Gewässersanierung · Umweltinformationssysteme · Regenwasserbewirtschaftung

Wassmann

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Schäfersee-Verfahren

Support or Remediation of Water Bodies with Oxygen-Depleted Water Layers and Heavily Contaminated Sediments

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Part I – Joint Short Report

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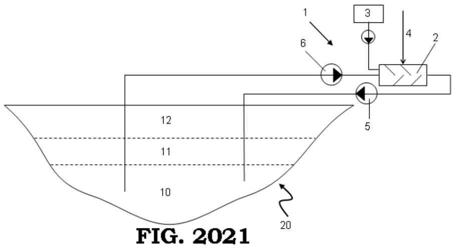

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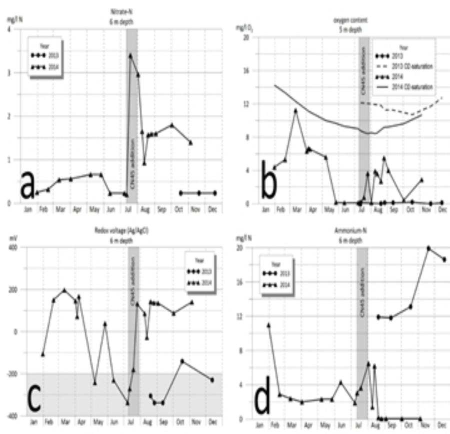

Short Report (Part I)

Research Project "Schäfersee-Verfahren®" – Support or Remediation of Water Bodies with Oxygen-Depleted Water Columns and Highly Contaminated Sediments through Stimulation of Climate-Neutral Microbial Degradation

The joint research project was conducted collaboratively by Büro Wassmann (coordination, field investigations, and application technology) and the Technical University of Berlin, Department of Environmental Microbiology (microbiological and molecular biological analyses as well as field investigations). The objective was the development, testing, and scientific evaluation of an environmentally compatible process for the support and stabilization of heavily impacted aquatic systems.

Many lentic water bodies in Germany exhibit oxygen deficiency and high organic loading. The causes include external substance inputs, eutrophication, and climate change, as well as internal processes such as microbial degradation of organic matter within the sediments. During these processes, available oxygen is rapidly depleted, leading to anoxic conditions, accumulation of putrefactive sludge, and the formation of toxic gases such as hydrogen sulfide (H_2S) and climate-relevant gases such as methane (CH_4). These processes promote the remobilization of phosphorus, cause odor nuisance, impair benthic communities, and accelerate eutrophication.

In urban environments, inputs of untreated stormwater runoff from roads further exacerbate the stress situation: In addition to elevated nutrient loads, organic contaminants such as mineral oil hydrocarbons (MOH) and polycyclic aromatic hydrocarbons (PAHs), as well as heavy metals, enter the systems. Under anoxic conditions, many of these organic compounds are only insufficiently degraded; heavy metals are not degradable and may accumulate in the sediments.

Schäfersee-Verfahren® was originally developed at Berlin's Schäfersee as a concept for the targeted manipulation of redox conditions. Within the present research project, this concept was further advanced, and a compact, intelligently controlled system was developed that integrates measurement, assessment, and regulation within a closed-loop framework. The combination of controlled calcium nitrate dosing with oxygen-enriched water and continuous online monitoring resulted in the development of an adaptive process control strategy that enables targeted steering of microbial degradation processes within the sediments.

The effectiveness and environmental safety of the process were demonstrated in three demonstration water bodies—the Schäfersee and Fennsee in Berlin and the Jröne Meerke in Neuss—covering different lake types and site-specific conditions. Shortly after the initiation of treatment, a complete suppression of hydrogen sulfide formation and a tendency toward reduced methane emissions were observed. At the same time, redox conditions stabilized, and phosphorus was retained within the sediments; geochemical investigations provided evidence for the formation of mineral phosphorus phases.

Accompanying analyses conducted by TU Berlin demonstrated, in one of the investigated water bodies, a shift in microbial community composition toward oxidative and denitrifying processes, as well as a tendency toward reduced abundance of methanogenic organisms. Despite existing sediment contamination with (semi-)metals and organic pollutants (PAHs, MOH, EOX), no relevant mobilization of hazardous substances was observed; in particular, there was no indication of treatment-induced metal release. Under the oxidative conditions established by Schäfersee-Verfahren®, no accumulation but rather a tendency toward a decrease of persistent organic hydrocarbons was detected (e.g., MOH/EOX, with PAHs largely remaining stable); additionally, indications of a reduction in dissolved organic carbon (DOC) were observed. Metagenomic analyses identified genes encoding oxygenases in the sediments, which catalyze the aerobic degradation of organic hydrocarbons, as well as functional genes associated with nitrate respiration.

Overall, the data obtained within the project demonstrate that the redox conditions established by Schäfersee-Verfahren® promote microbial degradation of organic substances, in particular through the provision of nitrate and oxygen as electron acceptors, without creating new environmental risks. During the treatment phases, nitrate concentrations in the water column remained at low levels, reflecting the controlled and demand-oriented dosing strategy. The process demonstrated that, through the combination of targeted nitrate dosing and intelligent process control, a resource-efficient, climate-neutral, and long-term stable support of eutrophic and contaminated water bodies is achievable.

Compared to conventional aeration or dredging approaches, Schäfersee-Verfahren® enables an energy-efficient, controllable, and ecologically compatible stabilization of aquatic system processes, as it relies on the targeted enhancement of microbial turnover processes rather than mechanical interventions. The insights gained within the project form the basis for the further application and optimization of Schäfersee-Verfahren® across different types of water bodies and provide important contributions to climate-adapted management of aquatic ecosystems.