

Macrophyte removal in LAKE KEMNADE, GERMANY

Background

Lake Kemnade (125 ha, 2.4 m average depth) near Bochum, Germany, is the youngest (1979) in a series of reservoirs in the river Ruhr. The main purpose of the lake is recreation (hosting more than 50 water sport clubs; Fig. 1), but it is also used for nutrient retention and has a water power plant in operation since 2011. Since 2000, mass developments of the invasive submerged macrophyte *Elodea nuttallii* have been occurring in the Ruhr reservoirs, including Lake Kemnade (Fig. 2). A specialised mowing boat (Fig. 3) has been deployed by local water authorities and continually removes the vegetation during the summer months.



Fig. 1: Leisure activities in and around Lake Kemnade



Fig. 2: *Elodea nuttallii* in Lake Kemnade in July 2020



Fig. 3: Mowing boat at Lake Kemnade in July 2020

The MadMacs project at Lake Kemnade

In summer 2020, two sections (each 50 x 100 m) of the lake were allocated for the MadMacs project. Surveys of the vegetation cover, PVI (plant volume inhabited, that is the percentage of the water column that is “filled” with macrophytes) and biomass were carried out before and after the removal of *E. nuttallii* from the impact site. The other site was left vegetated as a control (Fig. 4). In addition to vegetation data, we collected information on the water quality, greenhouse gas emission (Fig. 5), biodiversity and hydrology.



Fig. 4: Mowed (left) and unmowed (right) control sites at Lake Kemnade in July 2020



Fig. 5: Floating chambers to measure greenhouse gas emissions in Lake Kemnade in July 2020

Results

The mowing boat at Lake Kemnade could not remove all *E. nuttallii* biomass, since the boat is designed to leave the 50 cm of vegetation immediately above the sediment to prevent damage to the cutting mechanism from rocks and other objects. As a result, the macrophyte cover remained around 100% in the control and impact site, before and after mowing, with plant height being significantly reduced in the impact site (from 120 to 60 cm). As a result, the PVI (plant volume inhabited) was reduced by over 60% in the impact site (Fig. 6A). At the control site, both PVI and biomass remained constant during the experimental period. In the impact site, mowing removed 310 g of plant dry weight m⁻² (Fig. 6B).

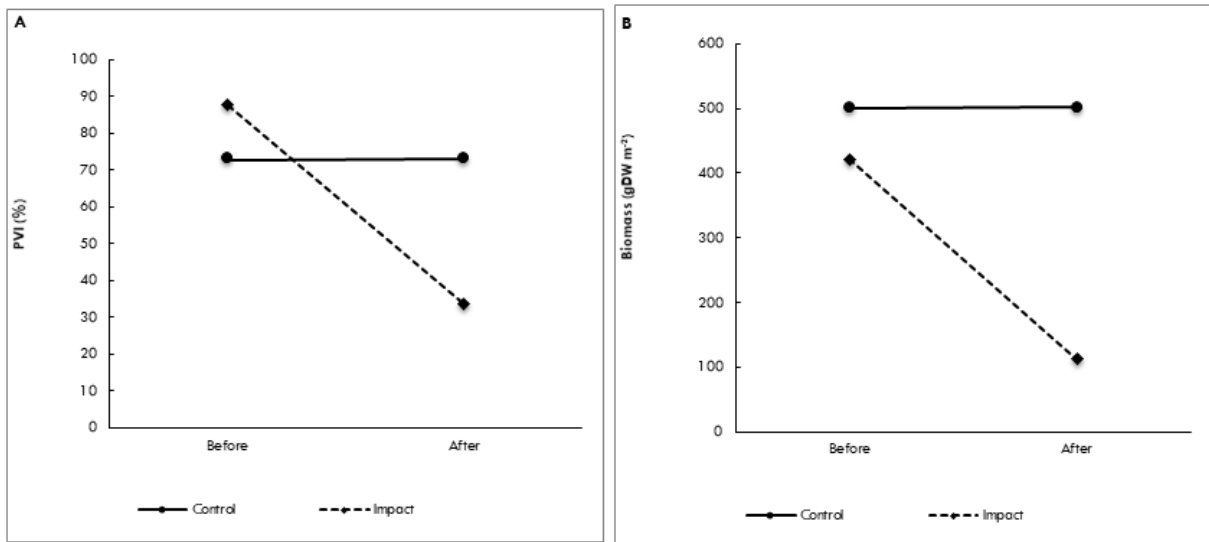


Fig. 6: Plant volume inhabited (PVI) before and after removal of *Elodea nuttallii* in the impact and control sites at Lake Kemnade (A). In addition, the amount of biomass (grams dry weight) present in each section before and after plant removal is depicted (B).

Water samples were collected at the impact and control sites multiple times before, during, 1 week after and 6 weeks after macrophyte removal. In addition, we recorded pH, conductivity, dissolved oxygen and other parameters along a depth gradient. For simplicity, we here only present a selection of data collected 1 week before and 1 week after.

With depth, there were more suspended particles in the water in both the control and impact site (Fig. 7), but no differences were found between the control and impact sites. Although phosphorus was already higher in the impact site before plant removal, the concentration increased strongly after mowing in the impact but not in the control site (Fig. 8). In the lake, nitrogen was predominantly available as nitrate (NO_3^- ; $91 \pm 4.5\%$; Fig 10), while the availability of ammonium (NH_4^+) increased with depth ($P=0.013$; Fig. 9). Furthermore, the concentration of NH_4^+ briefly increased in the impact site compared to control after mowing.

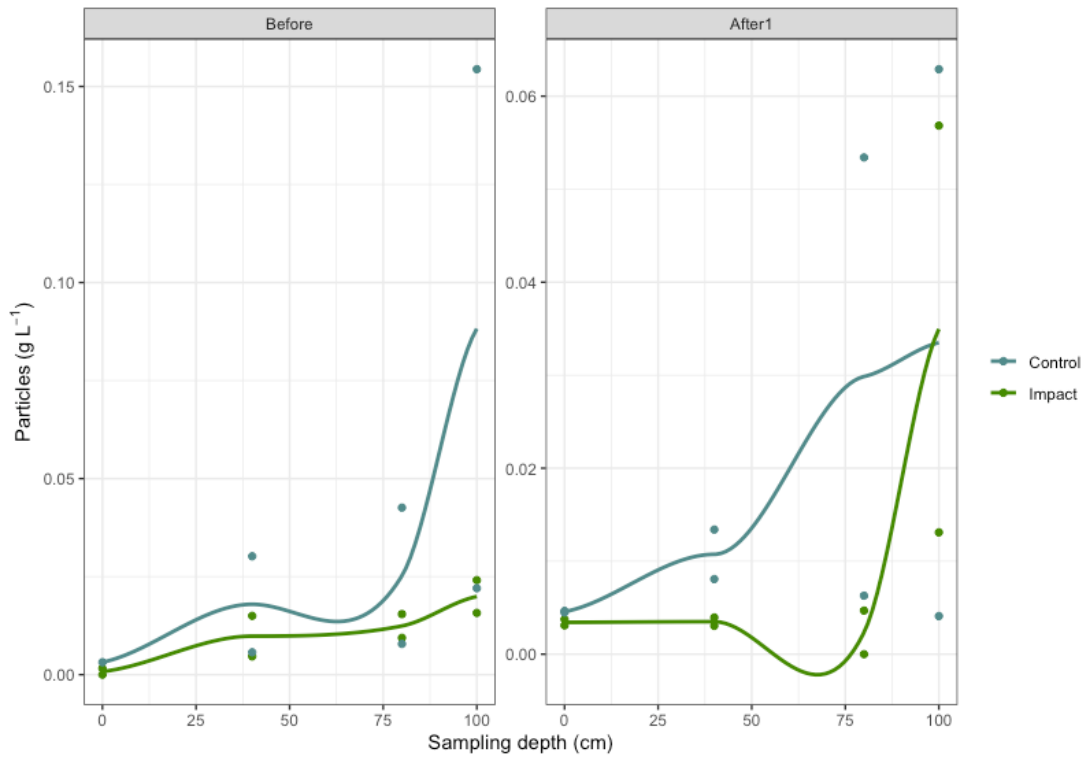


Fig 7. Concentration of suspended particles before and after mowing, in the impact and control sites at Lake Kemnade.

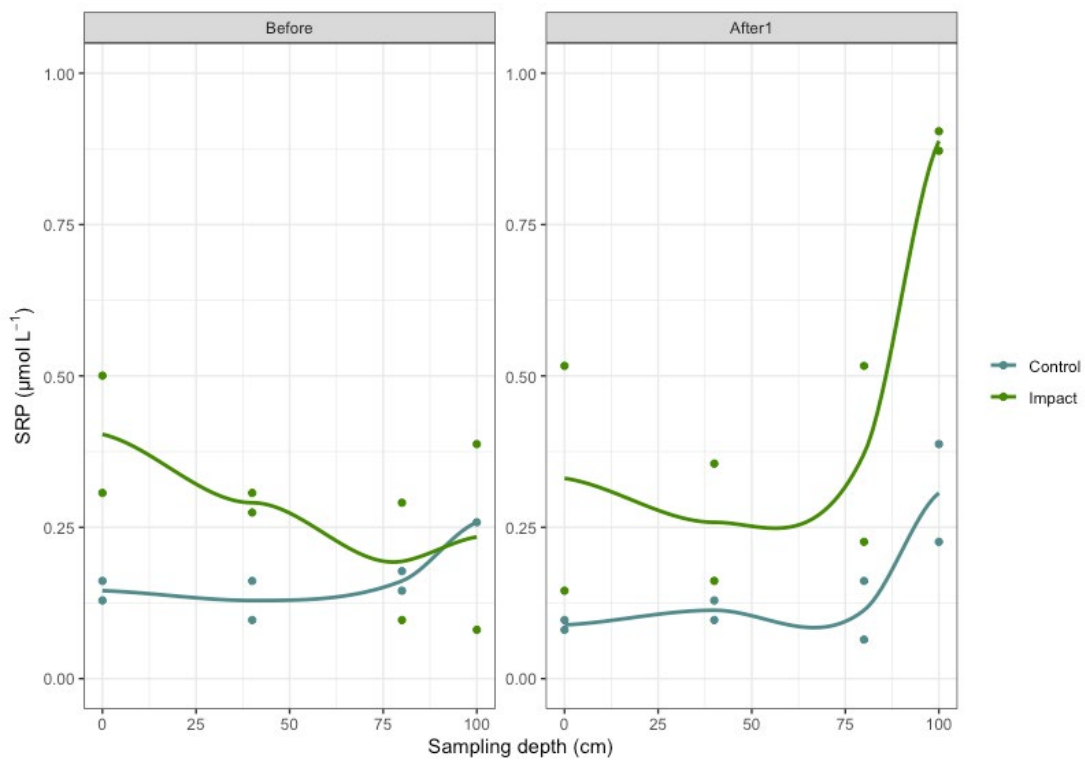


Fig. 8. Phosphorus (measured as Soluble reactive phosphorus (SRP)) concentrations, determined before and after mowing in the control and impact site at Lake Kemnade.

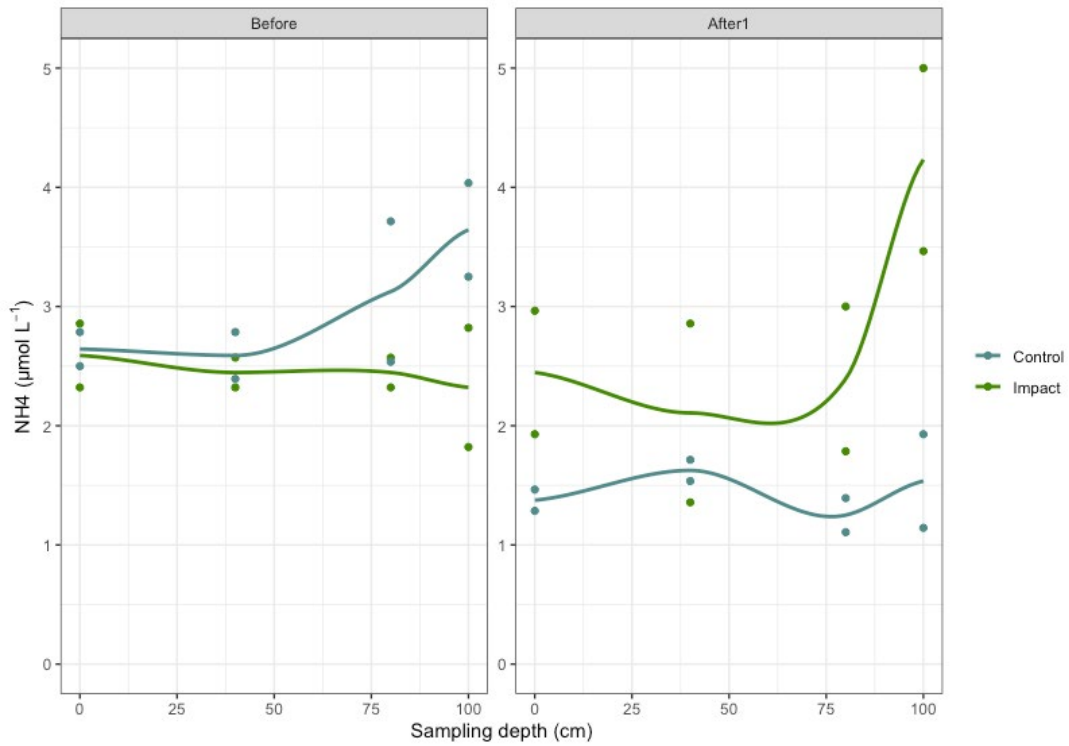


Fig. 9. Ammonium (NH_4^+) concentrations, determined before and after mowing in the control and impact site at Lake Kemnade.

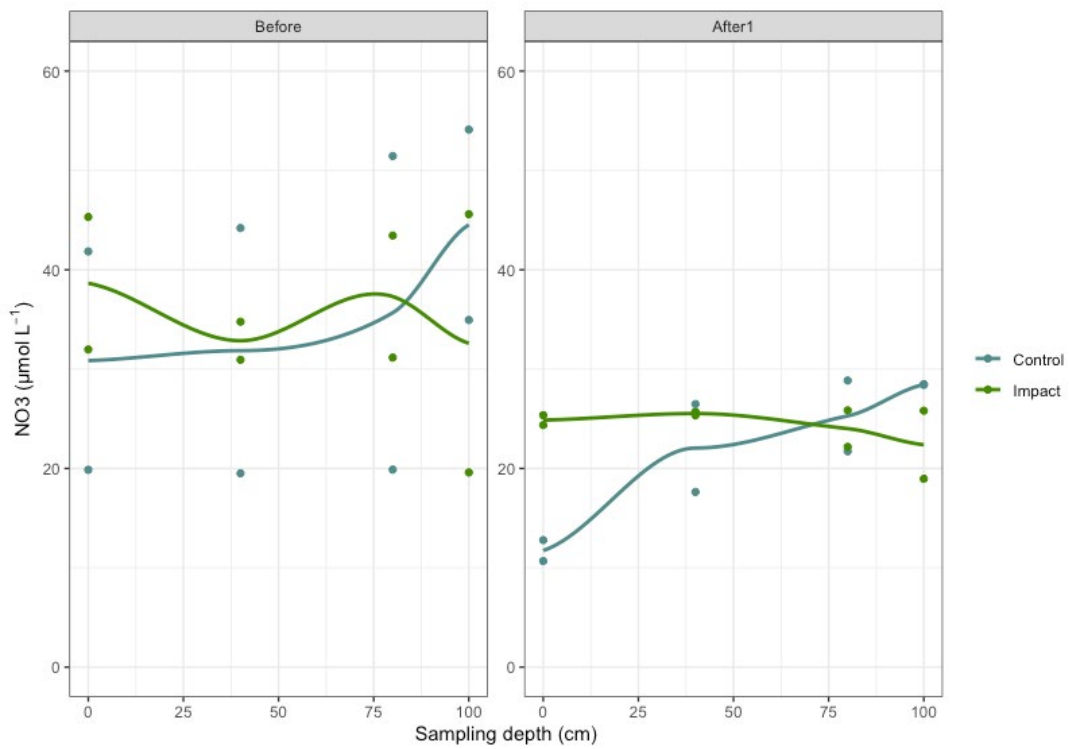


Fig. 10. Nitrate (NO_3^-) concentrations, determined before and after mowing in the control and impact site at Lake Kemnade.