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Benefits of seaweed

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Marine algaculture has strong potential to mitigate the effects of climate change. What do we do with the seaweed? We could sink it or eat it.

Although 2022 was not the hottest year on record owing to an ongoing La Niña event, it has been a year of extreme weather events, such as the unusual heatwave in the UK in July or the winter storm in North America in December. There are numerous signs that such weather extremes will become more frequent in future[1], and that agriculture will be challenged to cope with these extreme conditions. Mariculture, the cultivation of marine organisms in seawater, is less prone to such weather extremes and could develop towards being an important buffer for future food security. Specifically, algaculture – the controlled growth of marine algae or seaweed to produce food, biofuels or fertilizers, or for carbon dioxide sequestration – has considerable potential to compensate for the future effects of global warming.

Algae are rich in nutrients and have a long culinary history. In Japan, the red alga *nori* and the brown alga *wakame* have been consumed for centuries. Similar red algae are known in Korea as *gim*, and brown algae are known as *miyeok* and *dasima*. The red alga *Chondrus crispus* (better known as Irish moss) has traditionally been used to treat respiratory diseases and as a food additive. Today, it is cultivated for its polysaccharides (known as carrageenans) that are widely used in food industry as gelatinizing additives. Similarly, the gelling agent agar is extracted from the cell walls of *Gracilaria* red algae and is used in kitchens and laboratories around the world. Red algae from the genus *Porphyra* are also consumed in Wales as laverbread. In Chile, the giant brown alga *Durvillaea antarctica* is known as *cochayuyo* and has been harvested for centuries by Indigenous Mapuche coastal communities, and the green alga *Ulva lactuca* (sea lettuce) is used in salads or in soups along shorelines of large parts of the world. The further expansion of alga consumption is hampered by its often peculiar taste, which makes it difficult to replace food sources in regions where algae are not a common food product. However, the high protein content of many algae can make them a valuable resource for producing novel foods with tailored taste and texture.

Algae are also well-studied for their potential to produce biofuels. The focus is here on microalgae that can be grown in bioreactors. However, the energy investment required for the operation of bioreactor pumps is considerable, and the maintenance of such bioreactor growth facilities is costly. Furthermore, the light-exposed area of such facilities needs to be extremely large to be competitive with other energy sources. Alternatively, seaweeds could be envisaged as targets for biofuel production. Seaweeds could be grown and harvested in marine farms with low requirement for energy or manpower. As the natural content of lipids is lower in seaweeds than in many microalgae, the focus of research has been on the production of biogas and bioethanol[2,3].

As seaweeds are rich in minerals and easily accessible in coastal regions, they have been used as fertilizer from the earliest times. In Britain and Ireland, in particular, there is a long history of using composted seaweeds to ameliorate nutrient-poor soils. Only the development of chemical fertilizers in the twentieth century outcompeted the use of seaweed fertilizer (owing to cheap production costs and ease of transportation). Ironically, the massive increase in the use of chemical fertilizer has led to the eutrophication of marine coasts in the past century and consequently to seaweed blooms that endanger coastal ecosystems. Thus, seaweed farming is not only a revival of an ancient way of producing fertilizer but also a way to remediate eutrophicated ecosystems. Despite the prospect of seaweed farming aligning well with the circular economy, it is underdeveloped in Europe and North America as compared to Asia[4].

Finally, seaweeds are discussed as a potential carbon sink to mitigate global warming due to the accumulation of atmospheric carbon dioxide. In an Article in this issue of *Nature Plants*, Julianne DeAngelo, from the University of California at Irvine, and colleagues have calculated that sinking farmed seaweed to sequester one gigaton of carbon dioxide could be as cheap as US $480 per ton. In the future, the stability of such carbon sequestration needs to be investigated to avoid a scenario in which carbon sinks at the seafloor develop into new sources of carbon dioxide. Alternatively, when seaweeds are used as a resource for products such as biofuels or fertilizer that replace other, nonrenewable products, carbon dioxide emissions could be reduced while at the same time yielding a profit of US $50 per ton of carbon dioxide equivalent.

The idea of the circular economy is not new, but it is time to expand it to agriculture. As environmental cycles involve oceans, mariculture must be the counterpart of agriculture to close the circle. This requires international regulation across country borders and a working global economy. Seaweed farming could be an important cornerstone in such a global circular economy, for producing food, fuel and fertilizer, and for the sequestration of carbon dioxide from the atmosphere. Challenges of food supply owing to future weather extremes could at least be buffered by novel food products made from algae. To get there we need more research, a courageous food industry and a strong will to collaborate globally.

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