Green dreams: Algae biorefineries could help in the race to net zero

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Harvesting microalgae from a photobioreactor, Algae lab, Hobart. Credit: Chris Crerar/CSIRO

The world is looking for new solutions to address the challenges we're facing in the race to net zero. Things we rely on each day, like transport,

agriculture and plastics are significant contributors to greenhouse gas emissions.

Enter algae. This diverse bunch of tiny organisms are emerging as a solution to a number of our fossil fuel problems.

Algae are aquatic photosynthetic organisms, which means they use sunlight, water, and carbon dioxide to grow. Examples include seaweeds, microalgae, plankton and phytoplankton. There are thousands of distinct types of algae. And each type has specific uses and benefits that we are only just starting to discover.

From pond to pump: Know your algae

Algae fall into two main groups:

- Microalgae: these are single-celled photosynthetic micro-organisms, which can live in salt or freshwater.
- Macroalgae: these are multicellular aquatic plants that also photosynthesize. There are three types: green, red and brown. Each has different proteins, carbohydrates and fats which lend themselves to various uses.

Getting to net zero means we need to change our industrial processes. We need to increase efficiency of our traditional agricultural systems. And we also need to expand our ability to produce products like food, fuel and chemicals from new sources that are not reliant on fossil fuels. This is where algae come in.

Realizing the potential of algae biorefineries

Algae are promising because they don't compete for land, freshwater or

other precious resources, and produce high yields. They can also help purify the waters in which they grow by removing excess nutrients that lead to poor water quality.

Dr. Anusuya Willis is the Director of our Australian National Algae Culture Collection. She says much of the potential of algae is yet to be realized.

"The future of algae needs to be tempered because of a lack of fundamental research. None of the solutions will happen quickly but we need to make progress," she says.

Warren Flentje is the Industrial Decarbonization Lead for our Towards Net Zero Mission. Warren believes algae biorefineries could be the solution to several of our challenges. These facilities are similar to traditional biorefineries that process biomass, but algal biorefineries specifically use algae as the raw material. However, this technology is in the early stages of research, and requires more investment before it's ready to be rolled out.

"Algal biorefineries provide ingredients to make fuel, as well as other products like oils and plastics, and even new proteins for our diets or base products for health or cosmetic end uses," Warren says.

"We need to do more with less—in our existing systems. And at the same time, we need to be working on the systems of the future."

A sustainable source of bioenergy and biofuels

Biofuels can be a renewable and sustainable fuel for transport. Made from biomass, it can be used as an alternative to fossil fuels. Biomass is material from living things like agricultural crops and waste, animal fats and vegetable oils.

However, growing crops specifically to make biofuel takes up valuable agricultural land, which is already under increasing pressure from our food systems. So, we need new ways of producing the biomass feedstock that go into biofuels. Which is why we are looking at algal biomass and other future feedstocks.

Demand for biofuels is increasing. It's being driven by increased oil prices and climate change policies. People are already starting to reduce emissions with biofuels by using E10 (regular unleaded petrol with 10% plant derived ethanol) or by using sustainable aviation fuel.

Algae as a livestock feed additive

FutureFeed is a supplement for livestock made from a type of native seaweed (Asparagopsis). It can reduce methane emissions by more than 80% in cattle, sheep and goats. This is important because each molecule of methane has 28 times the warming potential of carbon dioxide (on a 100-year scale). This makes methane a potent greenhouse gas for our warming atmosphere.

Asparagopsis seaweed contains bioactives, which are compounds that have a biological effect and can interact with the microbes in a cow's stomach. They disrupt the normal processes that would lead to the formation of methane gas.

Dr. Michael Battaglia is a Director at FutureFeed and leads our Towards Net Zero Mission.

"FutureFeed, a great Australian innovation, looks promising. But for these solutions to create impact, we need to focus on scaling seaweed cultivation, aggregation and processing," Michael says.

FutureFeed has been driving commercialization of Asparagopsis, with

licensees growing the product. We're continuing to research and develop the product to drive adoption. However, we need to attract more investment in sustainable seaweed farming and speed up the regulatory process.

Seaweed can help tackle climate change and biodiversity loss

Seaweed ecosystems could also become strong nature-based solutions to tackling climate change, biodiversity loss and help protect our coastlines. Kelp is a kind of macroalgae, which creates large underwater forests. Kelp forests cover an area more extensive than coral reefs or rainforests.

Through photosynthesis, kelp use sunlight, water and carbon dioxide to grow. This converts carbon dioxide to organic biomass for short-term storage. If kelp is not grazed, consumed or decomposed, it can be buried in seafloor sediments or transported to the deep ocean. There it acts as long-term carbon removal to help mitigate emissions.

"A lot more work needs to be done in this area to accurately measure the long-term storage of carbon captured via kelp forests," Anusuya says.

Maintaining healthy seaweed and kelp ecosystems is part of the puzzle in protecting our oceans.

"If we want to use kelp in the ecosystem restoration economy, we need to incentivize kelp protection and restoration through carbon value," says Anusuya. "But the value of kelp in the carbon cycle is complex and ways to monitor sequestration aren't yet fully understood."

Challenges of scaling up algal-based solutions

Each type of algae comes with unique challenges. As demand for algae grows, we need to make sure we work to manage cultivation and farming to ensure sustainability.

Microalgae can be grown on land in controlled bioreactors. But for it to be useful, we need to invest in new ways of harvesting algae on a large scale. It is all about understanding how to grow algae in the most efficient way. On the other hand, we can't control the environments of macroalgae as much, because they grow and are farmed along our coastlines. To unlock the ability of kelp to retain carbon, while restoring balance and boosting biodiversity, we need to follow an ecosystem-based approach to sustainably manage kelp forests and protect the ecosystem.

For all these algae-based solutions, scaling up has challenges. But algae have a role to play in working towards net zero. They can increase efficiency in our traditional agricultural systems, while expanding our ability to produce products like food, fuel and chemicals from new sources. It's why we are working with research and investment to scale and de-risk some of these solutions to increase adoption.

Provided by CSIRO

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