Impact of a toxic algal bloom on benthic invertebrates in the Oder River

Impact d'une prolifération algale toxique sur les invertébrés benthiques dans la rivière Oder

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RÉSUMÉ

Au cours de l'été 2022, la rivière Oder a connu une catastrophe écologique sans précédent, attribuée à la prolifération de l'algue toxique *Prymnesium parvum*. Cet événement a entraîné une mortalité massive dans de nombreux groupes aquatiques, notamment les poissons, les moules et les escargots, perturbant l'intégrité de l'écosystème sur une grande partie de la rivière. Dans le cadre du projet ODER~SO (www.oder-so.info/en), des recherches approfondies sont menées afin de quantifier les impacts de la catastrophe sur divers biotes, ainsi que leur régénération attendue. Dans ce cadre, nous examinons les conséquences de la prolifération d'algues sur les invertébrés benthiques.

Les résultats préliminaires indiquent des changements dans la composition de la communauté, avec un impact important sur les moules Unionidae. La faune d'invertébrés benthiques de la rivière Oder est généralement dominée par les crustacés et les diptères. Notre étude vise à contribuer à une meilleure compréhension de la résilience des écosystèmes fluviaux affectés par des facteurs de stress humains combinés.

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ABSTRACT

In the summer of 2022, the Oder River experienced an unprecedented ecological disaster, attributed to a bloom of the toxic alga *Prymnesium parvum*. This event led to massive mortality across multiple aquatic groups, most notably fish, mussels, and snails, disrupting ecosystem integrity over a large stretch of the river. Within the project ODER~SO (www.oder-so.info/en), comprehensive research is conducted aiming to quantify the impacts of the disaster on various biota, as well as their expected regeneration. As part of this, we examine the consequences of the algal bloom on benthic invertebrates.

Preliminary results indicate shifts in community composition, with a strong impact on Unionidae mussels. Benthic invertebrate fauna in the Oder River is generally dominated by Crustacea and Diptera. Our study aims to contribute to better understanding the resilience of river ecosystems affected by compounded human stressors.

KEYWORDS

Rivière de plaine| Lowland river, Invertébrés benthiques | Benthic Invertebrates, prolifération d'algues | algal bloom, Rivière Oder | Oder River, tuerie de masse | mass kill

1 IMPACT OF A TOXIC ALGAL BLOOM ON BENTHIC INVERTEBRATES IN THE ODER RIVER

1.1 Introduction

Many rivers are impacted by multiple anthropogenic activities, and are now additionally affected by climate change. The Oder River at the border between Germany and Poland has been modified hydromophologically by impoundments in its upper course (Köhler et al., 2024) and groynes in its lower section (Sługocki & Czerniawski, 2023). Water quality in the Oder River basin is impacted by salt pollution (Sługocki & Czerniawski, 2023; Köhler et al., 2024; Krodkiewska et al., 2022; Sobieraj & Metelski, 2023) and high nutrient levels (Köhler et al., 2024; Krodkiewska et al., 2022). However, its largely free-flowing middle and lower sections (Köhler et al., 2024; Starck & Wolter, 2024) and a large protected area, the floodplain national park « Unteres Odertal », may still provide valuable habitat for riverine and floodplain biota.

Compound human impacts, including salt pollution and nutrient loading, have culminated in a toxic *Prymnesium parvum* bloom in 2022 (Köhler et al., 2024; Starck & Wolter, 2024). *Prymnesium parvum* is an alga with records of mass developments in brackish waters (Edvardsen & Paasche, 1998) that is able to produce prymnesin toxins that affect gill breathing organisms (Sobieraj & Metelski, 2023). Hence the toxic bloom on the Oder River in 2022 has caused a mass mortality among fish, mussels and snails (Köhler et al., 2024).

Over 500 km of the river were affected (Szlauer-Łukaszewska et al., 2024), with estimated losses of 1000-1650 tons of fish biomass (Starck & Wolter, 2024; Szlauer-Łukaszewska et al., 2024; Köhler et al., 2024) and about an 80-90% decline of Unionidae mussels and gill-breathing snails in the lower section (Szlauer-Łukaszewska et al., 2024). The event has also triggered secondary effects like hypoxia (Sługocki & Czerniawski, 2023), that has likely exacerbated the ecological damage in the most downstream region (Siwek & Podlasińska, 2023).

Within the project ODER~SO (www.oder-so.info/en), comprehensive research is conducted aiming to quantify the impacts of the disaster on various biota, as well as their expected regeneration. This study investigates the consequences of the catastrophe on benthic invertebrates diversity, abundance and community composition. By comparing post-catastrophe data with external pre-event-datasets, we aim to assess the immediate impacts and potential recovery of these communities. With our findings we aim to contribute to a better understanding of river ecosystem resilience in the face of compound human and natural stressors, offering insights for a more integrative river management and conservation planning.

1.2 Methods

Field work was carried out along the German river bank of the Oder River in Brandenburg, where 13 sites were chosen for benthic invertebrates sampling that started in November 2022 (Fig. 1). Mussels were mapped in groynes fields, starting in summer 2024.

For mussel mapping, in each chosen groyne field an area of 10 m^2 was sampled by dragging a net (mesh size of 3x4 mm) several times through the bottom substrate until no more mussels were found in the net. Species and age of Unionid species and *Corbicula* sp. were determined, and the presence of *Dreissena* sp. was recorded.

For other benthic invertebrates sampling, kick-net samples (net width 25 cm diameter, mesh size 500 µm) were taken from various meso-habitats in the wadable area of each sampling site. From stones and dead wood, invertebrates were retrieved by brushing into a net. All the obtained material, except already in the field identified individuals, were stored in ethanol.

Each sampling trip, between 2 and 6 mesohabitat-samples were taken from each site. Each sample represents an area of 0.25, 0.5, 1 or 2 m^2. In sum, the total sampled area of each site was between 1 and 5 m^2 at each sampling trip.

Taxa were validated, by e.g. using freshwaterecology.info (Schmidt-Kloiber & Hering, 2015) or the german federal taxonomic list of aquatic organisms (Schilling, 2020). Statistical analyses were performed using RStudio (R Core Team, 2023).

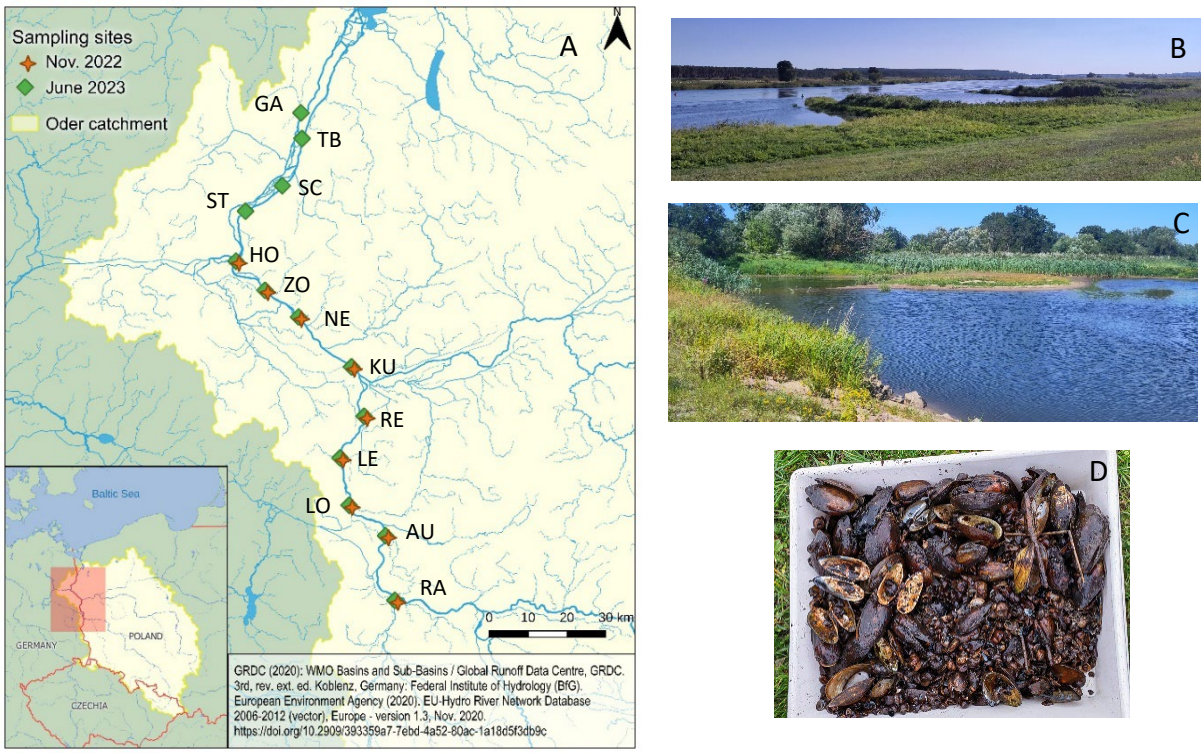

Fig. 1: A: Locations of benthic invertebrates sampling sites along the Oder River. B: Groynes near Stützkow (ST). C: Sampling site at Aurith (AU). D: Shells from dead mussels and snails collected three months after the catastrophe, Photo: M. Pusch

1.3 Results and Discussion

The analysis of samples collected in November 2022, a few months after the catastrophic algal bloom, revealed that benthic invertebrate communities were predominantly composed of Crustacea (mainly Gammaridae Gen. sp.), Gastropoda (mainly *Potamopyrgus antipodarum*), and Diptera (mainly Chironomidae Gen. sp.) (Fig 2.). The general numerical dominance of these groups across the surveyed sites in November 2022 suggests their potential role as pioneer species during recovery or might reflect potential resilience and adaptability to altered environmental conditions. In June 2023 the fauna was dominated by Crustacea and Diptera, with abundances being much higher than in November 2022. Thereby, the abundance of individuals varied considerably among sampling sites, likely influenced by habitat diversity.

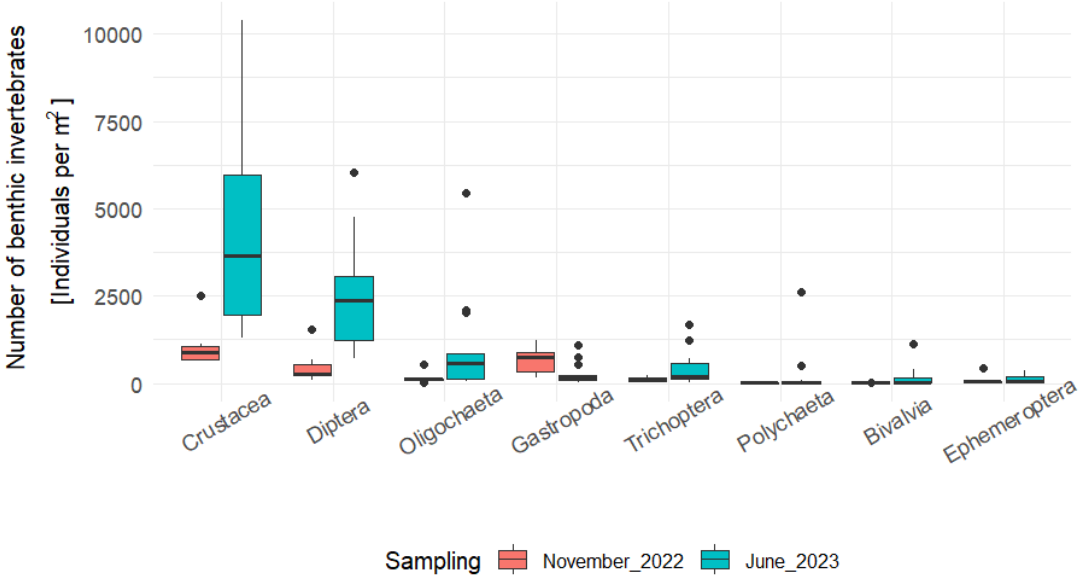

Fig. 2: Benthic invertebrates density of the most abundant groups for November 2022 and June 2023. Boxplots represent the mean numbers of the sampling sites, which was calculated as the mean of the different sampled habitats at each site.

In November 2022 the Gastropoda fauna was clearly dominated by Hydrobiidae and Physidae, whereas in June 2023 the Gastropoda fauna was more evenly distributed among the five most abundant families. The percentage of *Viviparus* sp.—a genus heavily impacted by the catastrophe (Szlauer-Łukaszewska et al., 2024)— increased from November 2022 to June 2023, while the species was however only found at three out of nine sites in November 2022, and 3 out of 13 sites in June 2023.

Table 1: Composition of Gastropoda families in November 2022 and June 2023 (as average percentage across all sampling sites). Gastropoda individuals which were not identified further than class Gastropoda were excluded before calculating the percentage. The proportions of the families Planorbidae, Acroloxidae and Ellobidae was less than 1% at each sampling trip and are not shown in the table.

	Percentage [%] of total Gastropoda	
Family	November 2022	June 2023
Hydrobiidae	71.0	24.5
Physidae	21.7	16.9
Lymnaeidae	3.4	19.9
Ancylidae	0.1	15.0
Bithyniidae	0.7	14.8
Viviparidae	0.3	5.9
Valvatidae	1.2	2.0
Ferrissiidae	1.3	0.7

In general, mussel mapping in groyne fields revealed a drastic reduction in Unionidae populations by the Oder catastrophe. Depending on the level of exposure, contact with the alga toxins was fatal to a large fraction of Unionidae species. Differences in the age structure of the populations are obvious, as more juvenile age stages were killed during the disaster. Overall, the total mussel density today remains far below the level before the disaster.

The results demonstrate that the toxic algal bloom in the Oder River in August 2022 has profoundly disrupted benthic invertebrate communities in the Oder River, with some taxa showing resilience, while others experiencing prolonged declines. These findings contribute valuable insights into the impacts and resilience of river ecosystems affected by anthropogenic and natural stressors.

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