"Algae" for the Sustainable Future

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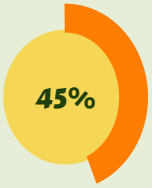
Addressing SDGs: 2, 6, 7, 13 & 14

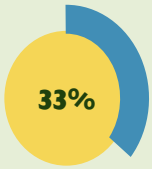
THE CHALLENGE

2 ZERO HUNGER

In 2030, 660 million people are estimated to be undernourished. Food insecurity, which heavily depends on political and economic issues, is the biggest driver of hunger. For instance, Ukraine crisis triggered food shortage and crop price rise. World really needs food security, sustainable farming, and nutrition balance to end hunger.

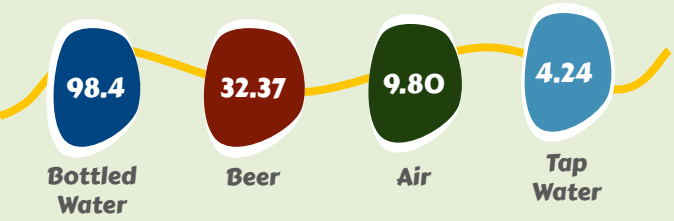


World child deaths are due to hunger & related causes



People lack access to balanced & regular food, worldwide

Average number of microplastic particles found per m^3 of selected consumables

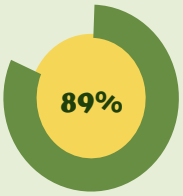


Many industries consume large volumes of water during the production processes, and later release about 70% of it as wastewater. With organic nutrients, heavy metals, and pathogens, microplastic contents are gradually increasing and ingested by humans every day, slowly escalating health risks.

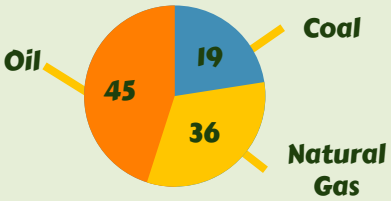
6 CLEAN WATER AND SANITATION

7 AFFORDABLE AND CLEAN ENERGY

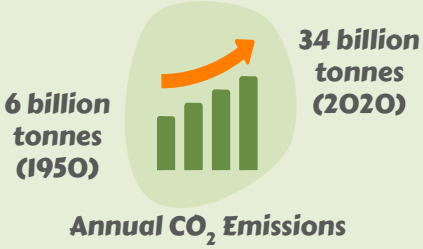
When fossil fuels including coal, oil and natural gas burned, the carbon and other greenhouse gases are released into the atmosphere that can cause dramatic changes to Earth's climate. Fossil fuels accounted for 89% US greenhouse gas emissions



CO_2 Emissions from Fossil Fuels



CO_2 Emissions by Source



Annual CO_2 Emissions

1.7 trillion ton of cumulative CO_2 released since 1750

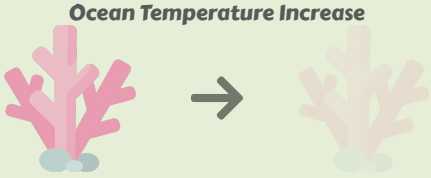
Carbon emissions reached the highest record in 2021 even with the climate actions. Energy Information Administration (EIA) estimates that the worldwide carbon emission will keep increase due to economic and population growth. Comprehensive climate action is required to stop global temperature rise.

13 CLIMATE ACTION

14 LIFE BELOW WATER

Marine biodiversity is very sensitive to temperature. A warmer ocean causes coral bleaching, habitat loss, and following consequences. A number of industries that heavily depend on the use of water discharge a massive amount of uncensored wastewater into rivers and streams. In consequence, this is directed into the ocean and impacts marine life.

Coral Extinction due to Ocean Temperature Increase



1.5°C: 70~90%

2°C: 100%

"ALGAE" for SOLUTIONS

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SOLUTION & IMPLEMENTATION

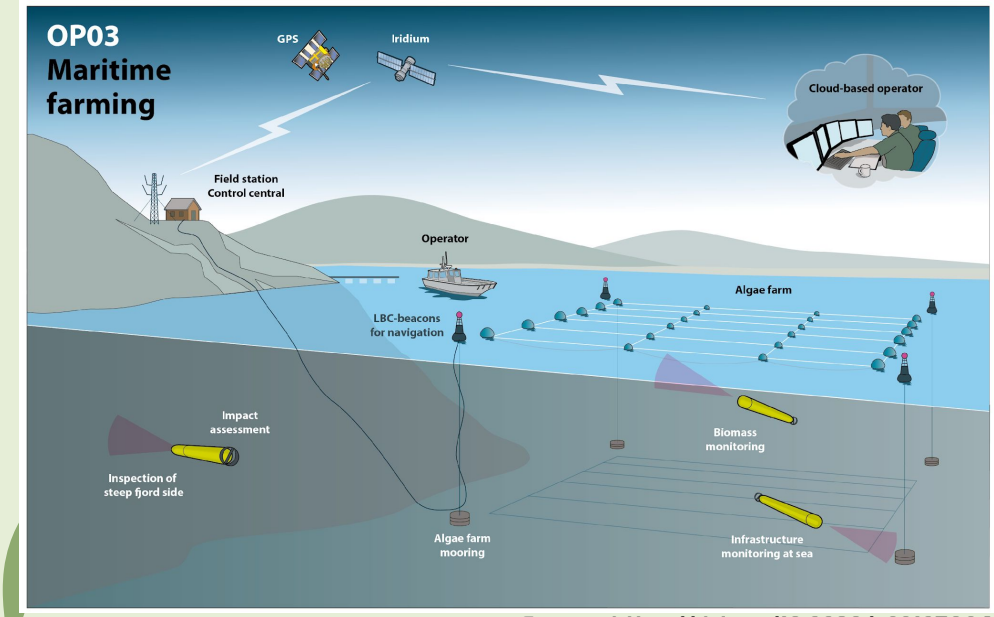
Macroalgae: Food Source, Ocean Life & CO_2 Reduction

Seaweed/kelp are a great alternative food sources, that can provide food security. It has higher productivity than most terrestrial crops, requiring less water and farmland. They grow completely within 6-8 weeks and can be re-planted immediately. Researchers also discovered the medical use of seaweed for new drug discovery.

Seaweed/kelp can fight ocean acidification and temperature rise by capturing CO_2. They are highly efficient at sucking up carbon from the ocean. Seaweed absorbs more CO_2 than any other marine plants like eelgrass, mangroves, and salt marshes.

Seaweed/kelp also stabilize nutrition levels and prevent ocean oxygen depletion. Excess ocean nitrogen and phosphorus levels lead to algal blooms, and further result in oxygen depletion. Seaweed/kelp consumes nitrogen and phosphorus in their life cycle, which plays vital role in controlling ocean nutrition and oxygen levels.

Feasibility - Seaweed farming has already taken place in diverse locations around the world. Local governments like Alaska, New England, and California are also in the process of scaling up their kelp farming. There are various kinds of seaweed and kelp for different marine environments, which open up the seaweed-farming door to every nation with ocean access. Seaweed/kelp farming is also easy and practical, once the infrastructure is installed. Infrastructure includes a hatchery for initial seed culture, mooring, and floating rafts.



Source: https://doi.org/10.3390/s22135064

Challenges - Researchers reported that over-farming of macroalgae can cause a reduction in phytoplankton net primary production (NPP) due to canopy shading and nutrient removal from the sea surface. Since the farming cycle of seaweed and kelp are much faster than regular terrestrial crops, over farming can easily happen and push the ocean to its limit. Continuous monitoring of ocean conditions and the surrounding marine ecosystem seem necessary to prevent any drawbacks.

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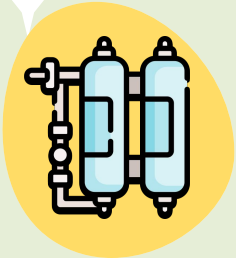
SOLUTION & IMPLEMENTATION

Microalgae

6 CLEAN WATER AND SANITATION

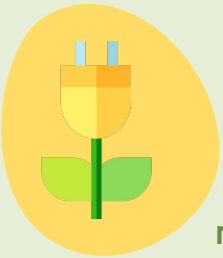
7 AFFORDABLE AND CLEAN ENERGY

Water Purification



Each microalgal species is capable of removing specific organic contaminants, heavy metals, or pathogens. Upon these captivities transpire conversion of the contents into cell compounds and rapid growth of microalgae for subsequent use for biomass.

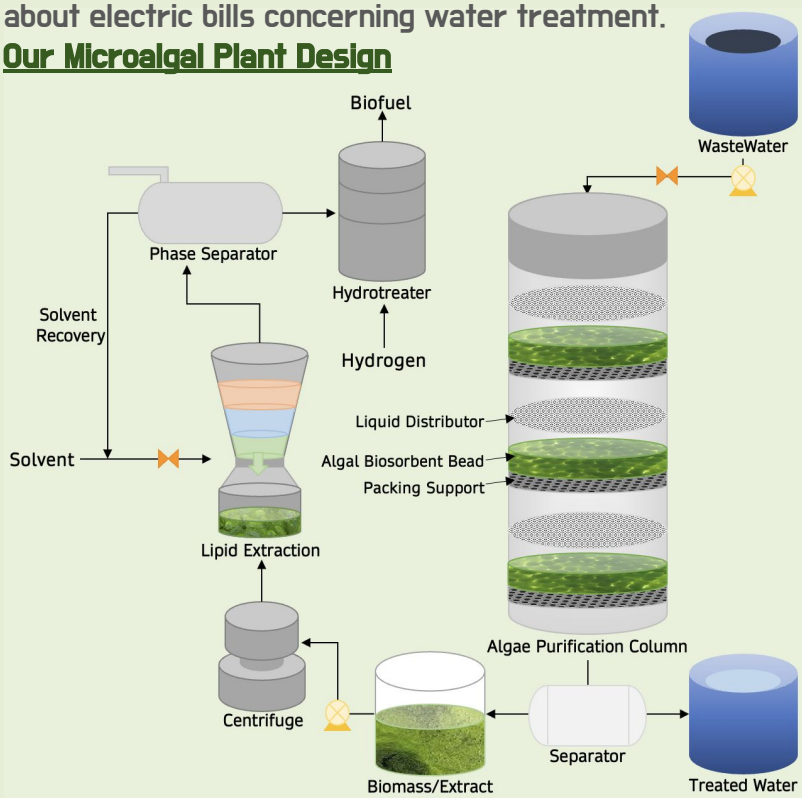
Bioenergy



Biomass derived from microalgal growth couples with improved energy efficiency for a sustainable energy system. Capable of producing in excess of oil 30 times more per acre than corn and soybean crops, microalgal biofuel is a strong competitor for clean energy.

Goal – A microalgal fractionation plant is proposed below as a substituent for both wastewater treatment and biofuel refinery system. Each microalgal species possesses distinct ability of removing desired components of wastewater. As wastewater is flown into the algae purification column, algal biosorbent beads at different levels placed with packing support perform adsorption, and the filtrate then flows down to subsequent plates for further filtration. In this process, produces oxygen that allows aerobic bacteria to decompose organic contaminants in the wastewater and removes excess nitrogen and phosphorous. Once purification is completed, the grown microalgae are extracted as biomass for lipid extraction. The extracted lipids undergo transesterification process and transform into biodiesel, and the biodiesel is separated and treated with hydrogen for successful refinery. The success of this proposal will have industries benefit from generating fuels out of waste contents and worry less about electric bills concerning water treatment.

Our Microalgal Plant Design



Feasibility – Many have already sought to employ microalgae as a means of wastewater treatment. With innumerable genera in existence, there is a vast pool of microalgal species to choose from depend under different adsorption conditions. Plus, conversion of biomass to fuel has been a known practice for many years.

Challenges – Despite all the investments and attention on microalgae-based systems, using microalgae as the adsorbents is yet at the initial phase of study. Moreover, operation of photobioreactors and other measures to harvest microalgae are reported to be 20-30% of the overall production costs of microalgal biofuels. Nonetheless, the financial costs may be deemed trivial when green benefits are considered in long term. Unceasing recognition and support of microalgae—whether it is financial or political—are crucial for the success of this proposal.

Acknowledgement

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