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Water for microalgae cultivation has significant energy requirements

A substantial amount of energy is needed to manage all the water used in the mass cultivation of microalgae for biodiesel. A recent study suggests that seven times more energy is required to manage the water, than is delivered by the biodiesel when it is used as fuel.

Producing biodiesel from microalgae is one potential solution to finding future renewable sources of energy, especially for the transportation sector. Different strains of microalgae have been identified for possible cultivation on a commercial scale to extract oils which can be converted to biodiesel. Alternatively, the algae themselves can be burnt as a fuel, or they can be used to produce other fuels, such as methane and ethanol.

However, there are concerns about the amount of water and nutrients needed to cultivate the algae and whether the life cycle energy consumed in the cultivation process exceeds the amount of energy recovered from the algal biomass. Algae require large amounts of water in which to live and grow. Water must be available and not drawn away from other uses and should not lead to the lowering of water tables. Other concerns relate to disposal issues, for example, of sludge waste.

In this study, the energy associated with the supply and management of water needed for the cultivation of algae in open ponds (raceway ponds) was estimated for mass production of microalgae in all 48 states of the USA. For algae to contribute significantly to future transportation supplies, cultivation must be large-scale and occur at many locations across the USA. Algal production for each state was estimated based on land potentially available, and geographic and climate conditions.

Energy inputs are required to handle the water. Freshwater or saline water must be sourced (typically pumped from surface or groundwater sources), held (e.g. in ponds lined with high density plastic film or concrete), circulated within the ponds (e.g. using paddlewheels), and pumped around the different areas for operation of the system. Energy is also needed to filter algae from the water and in the disposal of sludge.

The results suggest the potential energy output from the algae depends on how the energy is produced, the efficiency of separation process, the constituents of the biomass and the final products. Overall, it is estimated that seven times more energy needs to be invested in water management, compared with the expected energy return from the extracted biodiesel. If all the algae were burnt as fuel or used to produce other fuels (e.g. methane or ethanol), theoretically the estimated average energy input associated with water management would be more than twice the average potential energy output. The greatest demand for energy comes from pumping water between the ponds. The amount of energy depends on the rate at which the specific algae species grows; the environmental conditions; and the different types of production systems used to cultivate the algae.

Energy to source saline water for the cultivation of some algal strains is the next largest demand for water-management energy. Growing freshwater algae reduces this energy requirement by just over 50% and reduces the total water management energy demands by 14%. Using surface water would reduce the overall energy required for water management by an estimated 23%, although it is doubtful that surface water could produce the large quantities of biofuel needed. Energy needed to produce the plastic liners in the ponds is the third greatest demand for water-related energy inputs. The lifetime of the plastic was taken into consideration, e.g. estimated to be 10 years for lining evaporation ponds. Plastic liners protect the local environment from leakages and contamination by non-native algae and the nutrient-dense water.

Given the life cycle impact of energy requirements for the water management of the mass production of algae, the study advises that it is important to evaluate all energy inputs and outputs under realistic mass production over a wide area, rather than for limited, ideal conditions.

Source: Murphy, C.F. and Allen, D.T. (2011) Energy-Water Nexus for Mass Cultivation of Algae. *Environmental Science & Technology*. 45: 5861-5868.
Contact: cfmurphy@mail.utexas.edu
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