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Effects of anthropogenic salinization on biological traits and community composition of stream macroinvertebrates

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HIGHLIGHTS

- Studied the effects of salinization on macroinvertebrate communities and biological traits.
- Community structure and biological traits were altered by salinization.
- The trait-based method performed better than the taxonomy-based method.
- Five traits were affected by salinization.
- Our results are similar to other studies from Europe indicating trait convergence.

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ABSTRACT

Salinization of rivers resulting from industrial discharge or road-deicing can adversely affect macroinvertebrates. Trait-based approaches are a promising tool in ecological monitoring and may perform better than taxonomy-based approaches. However only little is known how and which biological traits are affected by salinization. We investigated the effects of anthropogenic salinization on macroinvertebrate communities and biological traits in the Werra River, Germany and compared the taxonomic and trait response.

We found a change in macroinvertebrate community and trait composition. Communities at saline sites were characterized by the three exotic species *Gammarus tigrinus*, *Apocorophium lacustre* and *Potamopyrgus antipodarum*. The frequencies of trait modalities long life cycle duration, respiration by gill, ovoviviparity, shredder and multivoltinism were statistically significantly increased at saline sites.

The trait-based ordination resulted in a higher explained variance than the taxonomy-based ordination, indicating a better performance of the trait-based approach, resulting in a better discrimination between saline and non-saline sites. Our results are in general agreement with other studies from Europe, indicating a trait convergence for saline streams, being dominated by the traits ovoviviparity and multivoltinism. Three further traits (respiration by gill, life cycle duration and shredders) responded strongly to salinization, but this may primarily be attributed to the dominance of a single invasive species, *G. tigrinus*, at the saline sites in the Werra River.

1. Introduction

Salinization of rivers may result from a wide range of natural and anthropogenic processes. Examples of anthropogenic increases in salinity (also termed secondary salinization) include mine discharge as well as entry of road deicing agents into freshwater systems and their effects have been found worldwide (Cañedo-Argüelles et al., 2013). These effects comprise changes ranging from physiological responses (Kefford et al., 2011) to alterations in the freshwater communities with subsequent reductions in ecosystem functioning (Schäfer et al., 2012). The impact of secondary salinization is usually assessed by taxonomy-based methods, though extrapolation to other geographic regions is difficult due to different species pools (Statzner et al., 2005).

Trait-based approaches are a promising tool in ecological risk-assessment and bio-assessment of ecological quality. Unlike taxonomy-based methods, traits may not be constrained to biogeographic boundaries and respond in a similar fashion (Baird et al., 2011; Bonada et al., 2006). Trait-based methods have potential to disentangle the effects of multiple stressors that often co-occur in freshwater ecosystems (Statzner and Bêche, 2010; Wooster et al., 2012). Moreover, they may help to understand the mechanisms behind the observed response patterns and thus allow for prediction of ecological effects (Bonada et al., 2006).

Currently there is little information on how the biological trait composition of freshwater communities is affected by salinization. To our knowledge only three studies have been published comparing traits

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at different salinity levels: Piscart et al. (2006) (northeastern France, four sites along one river), Diaz et al. (2008) (southeastern Spain, 16 streams in a catchment with complex gradients) and Kefford et al. (2012a) (Victoria, South-East Australia, approximately 3000 sites across catchments).

We investigated the effects of anthropogenic salinization on macroinvertebrate communities and their biological traits in the River Werra (Germany), a river with a known history of secondary salinization and availability of long term biomonitoring data (Bäthe and Coring, 2011). We compared the performance of both taxonomy-based and trait-based approaches to explain changes in the macroinvertebrate community. The traits exhibiting the strongest responses to salinization were identified and compared to other studies. Based on the assumption that the salinization stress acts as a filter that removes biota with specific traits (Poff, 1997), we expected similar trait responses as in previous studies, consequently indicating trait convergence of larger spatial scales.

2. Methods

2.1. Study area and available data

The River Werra has been used as effluent sewer for the potash industry in Thuringia and Hessia since the mid of the 20th century and is highly impacted by salinization. It has been part of a monitoring project since 1993 and is well studied (Bäthe and Coring, 2011). Therefore, the River Werra is well suited to examine macroinvertebrate trait responses to salinization.

We analyze data from Bäthe and Coring (2011) in this study encompassing abundance data from 15 sampling sites along the river Werra with a total of 183 taxa. The sampling sites covered a downstream salinity gradient originating from a point source downstream of Merkers (see Figs. 1 and 2). Macroinvertebrates were sampled with a dredger from the bank according to the method of Tittizer and Schleuter (1986) on two or three seasonal sampling events per year.

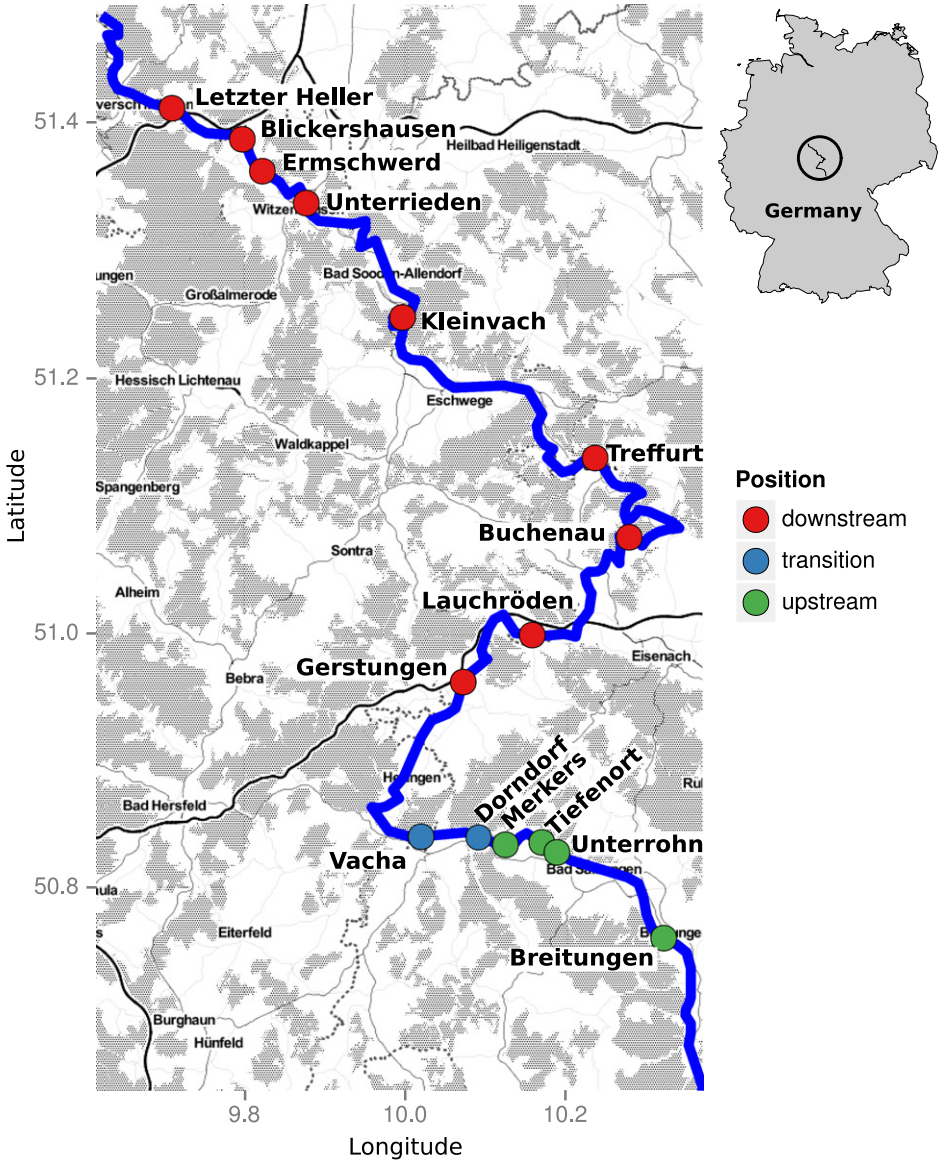

Fig. 1. Map of sampling sites. Salt brine is discharged downstream of Unterrohn. Sites were classified into up- and downstream of salt brine discharge. Sites 'Vacha' and 'Dorndorf' were classified as a transition zone. Map tiles by stamen.com, licensed under CC BY 3.0. Data by OpenStreetMap, licensed under CC BY SA. Small map shows the study area within Germany.