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The recovery of ecologically and chemically impaired tributaries in the Podyí/Thayatal National Park

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Abstract

The Fugnitz and Kajabach brooks enter the Podyjí/Thayatal National Park loaded with impacts from upstream reaches. In the Fugnitz brook fine sediments and bacteria from manured fields are washed in during rainfall, leading to a deterioration of habitats for aquatic invertebrates.

In the Kajabach brook with its more densely forested catchment area pressures are caused by fish ponds that alter the substrate conditions and release littoral species into lotic habitats. However, within the National Park the chemical and ecological situation improves markedly in both watercourses.

Keywords

tributaries, land use, bacteria, benthic invertebrates, precipitation

Introduction

On the Austrian side of the Podyjí/Thayatal National Park two major tributaries flow into the River Thaya, the comparably large Fugnitz brook (with a catchment area of 138 km²) and the much smaller Kajabach brook (with a catchment area of only 20 km²). The aforementioned runs through intensively used farmland and lacks larger areas of woodland, whereas large fishponds alter the ecological system of the latter. Due to the massive fine sediment loads that enter the River Thaya via the Fugnitz brook and heavily affect the aquatic coenoses there, a preliminary study on the fluvial morphology of the river and its tributary was carried out (PÖPPL 2010), clearly identifying several hot spots for land erosion along the Fugnitz brook. In a further step, the present biological survey was conducted, dealing with the impact of the eroded material on water chemistry, microbiology, and benthic invertebrates, as well as on the ecological status according to the EU water framework directive.

Methods

A total of seven sites was surveyed. In the Fugnitz brook four impaired sites were located in the upper reaches outside the National Park, in intensively used farmlands, in the vicinity of erosion hot spots, large fish ponds or impoundments, respectively (Fugnitz 1 – Fugnitz 4), whereas one as unimpaired a reference site as possible was chosen within the borders of the National Park near the mouth (Fugnitz 5). In the Kajabach brook an impaired site outside the National Park (Kajabach 1) was situated directly below the outlet of a large fish pond, created by impounding the stream, and an unimpaired reference site (Kajabach 2) was studied within the National Park, right below the mouth of a major tributary. In each sampling site benthic invertebrates were collected according to the Multi Habitat Sampling method (MOOG 2004) during aestival low flow conditions. Water chemistry and microbiology was evaluated at three dates, (1) following constant low flow conditions in summer, (2) at the peak of a sudden thunderstorm-induced flood event, and (3) during a receding flood event caused by a continuous rainfall for several days in a row. Water samples were taken and analysed at the laboratory of the Institute for Water Analyses (IWA) of the Linz AG (Asten, Austria).

Results

Water chemistry. (1) During aestival low water conditions all nitrogen parameters (nitrate, nitrite and ammonium) showed a continuous increase along the Fugnitz brook from Fugnitz 1 to Fugnitz 4; in the reference site Fugnitz 5 within the protected area they dropped markedly, reaching concentrations even lower than near the source. The same pattern was found with electric conductivity and sulphate. (2) The thunderstorm-induced peak discharge led to a massive increase in filterable substances and in organic matter in all five sites in the Fugnitz brook. Electric conductivity decreased in the four sites outside the National Park, when it remained more or less unchanged in the reference site Fugnitz 5. Dissolved organic carbon increased in the four impaired sites but remained stable within the National Park. (3) After a long and continuous rainfall filterable substances decreased in all five sites, reaching concentrations lower than during low water conditions. The same is true for organic substances. While in the four impaired sites chloride, sulphate, calcium, magnesium, carbonates and electric conductivity increased by far when compared to the situation after the sudden thunderstorm, the opposite was true for the site in the National Park.

Microbiology

1. Even during low flow conditions germ numbers were high for natural watercourse standards in both brooks; in the Fugnitz brook coliform bacteria densities ranged from 110 to 470 germs per 100 ml, the lowest concentrations occurring within the National Park. This is also true for the Kajabach brook where 275 bacteria per 100 ml outside and 150 germs per 100 ml within the National Park were detected.
2. During the thunderstorm-induced flood germ contamination increased abruptly and massively in all sampling sites in the Fugnitz brook with coliform bacteria densities continuously rising along the continuum, starting at 101,000 germs per 100 ml in the site nearest to the source and reaching more than 201,000 germs per 100 ml right outside the National Park. Within the National Park, however, a marked reduction was detected, nevertheless still reaching concentrations of 74,000 coliform bacteria per 100 ml. In the Kajabach brook the thunderstorm-induced flood led to a slight decrease of coliform bacteria in the pond outlet outside the National Park, but at the same time to a massive increase within the National Park.
3. After the peak discharge caused by a continuous multi-day rainfall, in the Fugnitz brook coliform bacteria were found in much lower concentrations than during the thunderstorm peak, but with densities still reaching from 14,500 to 20,100 germs per 100 ml. In the Kajabach brook the pattern was the reverse compared to the thunderstorm-induced peak; while there was an excessive increase of germs in the pond outlet, germ concentrations were markedly reduced in the reference site within the National Park.

Benthic invertebrates

Marked differences were detected in terms of the numbers of specimens per m² in the Fugnitz brook; densities ranged from only 500 to 4,200 invertebrates per m² in the four impaired sites outside the National Park, whereas they reached more than 6,900 within its borders. Biodiversity in terms of species numbers was highest in the National Park where 68 species were detected, whereas only 36, 42, 46 and 53 species, respectively, were found in the disturbed sites outside the protected area. Large differences were found with regard to species group compositions. In the site next to the most evident erosion hot spot the largest numbers of pea mussels, oligochaete worms and water lice were detected, whereas in the National Park those groups were largely absent and at the same time amphipod crustaceans reached their largest densities; as did caddisfly and mayfly larvae. Saprobic indices were found to rise continuously along the watercourse from an organically unimpaired 1.55 in the site next to the source to 2.12 at the erosion hot spot (clearly exceeding the natural state and thereby indicating organic pollution) and even to 2.73 right outside the National Park. Within the National Park, however, the index dropped abruptly to 1.69, restoring an organically unimpaired status. As for functional feeding groups, the composition proved natural or near natural in the two sites nearest to the source, but deviated markedly from natural conditions downstream of the erosion hot spot; in the National Park, the composition was found to be restored to natural. In all four sites outside the nature reserve there is need for action when the ecological status according to the EU water framework directive is concerned, with benthic invertebrate communities indicating either a moderate or even a poor ecological status. Only in the National Park a good ecological status was proven.
In the Kajabach brook invertebrate densities were similarly high in both sites, but species numbers differed markedly; in the fish pond outlet there were only 39 species, the natural stretch in the National Park comprised 67 species. While pea mussels, oligochaete worms and water lice were numerous in the impaired site, they almost lacked in the natural site where, on the other hand, mayflies, stoneflies and caddisflies reached much higher numbers than in the impaired site. In the stretch outside the National Park the saprobic index was 2.33, thus indicating organic pollution, within the National Park it was 1.61 and therefore organically unpolluted. While there is need for action in the site outside the National Park with a poor ecological status, a good ecological status could be proven within the National Park.

Conclusion

In the Fugnitz brook germ contamination was high at all times and in all sites. During low flow conditions coliform bacteria were represented by E. coli exclusively, clearly indicating recent manure fertilization in the catchment area as these intestinal bacteria hardly reproduce outside their hosts. The development of nitrogen parameters along the watercourse shows a constant increase from the source to the borders of the National Park, resulting from the intensive land use; in the National Park natural decomposition and reduced further input due to the densely forested catchment lead to a considerable reduction of nutrients.

Need for action was proven in all four sites in the Fugnitz brook outside the National Park, for different reasons – but the excessive input of fine sediments and the resulting siltation effects proved to be most relevant. In the morphologically intact site Fugnitz 1 near the source these siltation effects turned out to be responsible for missing the aim of a good ecological status; taxa dependent on high structure quality like mayflies, stoneflies or caddisflies were outnumbered by ten by indifferent dipteran species. A similar situation was detected in the massively impaired stretch Fugnitz 3 next to an erosion hotspot, where fine sediments cover the whole riverbed and drive away species with high demands. In site Fugnitz 5 within the National Park a considerable improvement was detected – the natural woodlands in the catchment result in a good ecological status, a markedly improved saprobic index, the lowest amount of coliform bacteria, the lowest nutrient concentration, the lowest increase of germs in the course of precipitation, or the lowest input of nitrite and ammonium during short and heavy rainfalls.

In the Kajabach brook, the differences between the two surveyed sites results mostly from a chain of three large fish ponds on the brook, resulting both in atypically high water temperatures and in large numbers of species typical for standing waters that have been washed into lotic stretches, partly replacing the typical fauna. Additionally, discharge is very low in this brook, hence its inability to take away accumulated fine sediments.

When within the National Park a significant tributary adds to the discharge, ameliorates the temperature regime and helps rinsing the natural substrate from fines, the ecological status improves markedly and abruptly.

The study showed that both watercourses suffer from various impacts, most of all from the intensive land use or water use, respectively. In both cases adverse effects on water chemistry, microbiology and benthic invertebrates – and eventually on the ecological status – were proven. Heavy rainfall onto open surfaces in the catchment lead to a distinct deterioration that could be mitigated in the natural landscapes of the National Park. This leads to the conclusion that a sustainable enhancement of the watercourses is only possible with considerable measures in the catchment area, e.g. by creating natural alluvial forests along the brooks to keep the amount of eroded material low.

References

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