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Historical Irrigated Meadows at the River Queich, Rhineland-Palatinate

Martin Alt[1], Constanze Buhk[2], Dörte Diehl[1], Rebekka Gerlach[2,3], Isabell Rudolph[2,4], Jens Schirmel[4], Kathrin Theissinger[5], Gabriele E. Schaumann[1]

1 Summary

For centuries the meadows at the river Queich in southern Rhineland-Palatinate were irrigated to enhance the quantity and quality of hay. With the introduction of fertilizers irrigation was stopped in most areas but partly reactivated within the last few years. Today we find a small-scaled mosaic of (non-) irrigated and (un-) fertilized meadows. The Institute for Environmental Sciences Landau at the University of Koblenz - Landau conducts interdisciplinary research on the meadows to investigate the effects of irrigation and the interactions between the involved terrestrial and aquatic systems.

Keywords: meadows; irrigation; soil; biodiversity; Rhineland Palatinate; interdisciplinary research; environmental sciences

Institute for Environmental Sciences Landau, University of Koblenz-Landau. Working groups:
[1] Environmental & Soil Chemistry
[2] Geoecology & Physical Geography
[3] Environmental Economics
[4] Ecosystem Analysis
[5] Ecotoxicology & Environment

2 Background & Location

The river Queich originates in the Palatinate Forest in southern Rhineland-Palatinate. When entering the plain of the Upper Rhine Valley the sediments of the river build an alluvial fan. For centuries this area has been used for extensive hay production.

To improve the yield in the medieval times farmers have installed an irrigation system that floods the meadows after retaining water of the Queich by hand-operated weirs (figure 1).

Figure 1: Swollen weir on an irrigation day near Landau.

Following a strictly regulated schedule, the irrigation events were conducted each spring and each summer. In spring (April & May), the water added nutrients and extended the growing season in warming the soil, while in summer (July & August), the dry soil was rewetted and water supply was increased. The additional water furthermore enhanced mineralization of the organic material by soil biota. Groundwater level was lifted and nutrients were thought to increase neutralization capacity of soils.

In the 1950s, the meadows lost importance because of the decline of animal husbandry. In addition, the introduction of fertilizers superseded the high-maintenance of the manually regulated irrigation system. Only one village has constantly been irrigating its meadows until today.

Within the last ten years, further villages have reclaimed their tradition and started to reactivate their irrigation systems.

Because of the division of estates the lots of land are very small and therefore differ in their management. This is most evident in the frequency and date of mowing, and the application of fertilizers. Additionally to the management, the fixed irrigation schedule, that allows a certain number of irrigation days for each village, lead to a heterogeneous and small scaled mosaic of land use on the meadows.

3 Research questions

In an interdisciplinary research initiative, the Institute for Environmental Sciences Landau of the University of Koblenz-Landau investigates interactions between the aquatic and terrestrial systems on the meadows with a main focus on effects of irrigation on ecosystem services (figure 2).

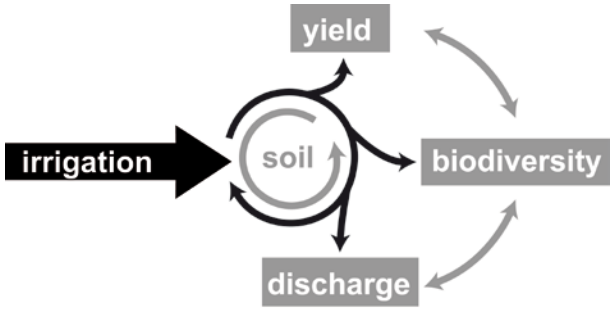

Figure 2: Relations between irrigation practices and ecosystem functions

In three research groups the following subjects are regarded: I) soil, pollutants and greenhouse gases; II) diversity of flora & fauna, genetics and economy; III) aquatic organisms and food webs.

4 First results

Preliminary studies showed differences between irrigated and non-irrigated meadows in terms of chemical soil characteristics, soil organism and microbial activity, and aboveground plant and animal compositions.

On irrigated meadows, lower concentrations of heavy metals, higher pH values and cation exchange capacity were detected, as well as higher water content. Rewetting was significantly better in irrigated than in non-irrigated meadows. In the topsoil (0 – 20 cm), microbial activity (N_{mic}, C_{mic}) was significantly higher in irrigated than in non-irrigated meadows. In deeper horizons (20 – 30 cm, 30 – 40 cm) activity was reduced and balanced (figure 3).

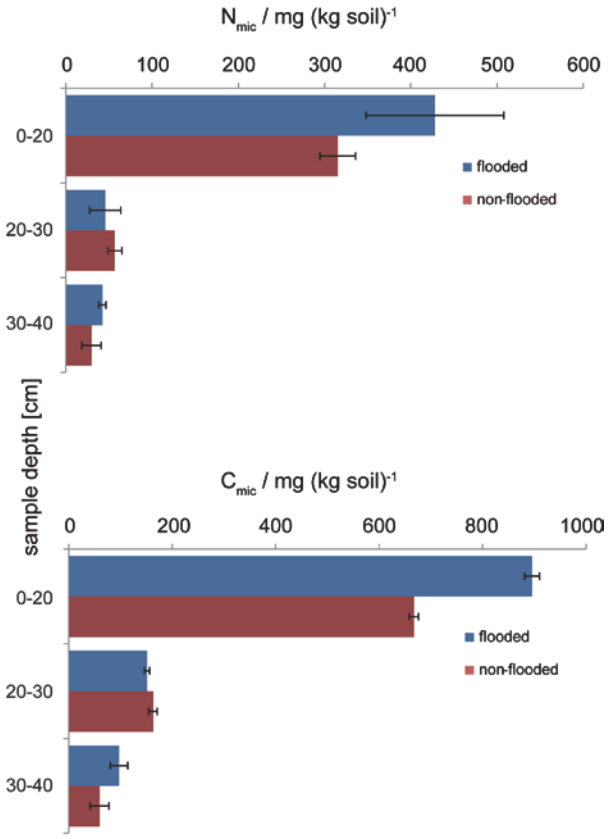

Figure 3: Microbial biomass N and C under the influence of irrigation on the meadows.

Exposition of bait lamina strips to estimate soil organism activity 14 days after irrigation demonstrates higher feeding activity at irrigated versus non-irrigated meadows (figure 4). The extremely low value at the fertilized non-irrigated meadow is probably due to strong compaction of the soil at this specific meadow.

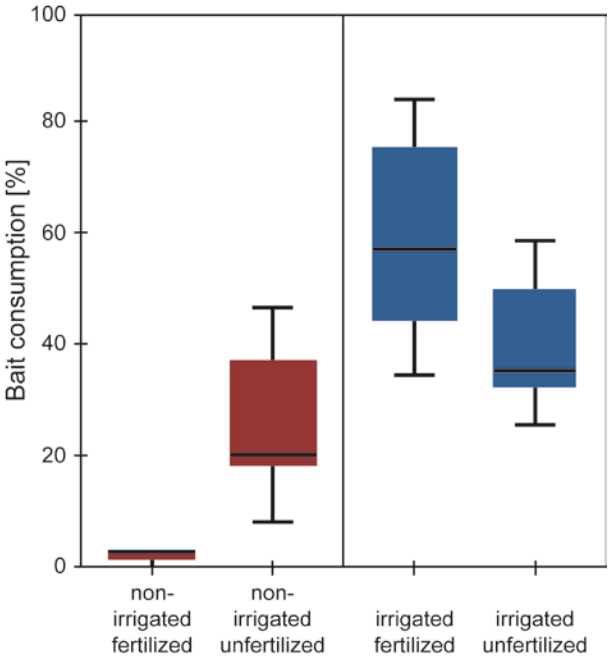

Figure 4: Food activity determined by bait test under the influence of irrigation and fertilization on the meadows.

Litter bags exposed on meadows covering different combinations of irrigation and fertilization indicated a positive impact of irrigation on abundance of soil macro- and mesofauna as well as a trend to higher litter decomposition on irrigated versus non-irrigated meadows.

A plant survey revealed a significant effect of irrigation on plant species and functional composition. On the functional scale a significantly higher cover of leguminous species in irrigated meadows was recorded (figure 5).

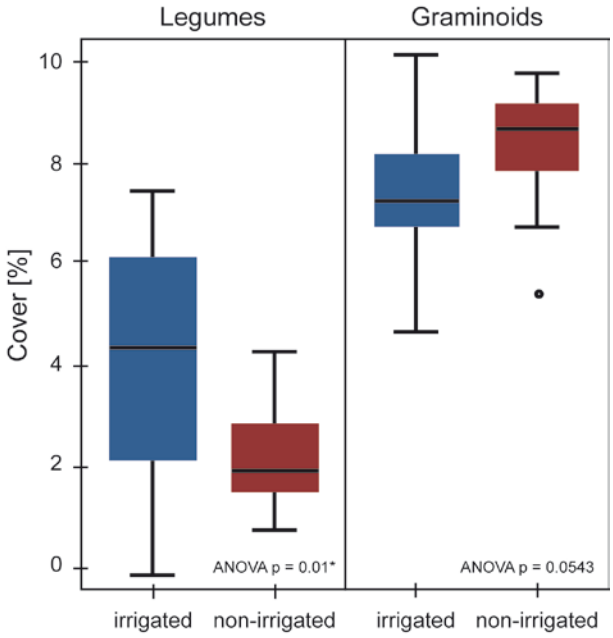

Figure 5: A plant survey showed a significant higher cover of legumes on irrigated meadows.

First faunal analyses showed that earth worm abundances were positively correlated with increasing days of irrigation. Irrigation also had a significant effect on species compositions of grasshoppers, ground beetles, and spiders. Endangered species (e.g. the grasshoppers *Stetophyma grossum* and *Mecostethus parapleurus*) were favored by irrigation (figure 6).

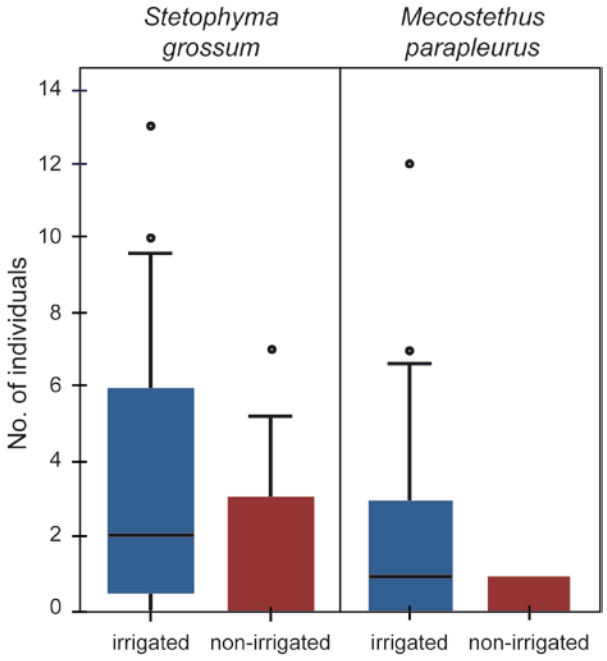

Figure 6: The occurrence of the endangered grasshoppers Stetophyma grossum and Mecostethus parapleurus is significant on irrigated meadows.

5 Outlook

The observed differences in microbial and chemical soil characteristics hint on an influence of irrigation practice on the composition of the microbial community and activity with further effects on chemical and physico-chemical properties of soil organic matter (SOM). Therefore, further research will focus on functional groups of the microbial community by analysis of phospholipid fatty acid (PLFA) and potential relations to chemical and physico-chemical SOM properties, like the amount of labile and stable carbon fractions, or surface properties, e.g., wettability.

Plant functional composition has been shown to be a great determinant for several ecosystem processes. Hence, further studies will investigate the consequences of this long-term effect on short-term effects of irrigation affecting nutrient dynamics at the soil-atmosphere interface.

A new project financed by the Deutsche Bundesstiftung Umwelt will deal with the question if irrigation can reduce or even substitute fertilization of meadows to enhance biodiversity but without the farmer's risk of cuts in hay yield.

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