Aquatic plants are essential to the ecosystem, but need good management, say researchers

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Underwater plants can form a dense vegetation. Credit: Michael Feierabend

Submerged macrophytes are declining in many shallow lakes around the world, with more algae and free-floating plants taking their place. But an opposite trend is also emerging: water bodies with improved water

quality are increasingly experiencing a mass growth of aquatic plants. Given that these plants perform many important ecosystem functions, careful management is required.

Macrophytes—large aquatic plants visible to the naked eye—are important habitats for a wide range of organisms and contribute to the self-purification of water bodies. If this type of vegetation disappears, leaving algae and floating plants to proliferate in water bodies, more greenhouse gases will be released. Sabine Hilt investigates why fewer submerged aquatic plants have grown in many water bodies in recent years.

"It is known that both the growth of algae and the turbidity of the water play an important role in this process. After all, the plants, with roots buried at the bottom of the lake, need sunlight at those depths for photosynthesis. But other stressors also play a role," explained the IGB researcher.

In agricultural landscapes, these stressors are, above all, various pesticides combined with nutrients. As part of a large team of scientists from France, UFZ Leipzig and LMU Munich, she investigated the effect of a cocktail comprising a herbicide, an insecticide, a fungicide and nitrate, as well as additional stress due to 3 to 4 °C warming, on aquatic plants and animals in the laboratory and in 600-liter mesocosms.

Typical communities from shallow lakes of temperate zones were established in these mesocosms, including three typical submerged macrophyte species.

Hilt also explored a similar combination of typical stressors together with a team led by the Chinese Academy of Sciences in Wuhan. They investigated the individual and combined effect of warming, nutrients and the pesticide glyphosate on the growth of algae and two aquatic plant

species.

As examples, the researchers chose species that are typically found in Chinese waters such as water thyme (Hydrilla verticillata), which forms a canopy at the water surface, and vallisneria (Vallisneria denseserrulata), which grows at the bottom of water bodies. To simulate shallow lakes, they used 48 mesocosms, each with a water volume of 2,500 liters.

The results of these two projects clearly show that the growth of aquatic plants is negatively affected, especially when several of the investigated stress factors come together. Continuous warming often enhanced the effect of the cocktail of pesticides and nutrients. Frequent heat waves have an even more damaging effect than continuous warming. There is therefore an increased risk of aquatic plants disappearing from shallow waters, especially in agricultural landscapes.

Shift in plant types in water bodies results in higher methane emissions

Nutrients also constitute a stress factor that poses a threat to remote lakes that were previously clear, as another study involving IGB shows. Recently, an increased occurrence of filamentous algae blooms has been observed in such water bodies. This is an unusual phenomenon for nutrient-poor lakes—and a cause for concern: mass developments of filamentous algae can change the ecosystem profoundly and cause problems for water recreation.

Filamentous algae, a collective term for various species of algae with a threadlike, filamentous shape, have higher nutrient requirements, especially for nitrate and ammonium. And indeed, nutrient inputs to several formerly clear, nutrient-poor lakes have increased in recent

years. One example is Lake Baikal in Siberia—renowned for its unparalleled richness of animal and plant species. This biodiversity is threatened because the biomass of filamentous algae has increased fivefold in the last ten years.

One reason could be nitrogen and phosphorus inputs from untreated human sewage discharged into the lake. Forest fires have also caused additional nutrient loading to the lake.

Mass developments of aquatic plants in summer

However, masses of aquatic plants can also be observed, especially in summer. This is when mass developments of aquatic plants occur in standing and flowing waters throughout Europe. The reason for this: "Macrophytes had disappeared for decades due to excessive nutrient inputs, and are now growing as water quality improves and nutrient inputs decline," explained Sabine Hilt.

Generally speaking, this is a positive development.

"Aquatic plants are an important element of our water bodies. They influence nutrient cycles and interact with other aquatic organisms. As they grow, they bind carbon dioxide, which can then be stored in the sediment for longer periods. Macrophytes absorb excess nutrients such as phosphorus and nitrogen from the water body and release oxygen through metabolism, which improves water and sediment aeration," stated Jan Köhler, who conducts research on macrophytes and algae at IGB. What is more, aquatic plants reduce turbidity and prevent sediment from being stirred up.

Macrophyte stands also promote biodiversity due to their diverse structure: a species-rich growth of algae and bacteria can develop on their surface, which in turn provides habitat and food for small animals

(zoobenthos). As well as providing shelter for small animals from predators, macrophytes are also food for various waterfowl. In addition, aquatic plant stands are valuable spawning and hunting grounds for fish, offering areas of refuge for their larvae and juveniles.

Therefore, from an aquatic ecology point of view, the advantages for nature often outweigh the disadvantages, even in the case of mass developments. Disadvantages arise mainly for human use and safety interests, especially in flowing waters: impoundment caused by macrophytes can reduce the flow velocity, raising the water level in the river and the groundwater level on adjacent areas.

Aquatic plants are often considered a nuisance

Densely growing aquatic plants can also interfere with boating and other water sports, hinder anglers or put off swimmers. This was the result of a comprehensive survey of water users in Germany, France, Norway and South Africa.

"More than 70 percent of the respondents at each location found the macrophytes disturbing," explained Jan Köhler, who was involved in the study together with Sabine Hilt. This was equally true for different recreational activities—swimming, boating, angling, appreciation of biodiversity, appreciation of landscape and birdwatching. Residents perceived the water plants as significantly more problematic than visitors Environmental mindedness of respondents did not influence the perception of nuisance.

Weeding or removing aquatic plants poses ecological risks

For authorities and other stakeholders involved in water management, it

can be very challenging to address the trade-offs between protecting or achieving good ecological status on the one hand and various human use interests on the other, and to develop approaches that take into account and balance all objectives. If these stakeholders decide to take action against macrophytes, weeding, i.e. the mowing or removal of aquatic plants, is the most commonly chosen method.

Although weeding creates space for recreational use or increases the flow of ditches and natural flowing waters in the short term, the process is very expensive. In addition, after weeding, plant fragments may drift into previously unaffected areas and become established there, causing macrophyte stands to spread. With some species, water-weed removal can even cause enhanced growth rates. Since weeding is not very selective, the process also quickly reduces rare plant species, destroys diverse habitats, and kills many creatures that live in aquatic plant stands. These measures can also lead to the stirring up of settled particles and increased oxygen depletion.

Impairment on biodiversity

The biodiversity of microorganisms also changes: Sabine Hilt and Jan Köhler were involved in a before-after-control-impact study that examined the effects of mechanical macrophyte removal on phytoplankton, zooplankton and macroinvertebrate assemblages. The study included five sites in four countries in Europe and Africa with highly variable characteristics. Repeating the same experimental design at all sites made it possible to disentangle common from site-specific effects.

Overall, the removal of macrophytes negatively affected biodiversity, in particular of zooplankton and macroinvertebrate assemblages. In contrast, phytoplankton communities were positively affected by the removal of plants. "Weeding therefore poses risks to biodiversity, and

can sometimes even cause a water body to change into a turbid, phytoplankton-dominated state that supports significantly fewer ecosystem functions and is less attractive for many forms of use," explained Sabine Hilt.

The ecological value of aquatic plants is often overlooked in the current public debate. With this in mind, economic, ecological and social aspects should be equally included in the analysis and planning of measures in the future. If it appears necessary to reduce aquatic plant stands, it would be preferable to take sustainable measures such as further reducing nutrient inputs or planting riparian trees.

A success story: Stoneworts return to lake Müggelsee

Berlin's Müggelsee is a good example of recolonisation by aquatic plants. The stonewort has at last returned to this lake, following a long period of absence. As early as the end of the 19th century, nutrient inputs increased, and massive discharges from the 1970s onwards led to the virtual loss of submerged vegetation in the Müggelsee due to the resulting high levels of water turbidity.

Aquatic plants only started to appear again slowly from the 1990s onwards, following a significant reduction in nutrient inputs. Since around 2011, turbidity in the Müggelsee has declined even further due to the influence of the quagga mussel, which has invaded the lake. Underwater flora is now present to a depth of 3-4 meters, forming very dense stands in places, and there has also been a significant increase in species richness.

Stoneworts and other low-growing species were last sighted in the Müggelsee over a century ago. Now, after 20 years of intensive mapping and diving surveys, not just one but three of these desirable species of submerged vegetation have been detected: the fragile stonewort (Chara

globularis), the starry stonewort (Nitellopsis obtusa) and another Nitella species (Nitella spec.).

Stoneworts are not quite algae and not quite plants, but they are certainly a clear indicator of lower nutrient concentrations and cleaner waters. In addition to having all the aforementioned positive effects, they do not interfere with water recreation because they do not grow to the water surface. It remains to be seen whether they can establish larger populations over the next few years—we truly hope so.

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