Recycling lake sediments for crop production: A sustainable solution for closing the phosphorus cycle

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Aerial view of the excavation process at eutrophic Lake Mustijärv, located in Viljandi, Estonia, taken in August 2016. Credit: Kristjan Lust

A four-year field experiment conducted on the shores of restored Lake

Mustijärv in Viljandi, Estonia, has revealed that recycling phosphorus-rich lake sediments back to agriculture could have positive impacts on crop production.

Appearing in *Science of The Total Environment*, the study was conducted by doctoral researcher Mina Kiani and the AgriChar research group, and it is globally the first of its kind to cover the environmental aspects of recycling lake sediments to agriculture over several years. Kiani defends her thesis on 21 April at the University of Helsinki Faculty of Agriculture and Forestry.

The study aimed to find a sustainable solution for closing the leaking agricultural phosphorus (P) cycle by recycling P-rich lake sediments back to agriculture and helping the restoration of the eutrophic lake by sediment removal. The experiment involved excavating all 7,500 m^3 of sediment from the 1-hectare shallow eutrophic Lake Mustijärv, which was then used as a growing medium for grass production. The sediment was also analyzed for various essential nutrients, including P, sulfur (S), calcium (Ca), magnesium (Mg), boron (B), zinc (Zn), and copper (Cu).

The results showed that sediment-based growing media sustained the grass biomass yield in the field condition, with the sediment being rich in organic matter and a good source of several essential nutrients. Additionally, the sediment continuously provided a moderate supply of N to the plants over the four-year field experiment.

Mina Kiani and Olga Tammeorg are collecting sediment samples from the Lake Mustjärv to evaluate its condition after being restored through complete sediment removal. Credit: Priit Tammeorg

The study also investigated the environmental impacts of various sediment application methods, including greenhouse gas emissions, N and P leaching, aggregate stability, and soil biota. Sediment-based growing media had different bacterial and fungal community compositions compared with soil, and it increased the risk of P and mineral N leaching. Biochar application increased the amount of N taken up by the plants but did not significantly reduce emissions or leaching.

The sediment application rate should be adjusted to match crop requirements, similar to how fertilizers are applied. This can help minimize nutrient leaching back into the lake and further help mitigate eutrophication of the lake.

Furthermore, in this project, the changes in P dynamics at the sediment-water interface in the restored lake were examined during a two-year follow-up period. Theoretically, no markable sediment P release could appear after complete sediment removal. Nevertheless, a large pool of releasable P was rebuilt soon after sediment removal due to an exceptionally high nutrient flow from the catchment. Particularly large quantities of sediment, most likely originating from the stream bed cleaning upstream of the lake, concentrated into the sediment accumulation basins, i.e. deeper parts of the lake created as a part of the lake restoration project. Regularly emptying such sediment accumulation basins may help to efficiently entrap point source nutrient inputs and facilitate future lake restoration efforts.

More information: Mina Kiani et al, Recycling eutrophic lake sediments into grass production: A four-year field experiment on agronomical and environmental implications, *Science of The Total Environment* (2023). DOI: 10.1016/j.scitotenv.2023.161881

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