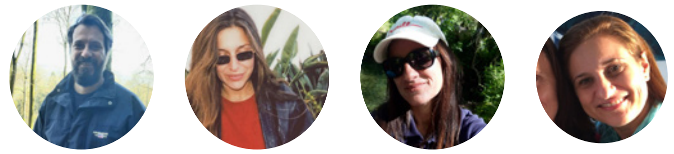
# Product Process | Interim Design

### Speaking with Experts

Speaking with experts on indoor air quality informed the project selection. The need for clean air in the home is one that is often overlooked by people due to lack of education on the topic, therefore justifying **the need for something different to the typical air purification device.**

### The User

User research through correspondence via e-mail, video calls allowed for the selection of parents as the target user group prior to the physical product development process, as they want to ensure that their children are healthy and educated. **Many parents found it hard to concentrate when working from home.**



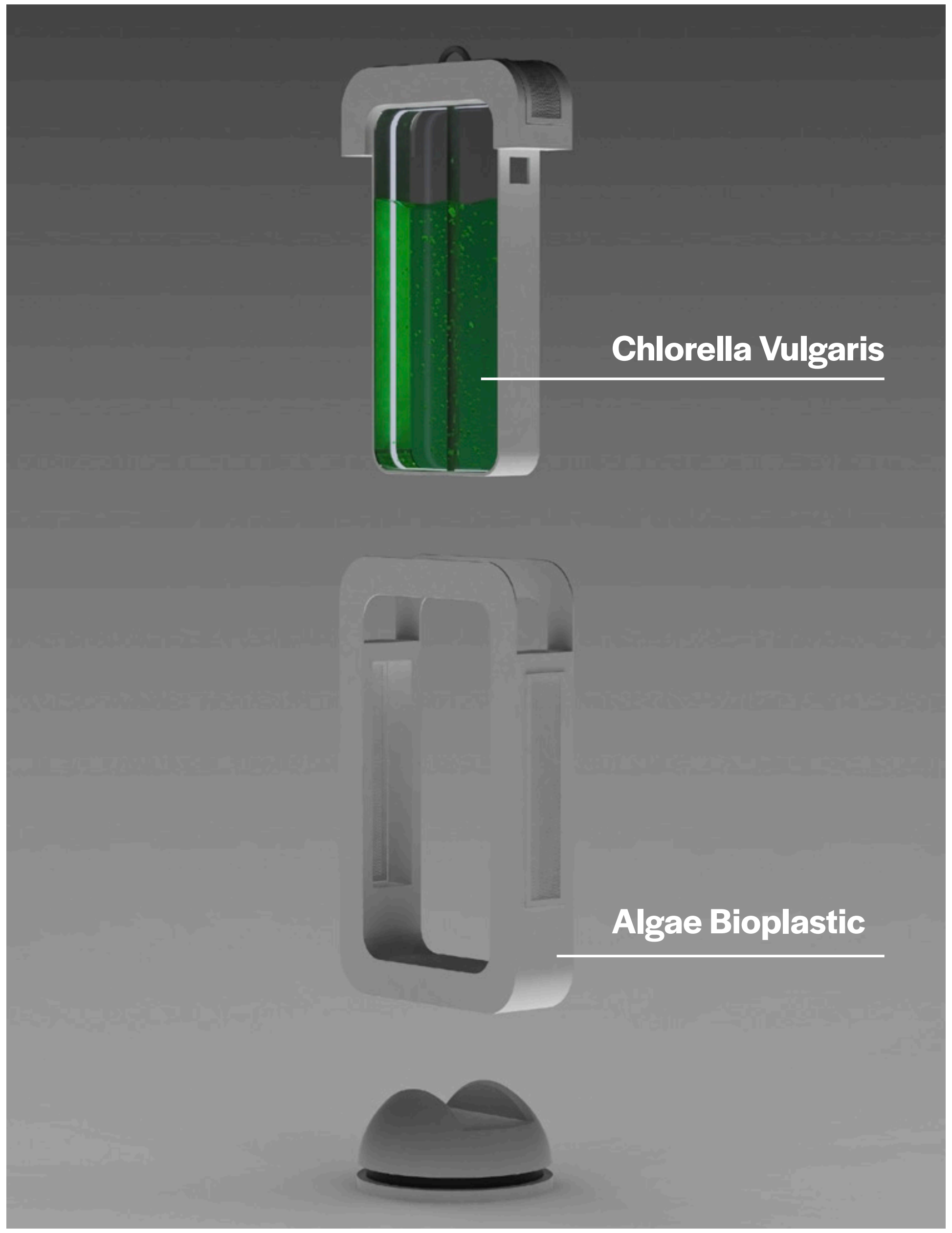
### Online research

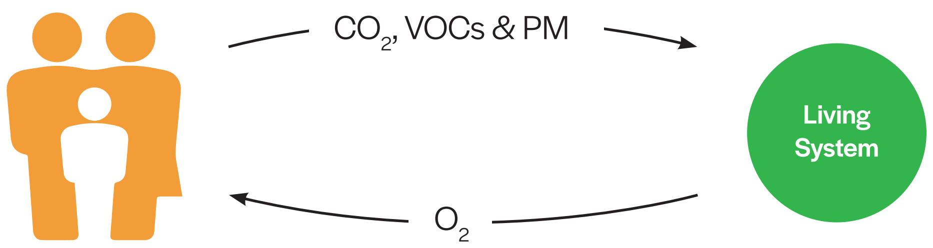
Methods of air cleaning were researched and alternatives were identified. Plants have capabilities of soaking up pollutants from the air, however many are needed to do this job effectively.

**Microalgae**, on the other hand, is much **more efficient at capturing carbon dioxide** than house plants. Since **carbon dioxide is linked to a loss of concentration**, further research was performed and an interim concept was formulated.

### Interim Proposal

The interim proposal was a home microalgae cultivation system, that would clean the air through a symbiotic relationship with the user. As the user respires, the system would reverse the process, capturing carbon dioxide and releasing oxygen.




**Important points raised:**

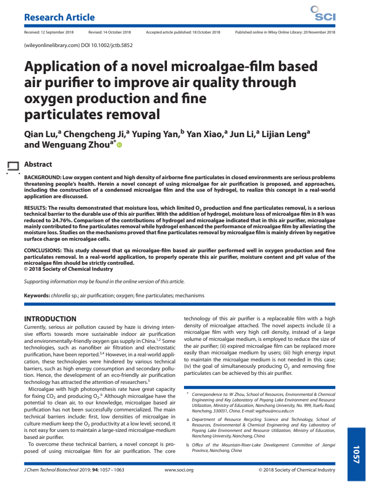
Will it really work?
Why are you using microalgae?
What happens to the algae after you're done with it?

# Product Process | Expert Consultation

**DANISH TECHNOLOGICAL INSTITUTE**

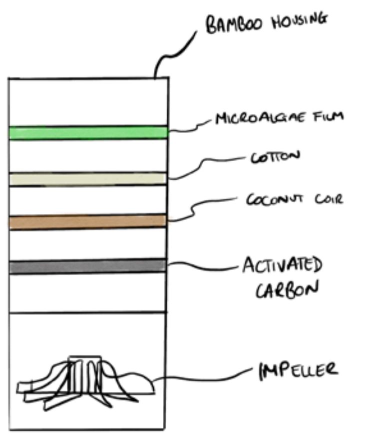
### Dr. Lars Jørgensen, Senior Plant Technologist at DTU

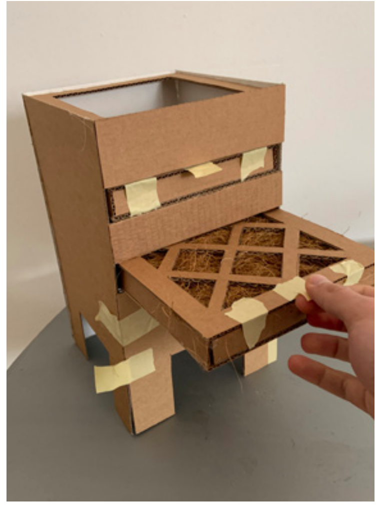
Dr. Jørgensen advised to **use cyanobacteria strain *Spirulina***, as it is easier to grow and more resilient to contamination from pollutants found in the home. Our discussion also concluded that **using microalgae as the sole air cleaning mechanism may not be feasible.** This lead to research into microalgae biofilms.


Research Article

Application of a novel microalgae-film based air purifier to improve air quality through oxygen production and fine particulates removal

Qian Lu, Chengcheng Ji, Yuping Yan, Yan Xiao, Jun Li, Lijian Leng and Wenguang Zhou

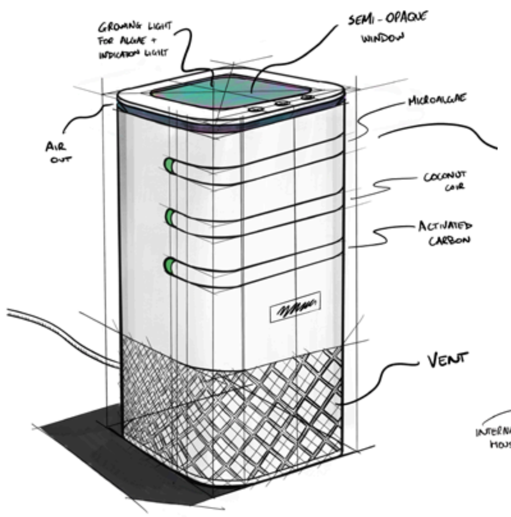


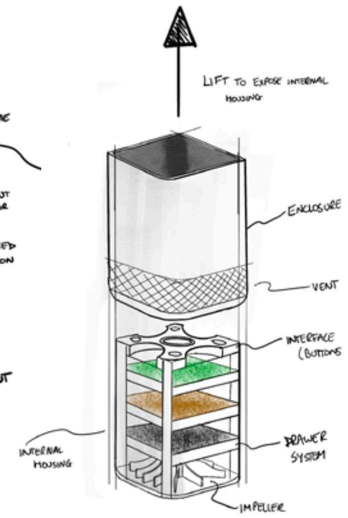




**L-Università ta' Malta**

### Dr. Gabrielle Zammit, Microalgae Researcher at UoM

Dr. Zammit gave insight into microalgae biofilms, and questioned their use in an air purifier. Conclusions were that **a system using biofilms could work**, but experiments needed to be carried out in order to verify this.

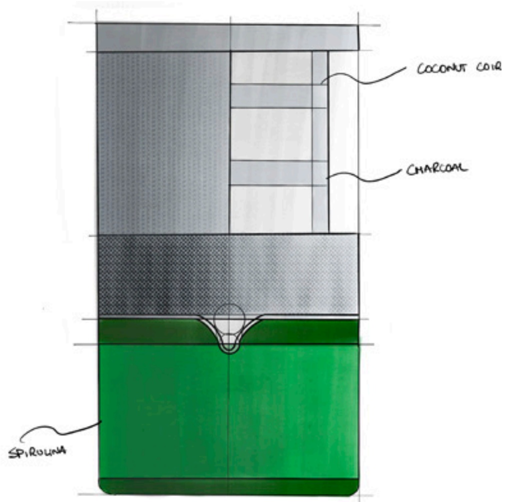


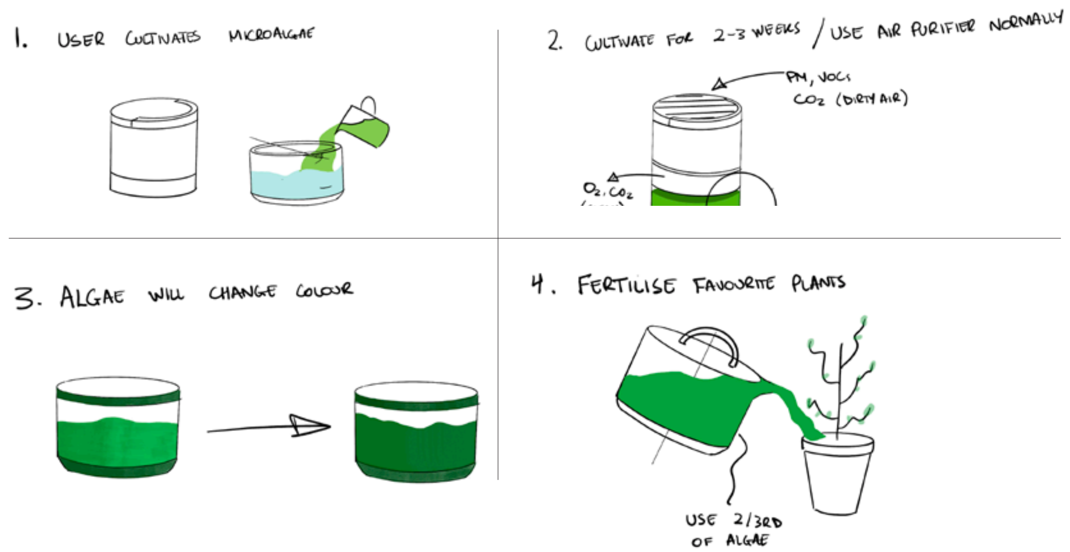




**University of Glasgow**

### Dr. Ian Watson, Microalgae Researcher at UoG

From discussions with Dr. Watson, it was concluded that there was **not enough research in microalgae biofilms** to justify their use in the project. The use of microalgae was questioned, who advised me to **"do something else" with the algae after its life as a $CO_2$ scrubber is over.** The proposal was therefore amended accordingly and consequently verified by Dr. Watson.



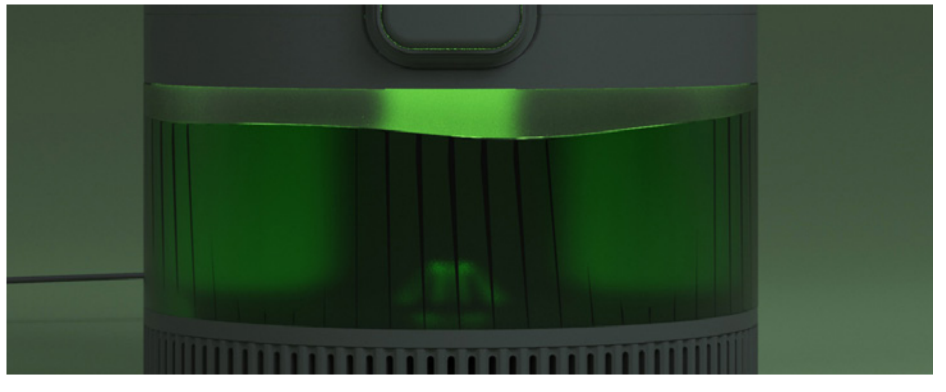



# Product Process | Technical Development

As lab testing was not possible, efforts were made to develop the devised Spirulina cultivation system by using literature sources. This aided in **supplementing the knowledge that would have been attained through lab testing**, in order to develop the devised system.

### Spectrum of Light

The product acts as **a link between two living systems**; users and microalgae. The effects of the spectral quality of light on people and Spirulina was studied in order to select the most appropriate colour. White was chosen for its ability to incorporate the entire visible spectrum, and provide a green glow in the algae which is known to be a **calming colour.**



### Carbon Dioxide Supply & Agitation

Supply of $CO_2$ is essential. In order to ensure that the Spirulina culture gets adequate exposure to $CO_2$, means of agitation through an **air pump** at a volumetric flow rate, Q, of 0.2L/min - 0.3L/min was incorporated into the product.

### Using Spirulina as a Bio-fertiliser

A live microalgae culture, when applied directly to soil has advantages over synthetic fertilisers. Spirulina has been proven to **enhance plant growth and increase germination rate**, due to its ability to fix atmospheric nitrogen within its cells, which then multiply in soil.

### Choice of filters

Filtration media are typically synthetic. Coconut coir was first investigated for its ability to capture coarse particles (PM10), however filters weren't readily available for purchase from suppliers.

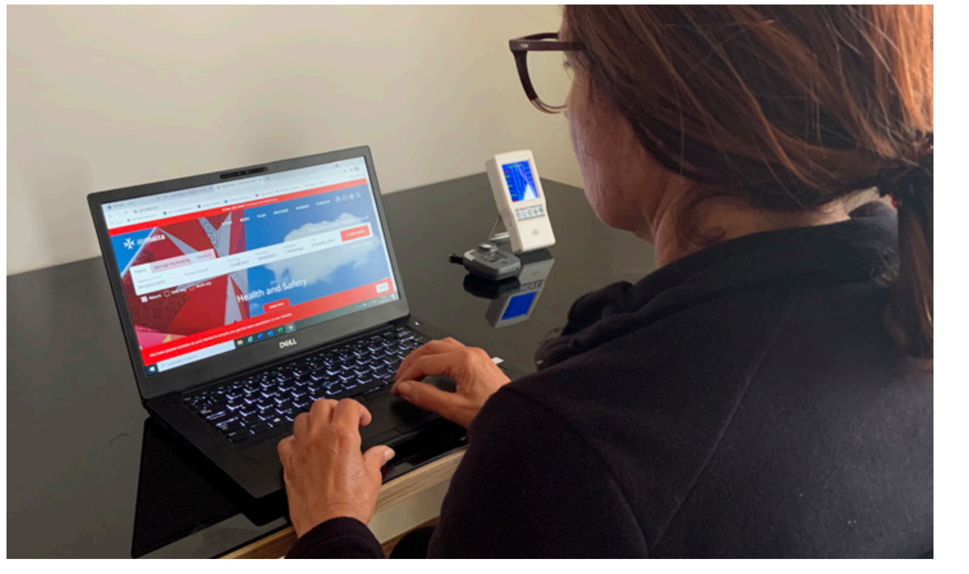
Through further research, a **MERV 8 hemp filter** was selected as it is available for purchase and may be customised by the supplier, and is **100% biodegradable**.

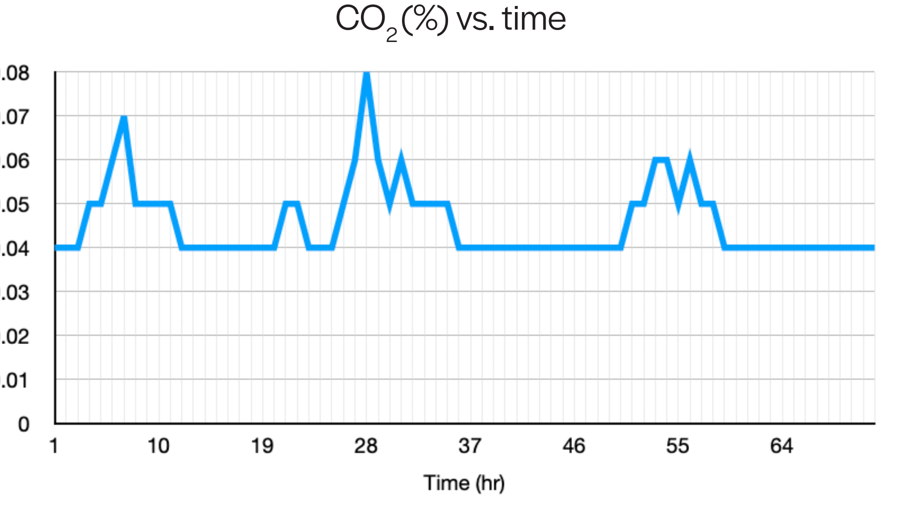
**Activated carbon** was selected to **adsorb gases, smells and odours**, some of which may be generated by the algae. The carbon filter will ensure that odours will not affect the user.



### Testing

Air quality in a WFH scenario was monitored, in order to determine if microalgae can grow in the designated environment. The results obtained verified that this is truly the case, and as Spirulina adapts to changes in environments, it also verified the choice of strain.

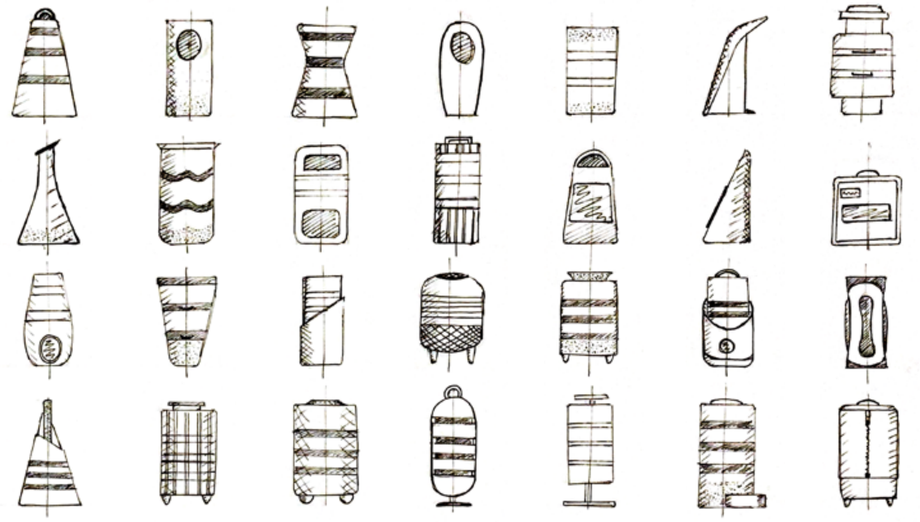





According to research, Spirulina is resilient, and is able to grow in environments with a minimum $CO_2$ concentration of 0.04%. It is also able to grow in environments with much higher $CO_2$ concentrations. Results demonstrated a peak concentration of 0.08%, which is well below what microalgae can handle (dependent on cultivation conditions, it can grow at 5%, indoor air should not exceed this concentration level).

# Product Process | Form

The product's features, functionality and ability to fit in with users' homes are all parameters which were determined by the form. Iterations were essential in order to form connections between these three key points.



A **cylindrical shape permits microalgae to grow and thrive**, due to a large illuminated surface area. Technically termed as a "tubular photobioreactor", it is one of the most commonly used methods of closed system microalgae cultivation.

Blending functionality with aesthetics was paramount, in order to **create something that portrays completeness**.

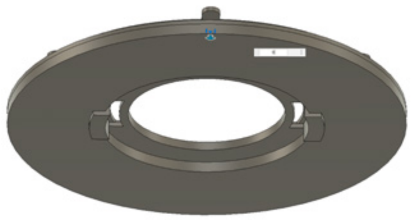
Cardboard prototyping was essential to create early iterations of the design in order to **truly understand the functional aspects of the product**.

Once the user journey and functionality of the product were properly defined, CAD modelling was used to generate refined forms. Clearly **defined visualisation of details** which would have otherwise gone unnoticed was important in order to **verify the aesthetic with stakeholders**. Feedback from these models was received by consistent communication with users via online messaging, or by consulting with family members through face-to-face conversations.

# Product Process | Mechanisms & Internals

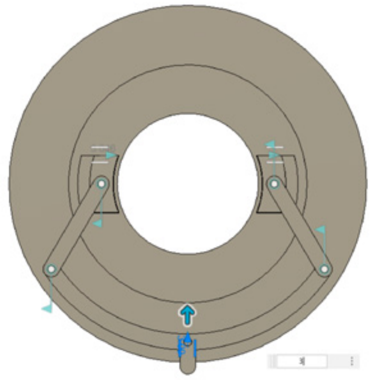
### Push mechanism development through CAD & 3D printing

The mechanism that transforms the product into a watering required a more solid prototyping medium than cardboard. Access to a small 3D printer enabled **scaled** iteration and development.



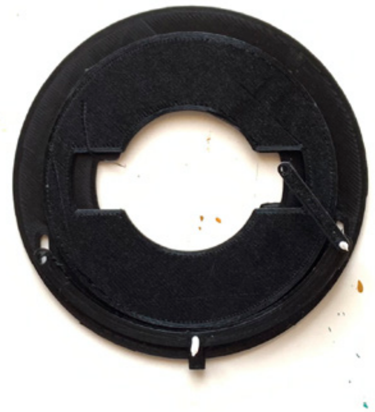
Locked - Microalgae tank cannot be detached from main body

Unlocked - Microalgae tank may be detached from main body



CAD Motion Study

Proof of concept

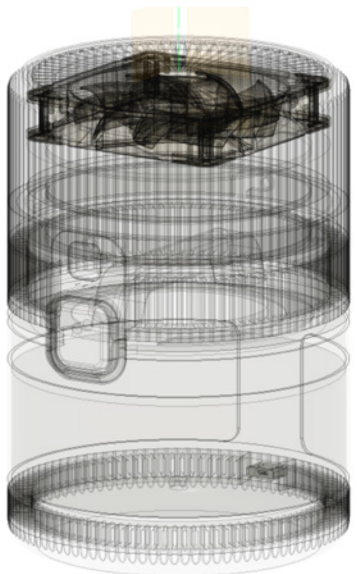


Failed due to lack of guides

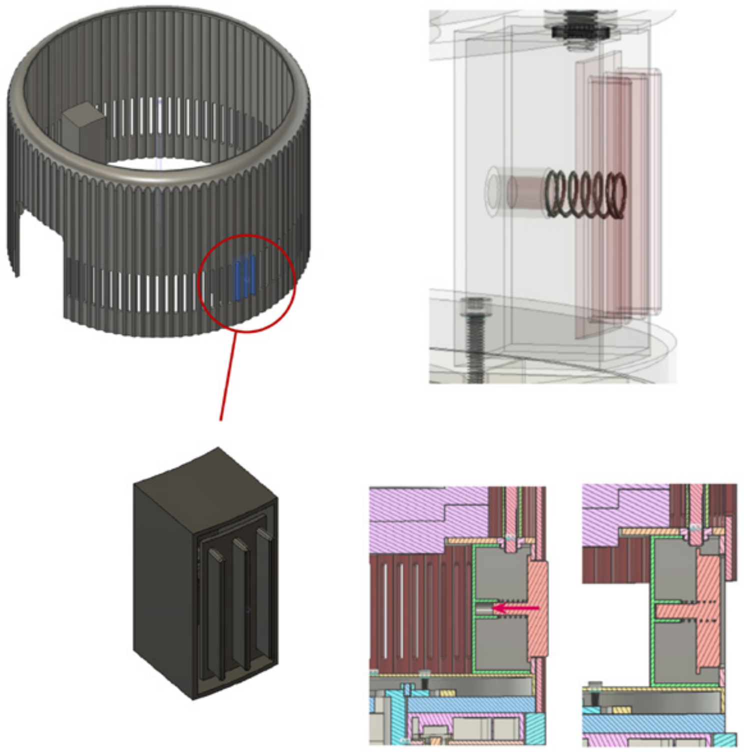
Worked, but could not be verified through full scale prototyping

### Detailing internals

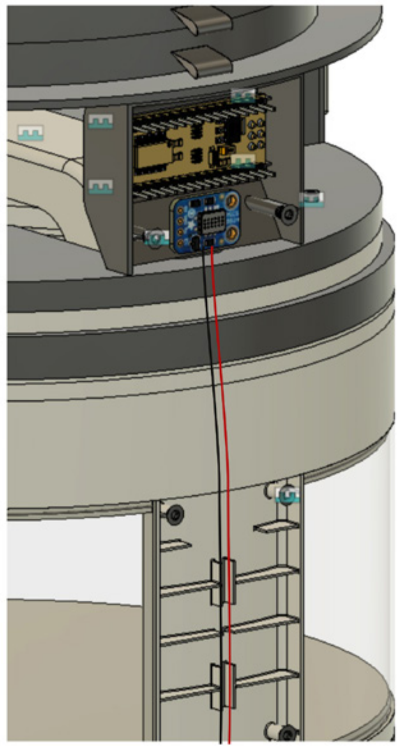
An understanding of the realities of creating the devised product was gained through fully detailing its interior. The inclusion of the above mechanism, along with a bayonet mount and spring loaded push buttons were included into the product.

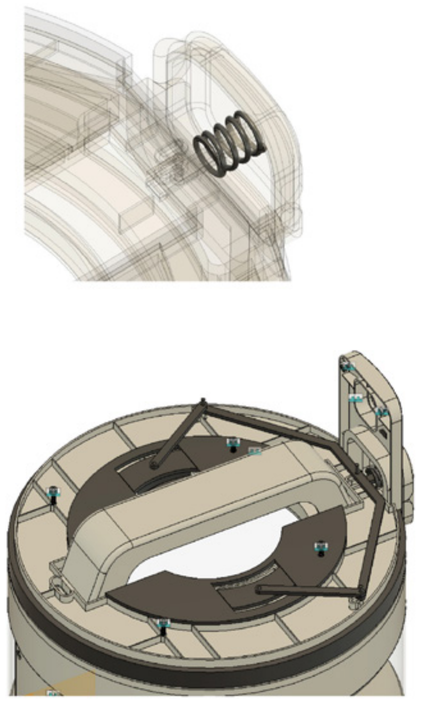
Product made almost entirely out of solid bodies



Addition of a concealed push mechanism within the vents



Wiring passage



Implementation of push mechanism

# Product Process | Materials & Manufacturing

Conclusion of the development process was done through considerations for materials & manufacturing feasibility of the product.

**Materials**

**KRION Solid Surface**, by Porcelonsa group was selected as the **external material.** Its remarkable ability to be injection moulded, as well as the absence of joints makes this a feasible material to achieve and produce the aesthetics of the product. Through its Keast technology, it is **able to purify air through photocatalysis**. It is also 100% recyclable, which is important to the product lifecycle.

In order to keep costs down, the material of choice for the **internals is HDPE**. The selection process of this material was done by communicating with experts at U-Recycle Ltd., a local recycling facility who gave insight into the recyclable realities of plastic products.

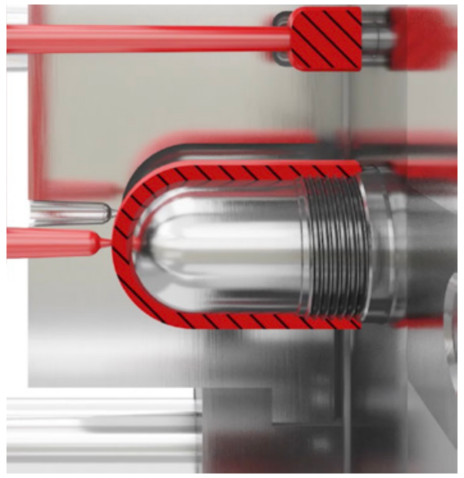

Selected colours with users

Examples of products made using KRION Solid Surface material

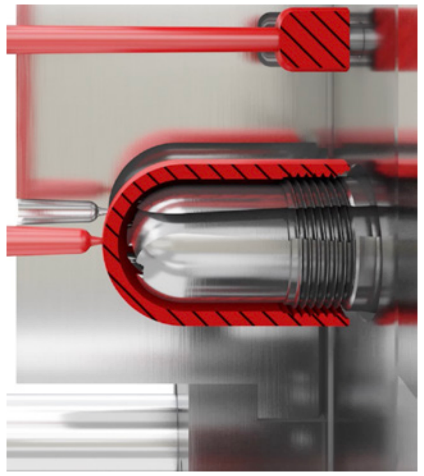
**Manufacturing**

The product is intended for mass manufacture, making **injection moulding** an ideal way of manufacturing the product. The challenge of the product's cylindrical shape and nature of surface texture are not easily achieved by injection moulding.

Using two mould halves and a collapsing core enables the part to be ejected with minimal draft. Naturally, **more complex manufacturing processes will increase its cost**. The external top half of the product was redesigned in order to **only perform this process for one part**; the outer shell. This process therefore informed a switch from an injection moulded bayonet mechanism to expose the product's internals, to a simple push to unlock button concealed within the vents.

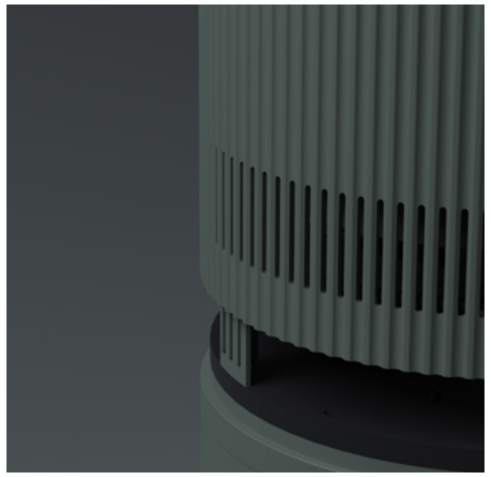


Before



After

Bayonet mount



Push to release

# User Cycle

1. Starter culture is poured into tank, along with water and nutrients

2. ALKA is closed, by placing the air filtration unit on the product

3. Product is placed in the vicinity of the workspace, and turned on


4. Colour is tracked visually, indicating harvestability of the algae


5. Algae turns to a dark green colour

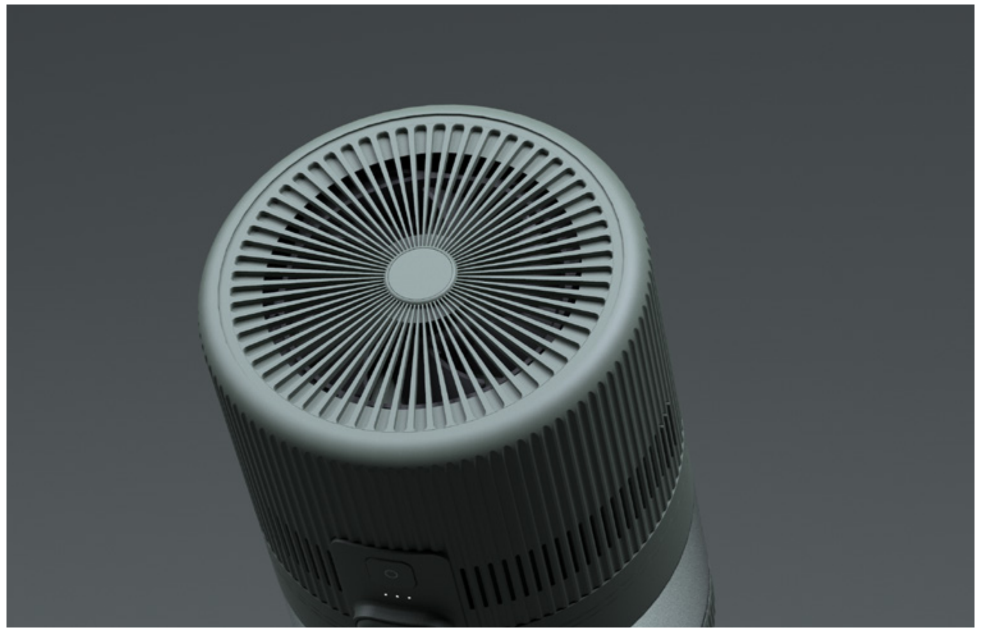
6. ALKA button is pressed in order to transform the product

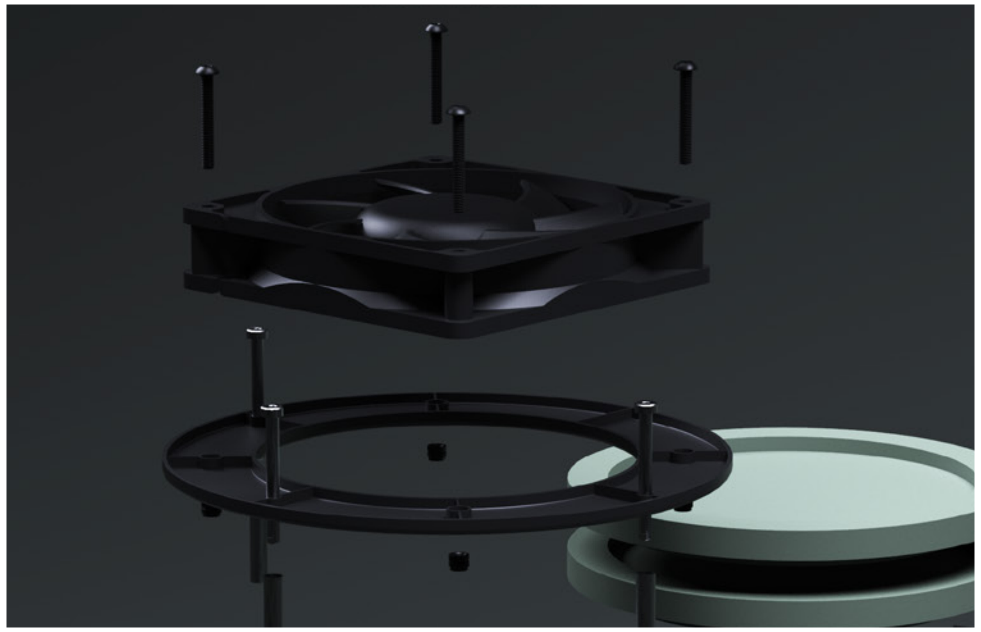

7. Accompanying app informs the quantity of algae for home plants

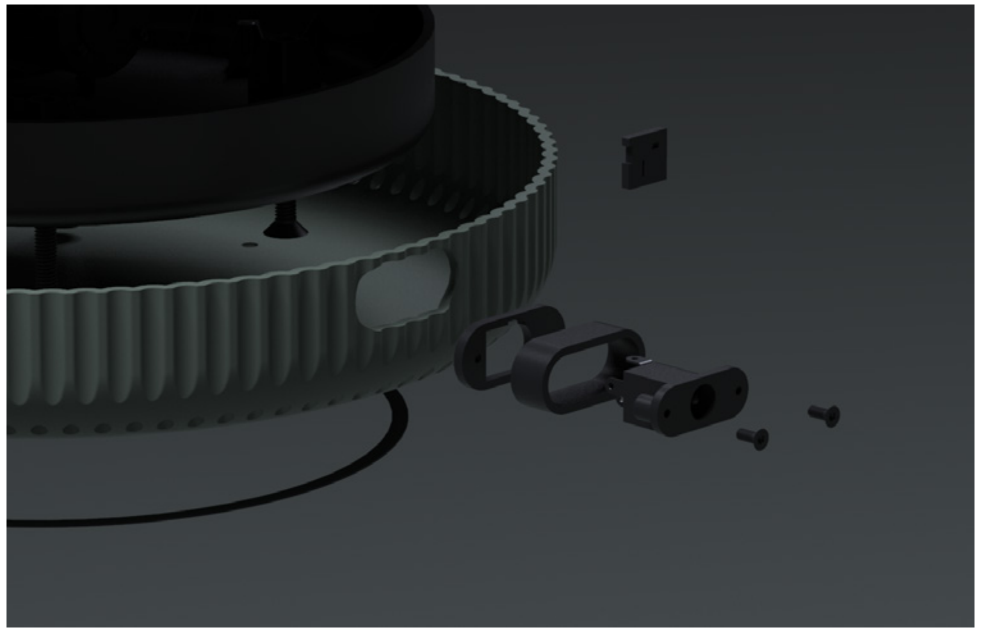
8. Spirulina is poured into plants as fertiliser

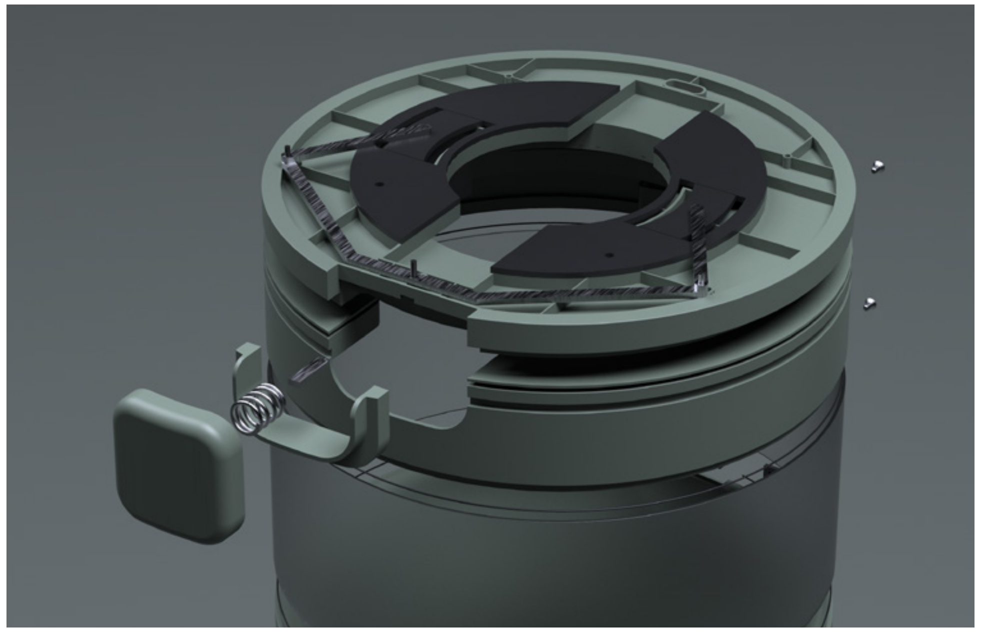

9. 1/3rd of algae is left in the tank, water & nutrients are added to regrow

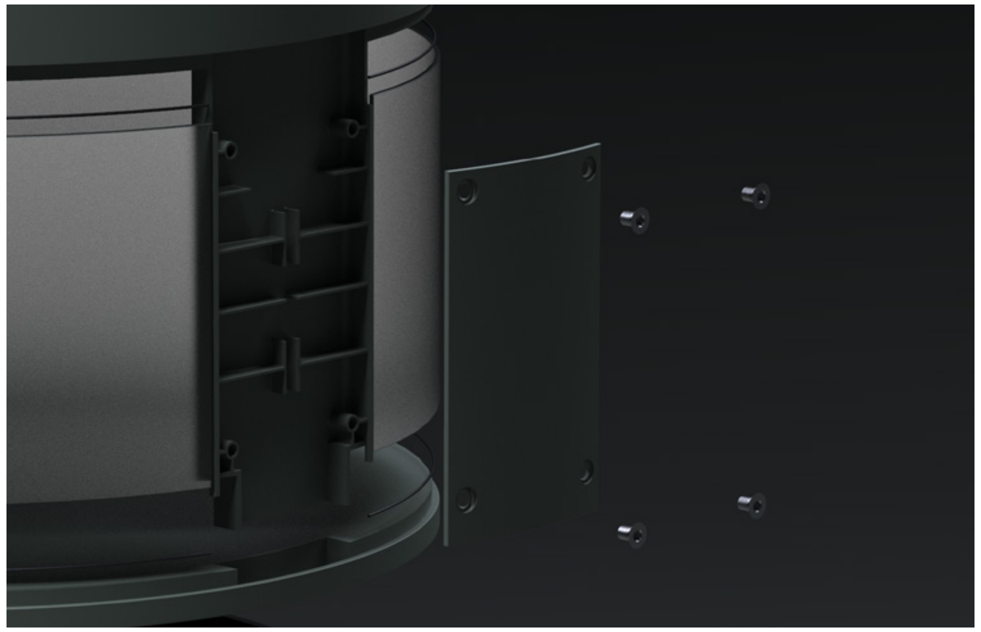
# Product Details - Exterior & Interior

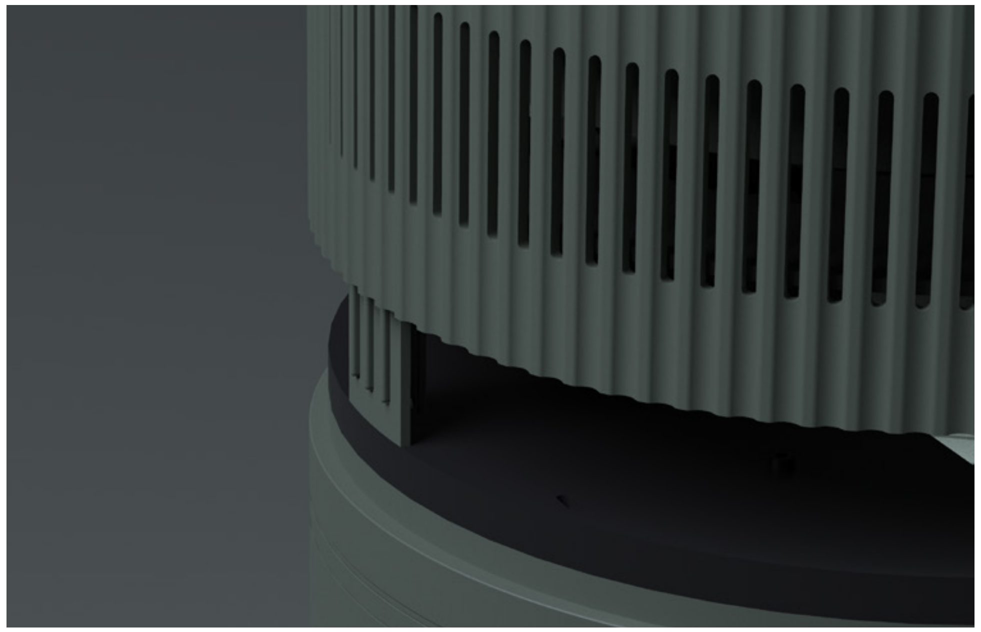


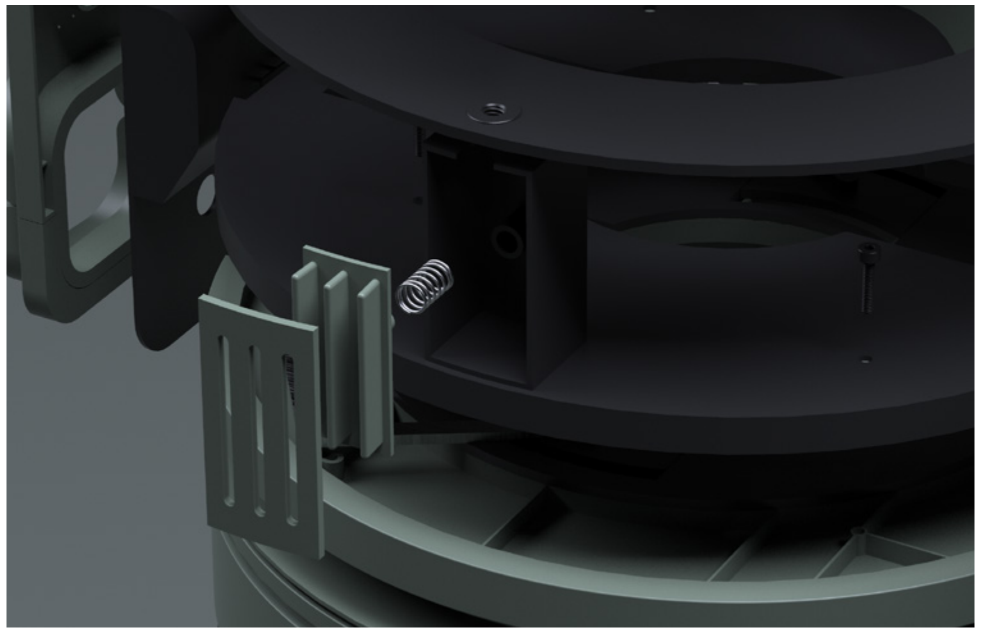










# Manufacture