SR2
A Systematic Review

MISTRA EviEM
EVIDENCE-BASED ENVIRONMENTAL MANAGEMENT

EviEM Fact Sheet 2016

Removal of nitrogen and phosphorus in freshwater wetlands

Created and restored wetlands are widely used and effective for tackling eutrophication

Eutrophication – the over-nourishment of water bodies from detergents, fertilizer or sewage – is a major environmental problem in large parts of the world. A widely used method to reduce the input of nutrients to freshwater and marine environments is to let water with high concentrations of nitrogen and phosphorous to pass through a created or restored wetland.

We defined a created wetland as being located on land where there has never been one before, and a restored wetland as a natural wetland that has previously been drained or altered by other means. Created wetlands can be of different types, and are usually classified as Free Water Surface Constructed Wetlands (FWS), Horizontal Subsurface Flow Constructed Wetlands (HSF), and Vertical Flow Constructed Wetlands (VF). Different wetlands provide different physical and chemical environments, enabling removal processes such as sedimentation, plant uptake, denitrification (for nitrogen removal), and sorption and precipitation (for phosphorus removal).

However, there is large variation in the results of measurements and modelling of nutrient removal in created and restored wetlands, which has made it difficult to assess the efficiency of such interventions. Therefore EviEM undertook a systematic review of this question. We found useful data on a total of 203 wetland studies, most of which were carried out in Europe and North America. This fact sheet briefly summarizes the findings of the review.

Wetlands are generally highly efficient for removing nutrients from run-off

Our systematic review shows that the removal efficiency on an annual basis (i.e. the annual relative load reduction) is generally high for both total nitrogen (TN) and total phosphorus (TP). We have also examined the removal rate in absolute numbers per unit of wetland area. The removal rate much depends on the loading rate; generally, the more nutrients that enter the wetland the more nutrients are removed.

According to our meta-analysis, the median TN removal efficiency was 39%, and the median TP removal efficiency was 46%. In both cases the removal efficiency was statistically significant. The median removal rates of TN and TP were 93 and 1.2 $g \cdot m^{-2} \cdot yr^{-1}$, respectively.

A wetland in the watershed of the Segeån River, Skåne, Sweden. Biogeochemical transformations in wetlands – for example denitrification, in which nitrogen dissolved in water transforms into nitrogen gas – tend to reduce the nutrient content of the water passing through the wetlands.
Photo: Johan Hammar

There is large variation in removal efficiency between different wetlands, and some wetlands actually release more phosphorus than they receive. Therefore, we divided the wetlands into subgroups in an attempt to identify conditions that may be more favourable than others. The subgroups were based on climate zone, type of wetland, type of water entering the wetland, land use history, and water flow regime. We also performed regression analyses. While in general there were only small differences between different groups of wetlands, the following clear tendencies were revealed:

- Wetlands receiving secondary treated wastewater removed TN more efficiently than wetlands receiving tertiary treated wastewater.
- Restored wetlands directly located on former agricultural soil removed TP less efficiently than other wetlands.
- Wetlands where the hydraulic loading rate (water flow rate per unit of wetland area) was driven by the amount of precipitation removed TP less efficiently than wetlands where the hydraulic loading rate was controlled.

The removal efficiency for both TN and TP generally declined with an increasing rate of average hydraulic loading. However, TN removal efficiency generally increased as mean annual air temperature increased, whereas TP removal efficiency generally rose in line with increasing TP concentrations at the wetland inlet. A majority of the studies only looked at concentrations of TN and TP, and didn't distinguish between the different forms in which they can occur, which prevented us from evaluating the impact of these different forms.

Implications of the findings

Restored and created wetlands remain appropriate and potentially sustainable ecological engineering approaches for removing nutrients from treated wastewater, lake and river water, and urban and agricultural runoff. The systematic review supports the view that created and restored wetlands are most efficient when they are placed where the inlet concentration of the nutrients is high and the hydraulic loading rate is reasonable low. However, we found that long-term efficiency has been poorly investigated, as have the effects of various management methods.

Free access to full report

A more detailed summary of this review is available at the EviEM website (www.eviem.se/en). The full report on the review can also be downloaded there. The report has been published in the journal Environmental Evidence (www.environmentalevidencejournal.org).

What is a systematic review?

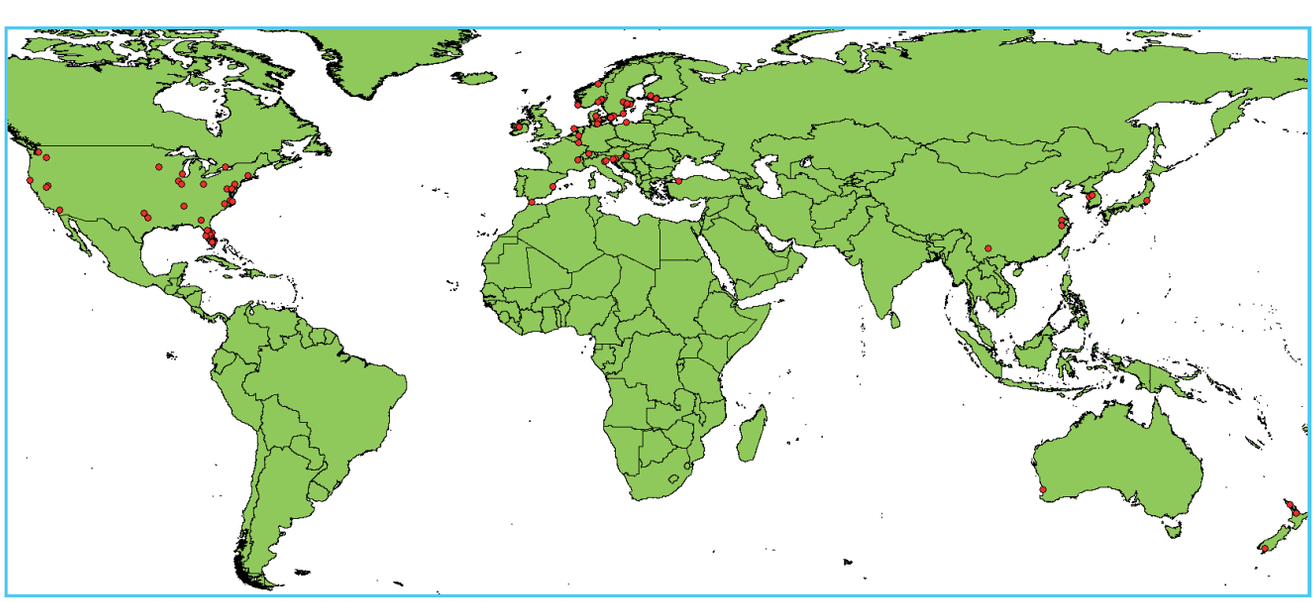
A systematic review is characterized by meticulous planning, methodical procedures and a transparent, complete documentation of all assessments carried out in the course of the work. This approach is designed to avoid bias and increase reliability and repeatability.

How this review was conducted

This systematic review was initiated and financed by the Mistra Council for Evidence-Based Environmental Management (EviEM). The review was conducted as a project by a specially appointed team of researchers chaired by Wilhelm Granéli, professor emeritus of aquatic ecology at Lund University in Sweden. The project was managed by Magnus Land, EviEM.

EviEM

The Mistra Council for Evidence-Based Environmental Management (EviEM) strives to ensure that environmental management in Sweden is informed by the best possible scientific evidence. Through systematic reviews of relevant research, we aim to improve the basis for decisions in environmental policy. EviEM is funded by the Swedish Foundation for Strategic Environmental Research (Mistra) and hosted by Stockholm Environment Institute (SEI). It is financially and politically independent.



Location of included wetland studies (indicated by red solid circles).

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