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Science for Environment Policy

Microalgae could be used to effectively bio-refine brewery wastewater

A circular economy, in which waste is minimised and resources are kept within the system, relies upon inventive ways of turning waste into a resource. A new study explored the possibility of using the microalga *Scenedesmus obliquus* to refine and process brewery wastewater. The alga efficiently removed pollutants from the effluent, produced biomass and biofuels in a range of different forms — and with different bioactive compounds — and encouraged waste barley and wheat to germinate at increased rates. This is especially important for breweries, as barley seeds are one of the main feedstocks for the industry — and thus are key to increasing its sustainability and circularity.

Beer is one of the most widely consumed beverages in the world. The main ingredient in beer is water, and the brewing industry is one of the largest industrial users of water worldwide. Producing a single litre of beer requires an average of six litres of water and generates up to 10 litres of wastewater. Water use, waste and availability are thus critical factors for breweries. Breweries produce huge volumes of wastewater which must be treated before it enters our waterways — untreated, it can cause nutrient pollution and eutrophication effects such as fish deaths, oxygen depletion and uncontrolled blooms of algae.

Tiny microalgae could play a valuable role in this treatment process within a biorefinery — a platform that transforms biomass into biofuels, energy, food, fertilisers, polymers and other high-value products. Algae could also help to mitigate the carbon dioxide emissions from this process and have proven to be highly efficient at removing nutrients from wastewater.

This study explored how the microalga *Scenedesmus obliquus* could be used to biorefine wastewater from a brewery in Vialonga, Portugal. The wastewater was pre-treated at the factory's industrial treatment plant.

The microalga was cultivated within the wastewater and the resulting biomass analysed in several different ways. The researchers extracted the bioactive compounds from the alga biomass using subcritical water (water maintained at a high enough pressure to keep it liquid at very high temperatures); used the biomass to produce biofuels via a mix of bio- and thermochemical techniques; and tested the biomass' effects on barley and wheat seed germination. They compared their results to a sample of the microalga cultivated in a synthetic medium.

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Microalgae could be used to effectively bio-refine brewery wastewater *(continued)*

The results showed *S. obliquus* to be highly effective at removing pollutants from the wastewater, with an especially high removal rate for nitrogen of over 80%. The alga biomass comprised a mix of proteins (31.4%), carbohydrates (30.2%), lipids (17.9%) and other substances — similar to other refinery techniques, demonstrating that the biorefinery process did not compromise biomass composition.

The use of subcritical water in the refinery process also had several advantages. The process successfully extracted the bioactive components of the alga biomass (that is, substances capable of having a biological effect on other organisms — in this case a mix of phenols and flavonoids), suggesting that the process could result in useful, functional products. It also had the ability to destroy spores, yeasts, moulds and various bacteria within the biomass, further enabling the production of products that are microbiologically clean and safe.

The wastewater-cultivated biomass was used to create biohydrogen (via fermentation, a biochemical technique) and to create bio-oil, biochar and biogas (via pyrolysis, a thermochemical technique). The yields of biohydrogen, bio-oil and biochar were higher than those produced by the synthetic medium, and the purity of the biohydrogen was not compromised.

Finally, the researchers created a biomass pellet from the microalga and applied this to barley and wheat seeds. The barley seeds germinated and grew faster, and in larger numbers, than the wheat seeds, but both showed greater, faster growth with the microalgal pellet than the synthetic one. This suggests that the alga has a notable growth-stimulating effect and could be an effective biofertiliser.

The researchers note that the economic cost of cultivating the microalga was high and must significantly decrease to make alga biorefineries comparable to conventional treatment plants. However, the study demonstrates the potential of using algae to process wastewater and remove pollutants, produce biofertiliser to enhance plant growth and extract value-added compounds from biomass. Innovative microalgae biorefinery structures could offer economic and environmental benefits to the brewery industry and contribute to a circular economy.