SOMA WATER FILTRATION

Business proposal prepared for :

2024 ALASKA AIRLINES ENVIRONMENT INNOVATIONS CHALLENGE

Sophia Hashmey
Sheridan Stanner
Koumudi Thanda
Eytan Legros
Meera Patel
Korena Mafune - Advisor
Annika McCarty
Jana Chiang
Fangzhou Xie
Yuanxi Li
Rampranav Navendran

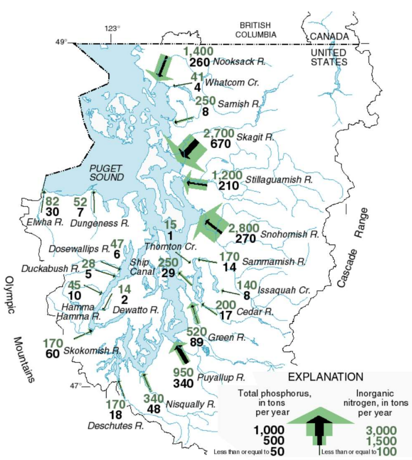
Summary

Soma Water Filtration utilizes the power of mushroom mycofiltration[1] to remediate polluted water sources affected by stormwater runoff. Our goal is to simplify a way for the public to contribute to the process of remediating polluted bodies of water and improve a regional capacity to filter water.

Problem

The pollution of waterways by synthetic fertilizer use, fossil fuels, and untreated sewage is a threat to the health of wildlife, soil ecosystems, and human populations. Nonpoint source pollution generated from agricultural sites generally goes untreated by agricultural water treatment practices. These nonpoint sources of pollution include runoff of fertilizers and pesticides, and are especially prominent during precipitation events following application of these contaminants. Many traditional farms also generate point-source pollution by spreading animal waste in empty fields and constructed wetlands. These pollutants can end up in local waterways, including streambeds, lakes, and private water wells. From soil erosion and habitat loss to eutrophication and unsafe drinking water– the range of effects from polluted runoff cannot be underestimated [2].

The main pollutants that typical water treatment methods aim to remediate are nitrogen, phosphorus, heavy metals, and bacteria that may cause illness[3]. The nitrates and phosphates within the synthetic fertilizers that infiltrate local waterways also cause sickness when ingested. Blue Baby Syndrome is a severe illness that occurs in infants whose mothers have consumed water polluted with nitrates, and results in blue-gray skin and lethargy, leading to coma and death[4]. Nitrates and phosphates also lead to hypoxic water conditions known as eutrophication in lakes and ponds. There is a yearly input of approximately 11,000 tons of inorganic nitrogen and 2,100 tons of phosphorus deposited into the Puget Sound Basin. The Skagit and Snohomish River basins, which account for 47% of Puget Sound Basin drainage, transport approximately 49% of the inorganic nitrogen and 45% of the phosphorus content transported to the Pugent sound and surrounding waters[5]. Runoff from agricultural activity in the Midwestern United States cascades down the Mississippi water basin, leading to unprecedented anoxic

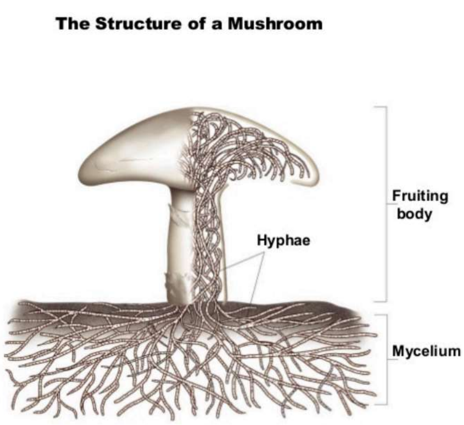


3 Annual nutrient loads transported by Puget Sound Basin rivers and streams

conditions in the Gulf of Mexico. The sources of excessive nutrients in both of these examples can be traced back to agriculture and animal manure.

There is a distinct problem arising from the mis-management of water in agricultural areas. Through our research and innovation, we have composed a solution to sustainably remediate nitrates, phosphates, and additional pollutants such as heavy metals in local waterways.

Solution

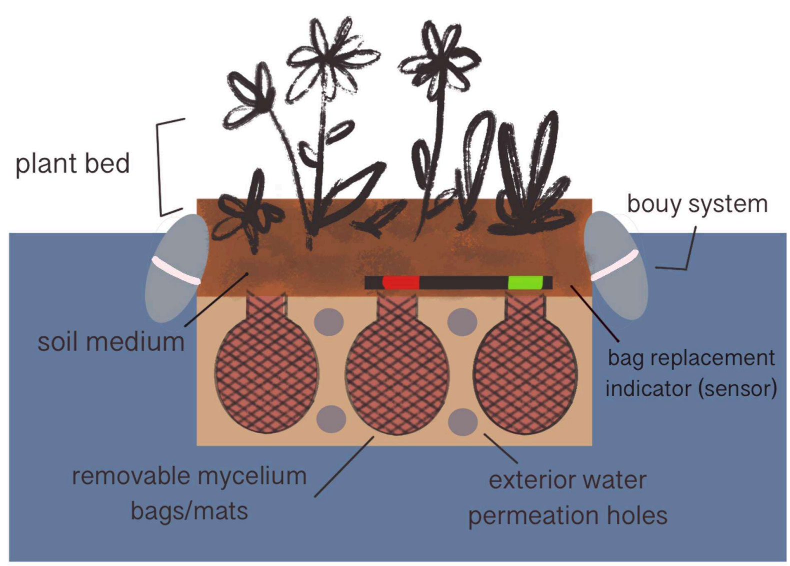


Pandey 2021
Structure of Fungi

Mycelium is the fiber of the mushroom body[6], with a special capability to absorb oils [7,8], heavy metals[9], excess nitrates[10], phosphates[11], and other waste contaminants in water and sequester them within their tissue. Fungal hyphae, structures within the mycelium system, have a diameter of 4-6 micrometers[12] and actively work to filter out contaminants. Introducing layered mycelium mats to bodies of water impacted by the previously mentioned pollutants will decrease the concentration of particulate matter in the water in which they are placed. These mats are easily transportable and could be applied to local water ways to improve water quality[13] and consequently environmental health.

DEMO

Design of the platform would entail two stories; the first story would be slightly below the water's surface and would house mycelium pods. These pods would have a removable design that would allow for the mycelium to be pulled from the water and replaced with new pods if water testing indicates that their absorption capacity has been reached. Testing would need to be performed on the removed pods to



determine if the tissue contains mostly nutrients (like nitrogen and phosphorus), or heavy metals. If the former is found, the pods could be left to start the decomposition process and used as an alternative to store bought fertilizer. This option would allow the user to repurpose the nutrients collected in a manner that would be beneficial to the local habitat or their farmland. If heavy metals are found, the pods would have to be disposed of in a manner that complies with the regulation for disposal of the heavy metal in question. Above the layer of mycelium pods, lies a mat of native plants feeding off any decaying matter from the mycelium, encouraging the development of a holistic ecosystem and improving the product's aesthetic appeal.

We will use our approved prototype funding of $1,200 from Buerk Center of Entrepreneurship to make our demo structure and test the water filtration. Our adviser, Dr. Korene Mafune, will also provide us the UW fungal testing labs within the Winkler Labs for our prototype testing.

Market Appeal

Washington has more than 2,000 polluted waters listed in areas where agriculture is the primary land use activity[14]. Meeting clean water standards is becoming increasingly difficult for regulation to encourage. Because of this, state laws require landowners to internalize their runoff externalities.

Demand for local water filtration systems for the market appears through two main avenues:

1) <u>state law regulation</u>
Meeting clean water standards is becoming increasingly difficult for regulation to encourage. Because of this, state laws require agrarian landowners to internalize their runoff externalities or suffer penalties.
2) <u>increased public interest in conservation</u>
The demand for sustainable agrarian practices and water reuse has seen a rapid increase in recent years. The EPA has donated $11 million to enhance water quality and support sustainable agriculture through innovative practices across the Gulf of Mexico Watershed, emphasizing the pivotal role of farmers in environmental conservation and pollution reduction[15]. Washington farm families, ranchers, and landowners majority have shown increasing urgency for personal pollution mitigation; EPA surveys indicate that 61%

approve of sustainable advances by local agencies. Communities exposed to polluted wetlands and water basins understand the damage runoff brings and find interest in mitigating their effects.
In terms of available supply, there are currently limited ways for landowners to regulate their own property without involvement of local government agencies. A product such as the personal mycelium garden reduces the costs of remediation while providing additional consumer benefits (aesthetic and community value).
Because there is no "one-size-fits-all" approach to reducing runoff contaminants, there is large market potential to increase the variety of pollution prevention and remediation.

Cost Analysis

Placement of runoff mitigation responsibility on agrarian landowners is unpredictable and costly. EPA reports have listed mediation costs representing a single dose for a year to treat the average water body to result in $36,745 in capital costs using current aluminum sulfate treatments [15,16]. Additionally, nutrient imbalances that stimulate harmful algal blooms have attempted to be mitigated through other costly forms of in-lake mediation methods by local agencies. These costs range from $11,000 for a single year of barley straw treatment and efforts such as aeration, alum treatments, biomanipulation, dredging, herbicide treatments, and hypolimnetic withdrawals[16].

In contrast, mycelium-based products are significantly cheaper than many conventional materials. For example, mycelium-based mats are 20 times less expensive than chemically induced filtration plants using higher capital investments and additional maintenance costs[17]. The creation of a mycelium mat with oyster mushroom mycelia is simple in construction and effective in practice. Agar cultures of mycelium can also be stored refrigerated for years; re-culturing them may only occur within 6-12 months of each cycle.

The unit-cost of a single half cubic meter mycelium block averages around $150 through purchase and assembly of filtration materials. As it is difficult to currently analyze the full effects and costing of per-unit production, we can estimate a filtration capacity and amount saved through alternate stormwater filtration.

Year	Financial costs in terms of relative amount saved	Production Volume	Market Penetration(Users, Regions)	R&D Milestones
1	Soma costs: $15,000 VS chemical plant costs: $30,000	100 units (fixed costs included)	Initial launch in WA agrarian regions; local farmer families and small businesses	Development and testing of filter prototypes; partnerships with local farmers
2	Soma costs: $20,000 VS chemical plant costs: $80,000-100,000	500 units	Appeal to EPA distribution of local resource opportunity	Introduction of enhanced filter versions; exploration of additional applications
3	Soma costs: $30,000 VS chemical plant costs: $150,000	1000 units	Northwest outreach and government agencies	Optimization of production processes; cost reduction strategies
4	Soma costs: $40,000 VS chemical plant costs: $150,000	1000 units	Entry into national markets	Development of complementary products (different types of pollutants)

Go-To Market Plan Incorporating Cost-Effectiveness

Placing remediation efforts through consumer interest relieves some of the strain on local agency plant-based externality absorption (such as aluminum-sulfate treatments). There is a high need for local communities to participate in filtering and cleaning stormwater runoff -- especially those most affected by clean water and habitat loss.

Socially, the public has become increasingly aware[18] of the effects of stormwater runoff[19]--especially those who use industrial grade water and those working in the agricultural center. EPA has developed a range of outreach materials aimed at increasing public awareness of the effects of stormwater runoff. It is a strong strategy to engage communities in sustainable stormwater management practices, emphasizing the significance of individual and collective actions in protecting water quality.

To encourage this process, our market plan incorporates public-private partnerships (CBP3s) to help fund, implement, and encourage our product and service. These partnerships can triple the local return on investment and create opportunities for strategic community improvements.
Examples:

- EPA collaborations with local agencies and remediation businesses in funding
- Local community mycelium gardens

Environmental Impact

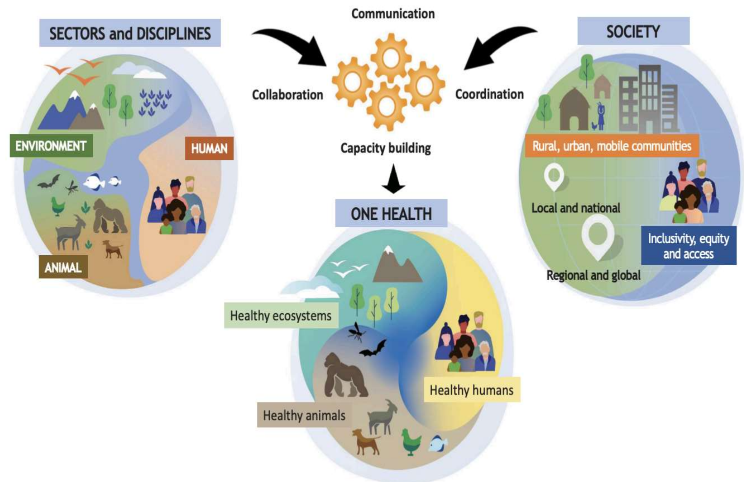
Eutrophication
conserve-energy-future.com

The mycofiltration system we propose would reduce the presence of excess nitrogen and phosphorus in the waterways in which they are placed. Although phosphates and nitrates are vital nutrients for the growth and sustenance of aquatic ecosystems, if the water is overly enriched with these nutrients, eutrophication (the excessive growth of photosynthetic organisms) can occur. Eutrophic conditions can lead to Harmful Algal Blooms (HABs), as well as high rates of respiration that can create hypoxic conditions in which oxygen is not available. As nearly all biota require oxygen for the processes which sustain them, these conditions can send an entire ecosystem into a state of shock. Some additional considerations of excessive nitrates and phosphates in an aquatic environment include pH, organic carbon, turbidity, chlorophyll 1a, and total suspended solids. As ecosystems have extreme sensitivity to imbalance, fluctuation in any of these parameters can cause additional stress. Mycofiltration mats that act as a "live-in" filtration system would keep nutrients at a level that would allow the flora and fauna that rely on them to execute their biological processes while keeping the concentration of phosphates and nitrates below levels that would lead to eutrophication.

Climate Impacts

Lakes and ponds as large water bodies act as carbon sinks when in a healthy chemical balance. Bodies of water experiencing eutrophication cannot execute the processes of gas exchange necessary for this carbon sequestration to occur. Soma's product will ensure that bodies of water avoid eutrophic states, maintaining their ability to capture carbon. The carbon footprint of the project itself relies on the methods that will be used to harvest the mycelium and produce the body of the device. The native plants that will be grown on the product's platform will work to offset some of the environmental impact of the product's manufacturing.

One Health Impacts



In addition to the positive environmental impacts, Soma Water Filtration addresses the intersection of environmental, animal, and human health by using the One Health framework.

The One Health framework is a transdisciplinary approach to understanding the relationship between the environment, animals and humans. As aforementioned, nitrate and phosphate runoff from agriculture (human made) contaminates the water and destroys the ecosystem of the waterways. But this also affects the animals and humans using the contaminated water as a drinking source[20]. To tackle this circle of issues, we used the Water Emerging Contaminants & Nanoplastics Journals' integrated One Health approach to water contamination[20] while designing Soma Water Filtration:

1. respect for sociocultural practices	2. improved land management	3. improved infrastructures and management
4. surveillance of water bodies	5. improved agricultural practices	6. prevention through environmental management systems

Specifically, we focused on incorporating recommendations 1, 5 and 6 into our product. Firstly, we respect sociocultural practices by focusing our system on local plants, prioritizing native mycelium (oyster mushrooms)[21] and testing accessibility/affordability of resources. Additionally, we are also strengthening our foundation to raise awareness among local Native American communities about the use of mycofiltration systems on their industrial or drinking water use. Secondly, we focus on the improvement of agricultural practices through the promotion of sustainable materials but mainly our filter can limit the amount of contaminated water agricultural sites release. Lastly, the use of mycelium, a natural resource, is an innovative part of an environmental management system (EMS) in itself. While it can be used on its own for filtering single servings of water and be considered an EMS, we also hope it can be used as part of a large-scale water quality management's system to improve their responsibility of consciously filtering out their water.

In conclusion, Soma Water Filtration presents an innovative solution to address the pressing issue of water pollution caused by agricultural runoff, utilizing mycofiltration to effectively remediate contaminated water sources. By integrating sustainable technology with a consumer-friendly design, our proposal not only offers a practical method to improve water quality but also aligns with the principles of One Health, promoting a holistic approach to environmental, animal, and human well-being.

The Team

Sophia Hashmey	Economics; minor data science, and environmental studies	Project Coordinator Economic impact, CA, and Implications Lead
Sheridan Stanner	Environmental Science	Environmental Impact and Research Lead
Meera Patel	Industrial Engineering	Prototype Coordinator and Business Dev lead
Jana Chiang	Community, Environment, and Planning	Implications and Environmental Health
Koumudi Thanda	Public Health - Global Health	Implications and One Health Lead
Annika McCarty	Ecology, Evolution, and Conservation	Environmental Impact and Research
Eytan Legros	Marine Biology	Environmental Impact and Research
Yuanxi Li	Informatics	Data and website co-lead
Fangzhou Xie	Statistics	Data and website co-lead
Ram Navendran	Electrical Engineering	Prototype development
Korene Mafune	PhD, Fungal Communities	Adviser

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Soma Water Filtration Team