Landscape features

Impact: Nutrient leaching_run-off

Reference 14

Valkama, E; Usva, K; Saarinen, M; Uusi-Kamppa, J 2019 A meta-analysis on nitrogen retention by buffer zones JOURNAL OF ENVIRONMENTAL QUALITY, 48(2), 270-279. 10.2134/jeq2018.03.0120

Background and objective

Buffer zones, established between agricultural fields and water bodies, are widely used as a measure to reduce N in surface runoff and groundwater. However, the literature indicates inconsistent results on the N removal efficiency of buffer zones between studies. The present study aimed to summarize global studies on the retention of NO3–N and the total N in surface runoff and in groundwater by using a meta-analysis. The authors examined the source of variation in retention capacity, such as the design and duration of experiments, as well as the metrics of outcomes (concentrations and loads), N forms, climates and locations, sources of pollution, the N concentrations entering the buffer zones, soil texture, buffer zone vegetation and species number, as well as the buffer zone slope and width.

Search strategy and selection criteria

The authors found the articles by searching for keywords “buffer zones” or “buffer strips or “filter strips” or “vegetative strips” or “riparian forest buffers” or “riparian zones” or “vegetated buffer strips” ” AND “nitrate” or “NO3–N” or “nitrogen” or “nitrogen leaching” or “nitrate leaching” in the Web of Science Database, in addition to Scopus, and ScienceDirect. They also found journal articles in the reference lists of previously published articles.

1. The study was conducted in the field concerning natural or artificial runoff; 2) The sources of pollution were agricultural fields for grass or cereal production, natural pasture or feedlots; 3) The study had an appropriate control group without buffer zone: (a) control plots in surface runoff studies, which were generally arranged in randomized block design; (b) field edge (above buffer zone) in groundwater monitoring assessment along a vegetation transect; (c) control waterways in a paired watershed comparison studies (monitored in both surface and groundwater studies); 4) The buffer zone was nonfertilized; 5) The study assessed the buffer zone effects on NO3–N or the total N in the surface runoff or on NO3– N in the groundwater; 6) The NO3–N or total N were recorded as either original data for each experimental year, or as a sample or replicate, or as means of treatment (i.e., with a buffer zone) and control (i.e., with no buffer zone) with SDs and sample sizes.

Data and analysis

Authors used MetaWin 2.0 statistical software to carry out the meta-analysis. A random effects model served to combine estimates across the studies, assuming that studies in each subgroup do not share the same effect size. They used a bootstrap statistical method to generate bias-corrected 95% CIs around the logarithm of the effect size from 4999 iterations.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
46	Field studies where water run-off comes from agricultural fields for grass or cereal production, natural pasture or feedlots	Buffer zone	No buffer zone	Metric: Nitrate-N surface run-off, Total-N surface run-off, Nitrate-N groundwater; Effect size: Logarithm of ratio of the considered metrics in the intervention to the considered metrics in the control	75%

Results

- The summarized effect of buffer zones was a 33% reduction in NO3–N (95% CI = −48 to −17%, n = 25) and a 57% reduction in total N (95% CI = −68 to −43%, n = 16).
- A summarized effect of a 70% (95% CI = −78 to −62%, n = 38) reduction compared with controls with no buffer zones was observed for NO3-N in groundwater.
- A meta-regression indicated that the N retention by the buffer zone from surface runoff and groundwater increased with increasing N concentrations entering the buffer zone from the source of pollution.
- No buffer zone impact was found for the fields used for grass production, probably due to their initially low levels of pollution; however, double N retention was observed for fields used for cereal production and feedlots, which also had higher levels of pollution. In contrast, buffer zones improved groundwater quality to the same extent regardless of the source of pollution; moreover, concerning the same source of pollution, the groundwater quality clearly benefited more from buffer zones than the surface runoff.
- NA

Factors influencing effect sizes

- Duration of treatment : According to a meta-regression, the buffer zone efficiency in reducing NO3–N and the total N in surface runoff decreased with increasing buffer zone age.
- NA : NA
- NA : NA

Conclusion

Buffer zones more effectively reduced N in groundwater than in surface runoff, despite the large variation of results across the studies.