Landscape features

Impact: Nutrient leaching_run-off

Reference 19

Land, M; Graneli, W; Grimvall, A; Hoffmann, CC; Mitsch, WJ; Tonderski, KS; Verhoeven, JTA 2016 How effective are created or restored freshwater wetlands for nitrogen and phosphorus removal? A systematic review ENVIRONMENTAL EVIDENCE, 5, 9. 10.1186/s13750-016-0060-0

Background and objective

A widely used method to reduce the input of nutrients to freshwater and marine environments is to allow water to pass through a created or restored wetland. However, the large variation in measured nutrient removal rates in such wetlands calls for a systematic review. The objective of this review is to quantify observed removal rates of nutrients (nitrogen and phosphorus) in created or restored wetlands, and to examine the distribution of these rates and quantify the variation between different studies.

Search strategy and selection criteria

Searches for literature were made in ISI web of science, Georef and geobase, Scopus, Agricola, ASFA, Academic search, Biological abstracts, Wiley online library, directory of open access journals and ScienceDirect. No particular time, document type or language constraints were applied. Grey literature was searched for using the search engine Google where simplified search strings were used. In addition, the websites of relevant specialist organisations were also searched. Generally, the first 100 hits were examined in the searches using Google and on specialist websites. 1) Relevant study: secondary or tertiary treated domestic wastewater, urban storm water, stream/river water, freshwater aquaculture effluents, and runoff from agricultural fields were considered in the study. Untreated wastewater was not considered since it is not permissible to discharge such water into the environment in most European countries. Industrial or agricultural wastewater can vary considerably in composition, and was therefore also excluded. Farmyard runoff was in most cases classified as agricultural wastewater, and thus excluded, since it is often mixed with untreated parlour washings and silage/farmyard manure effluents, among other things; 2) Types of intervention: creation or restoration of wetlands; 3) The comparator has to be no intervention (inlet conditions can serve as control); 4) Types of outcome: included outcomes are mass removal of total nitrogen (TN) or total phosphorus (TP) from the water body per unit wetland area and year. Removal efficiency of TN or TP (% of load); 5) To be included in the review, it is a prerequisite that the wetland is established in field conditions and exposed to the ambient climate. This means that laboratory and greenhouse studies were excluded and that each study must cover at least one complete annual cycle; 6) In order to reflect realistic conditions the wetland must be of a reasonable size. While typical microcosm studies were excluded, mesocosm studies were included since they potentially provide valuable information on the variability of the outcomes based on true replicates. A cut-off wetland size of 1 m2 was applied; 7) Climate: studies conducted in snow climates, warm temperate climates, and equatorial climates with one dry season were included; 8) To be included the studies must have taken all removal processes into account.

Data and analysis

The studies with true or temporal replication (n = 39) were subjected to meta-analyses, using random effects models. To examine how the removal of nitrogen of phosphorus was influenced by effect modifiers (hydraulic loading rate, concentrations of nitrogen and phosphorus in the inflow to the wetlands, type of wetland, type of inflow, climate zone, average air temperature, and wetland area) all included studies (n = 93) were subjected to

meta-regression by response surface analyses various regression models. Publication bias was analysed (in the present case publication bias was not considered as a major concern).

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
93	Croplands	Outflow load	Inflow load	Metric: Total nitrogen (TN); total phosphorus (TP); Effect size: Logarithm of ratio of the considered metrics in the intervention to the considered metrics in the control	94%

Results

- The overall average summary effect represents a median TP removal ratio (R) of about 0.54, which can be recalculated to a median TP removal efficiency of 46 %, with a 95 % confidence interval of 37 to 55 %.
- The removal efficiency of total phosphorus was correlated with total phosphorus concentrations at the inlet, hydraulic loading, wetland area, and air temperature. The total phosphorus removal rate was positively correlated with concentration at inlet and hydraulic loading rate. In contrast, the total phosphorus removal rate was negatively correlated with wetland area, especially for wetlands smaller than 2*10^4 m2.
- The overall average summary effect represents a median TN removal ratio (R) of about 0.63. This means that the median TN load reduction, or removal efficiency, is 37 %, with a 95 % confidence interval of 29 to 44 %.
- Removal efficiency of total nitrogen in wetlands was positively correlated with average annual air temperature and negatively correlated with hydraulic loading rate. The model fit was better if interaction effects between these variables were allowed. The total nitrogen removal rate was positively correlated with the inflow concentration and was also found to be positively correlated with hydraulic loading.
- NA

Factors influencing effect sizes

- Temperature : Higher removal efficiency of Tpand TN when temperature increases.
- Hydraulic loading rate : Positive correlation between removal efficiency of TP in wetlands and hydraulic loading rate but lower removal efficiency of TN in wetlands when hydraulic loading rate increases.
- Wetland area : The TP and removal rates were negatively correlated with wetland area.

Conclusion

Restored and created wetlands remain appropriate and potentially sustainable ecological engineering approaches for removing nutrients from treated wastewater and urban and agricultural runoff.