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Nutrient pressures and legacies in a small agricultural karst catchment

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Catchments with short subsurface hydrologic time lags are commonly at risk for leached losses of nitrogen (N) and phosphorus (P). Such catchments are suitable for testing the efficacy of mitigation measures as management changes. In some sites, however, N and P may be retained in the soil and subsoil layers, and then leached, mobilised or attenuated over time. This biogeochemical time lag may therefore have enduring effects on the water quality. The aim of this study was to improve the understanding of N and P retention, attenuation and distribution of subsurface pathway in an intensively managed agricultural karst catchment with an oxidised aquifer setting, and also to inform how similar sites can be managed in the future.

Results showed that in the years pre-2000 slurry from an on-site integrated pig production unit had been applied at rates of 33 t/ha annually, which supplied approximately 136 kg/ha total N and approximately 26 kg/ha total P annually. This practice contributed to large quantities of N (total N and NH4-N) and elevated soil test P (Morgan extractable P), present to a depth of 1 m. This store was augmented by recent surpluses of 263 kg N/ha, with leached N to groundwater of 82.5 kg N/ha and only 2.5 kg N/ha denitrified in the aquifer thereafter. Sub hourly spring data showed the largest proportion of N loss from small (54-88%) and medium fissure pathways (7- 21%) with longer hydrologic time lags, with smallest loads from either large fissure (1-13%) or conduit (1-10%) pathways with short hydrologic time lags (reaction time at the spring from onset of a rainfall event is within hours). Although soils were saturated in P and in mobile forms to 0.5 m, dissolved reactive P concentrations in groundwater remained low due to Ca and Mg limestone chemistry. Under these conditions a depletion of the legacy store, with no further inputs, would take approximately 50 years and with NO_3-N concentrations in the source area dropping to levels that could sustain groundwater NO_3-N concentrations below admissible levels within 9 years.

Biogeochemical time lags (decades) are longer than hydrologic time lags on this site (months to years). Future management should target farm surpluses that maintain a legacy store at or below a soil organic N mass of ca. 20 kg N/ha. Incorporation of biogeochemical and hydrologic time lag principles into future water quality regulations will provide regulators with realistic expectations when implementing policies.