Has the hydro(geo)logy changed after drainage in restored lowlands?

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Many countries aspire to expand the amount of restored carbon-rich lowlands, as part of their efforts to reduce greenhouse gas emissions, while also promoting desired ecosystem services. The practise has received increasing attention, yet there is limited information available on how restored agricultural fields' hydro(geo)logical and hydrogeochemical functioning has changed due to previous drainage and nutrient load, and in turn, how that could influence the intended outcomes. To decrease the knowledge gap, we have sampled precipitation, surface waters, shallow (<1 mbgl) groundwater from 61 wells, and deep (4-8 mbgl) groundwater from 10 wells in 12 riparian wetlands in Denmark, during one year. Six of the sampling sites are restored, while the other six sites are near-natural. They have also been classified based on management (grazed or ungrazed). The wetlands are located along three separate stream valleys, with subsurface geologies consisting of carbonate rock, glacial till or glacial outwash sand. Six sediment cores of the top 30 cm soil were collected from each wetland, 72 in total, and analyzed for organic and inorganic carbon content, mineral content and bulk density. Shallow groundwater of restored wetlands had strongly elevated concentrations of iron(II) (median 15.2 mg/L) and phosphate (median 1.8 mg/L), compared to their near-natural counterparts (medians 0.1 and 0.1 mg/L, respectively), despite the fact that restoration took place 13-18 years ago. In comparison to the near-natural sites, the restored sites displayed lower dissolved oxygen concentrations, along with enriched mean and range of water δ^2H- and δ^{18}O-values that indicated younger water ages. The combined oxygen depletion and isotopic indication of younger water suggest that restored sites have abundant reactive organic carbon, while near-natural sites are limitied in reactive organic carbon. Furthermore, analysis of the sediment cores shows that restored sites have a higher bulk density (mean 1.3 g/cm^3), and lower soil organic carbon content (mean 14%) than near-natural sites (means 0.7 g/cm^3 and 33%, respectively). This indicates that both physical (compaction) and chemical (peat degradation) processes during previous drainage have caused long-term changes to the wetlands' soil properties, and thus, the hydrological conditions. With changing climate, wetland areas will probably increase in the landscape. This study aims to increase the knowledge of wetlands' response to past drainage and nutrient loading, and thereby facilitate the increased success of on-going and future restoration programs.