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FACT SHEET

State of knowledge on the toxic alga *Prymnesium parvum* in the Oder River

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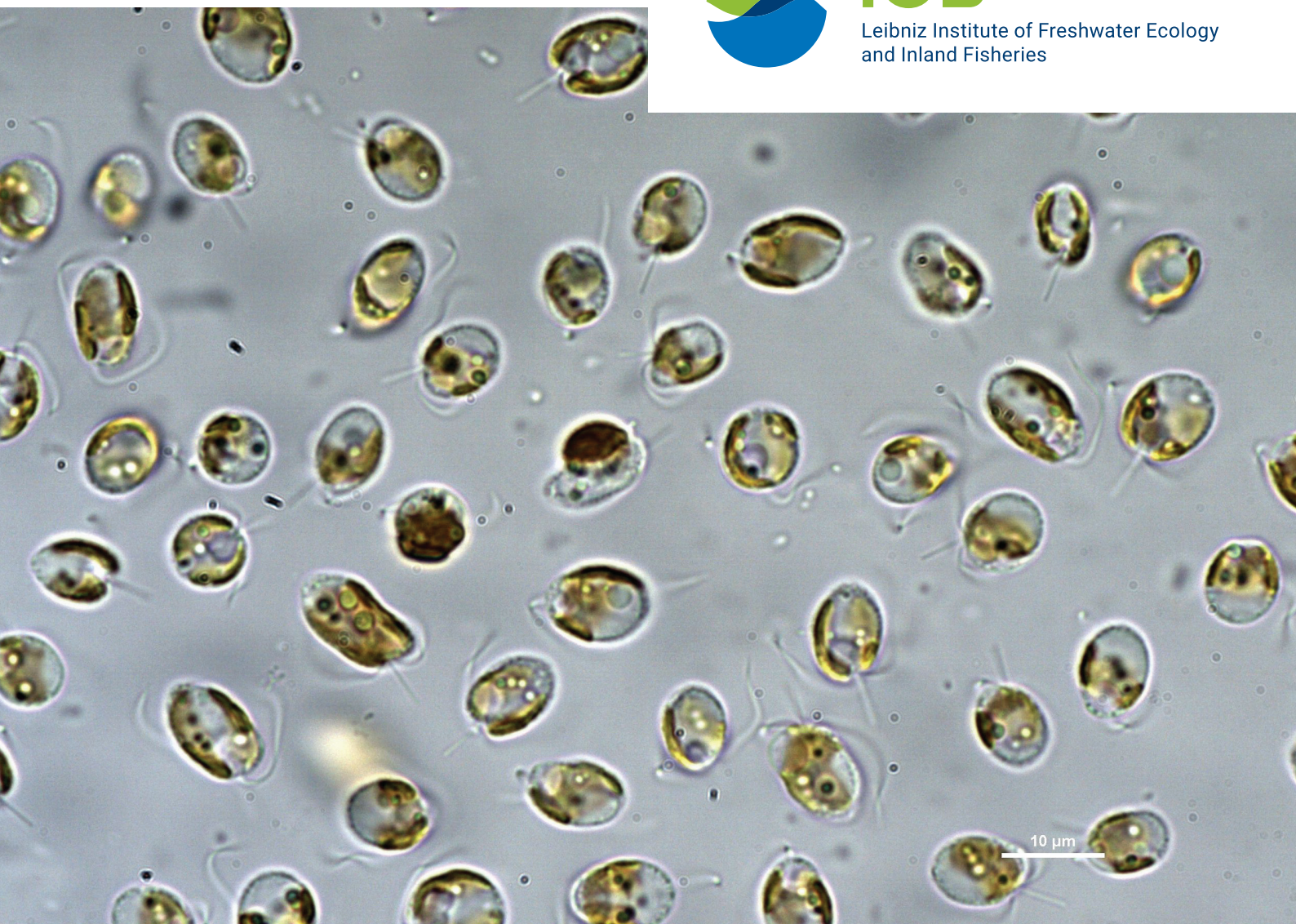
Leibniz Institute of Freshwater Ecology and Inland Fisheries



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In July and August 2022, a man-made environmental disaster occurred in the Oder River: a mass die-off of fish, mussels and snails that started in the Polish section of the Oder and then continued downstream until it reached the border Oder. Researchers estimate that up to 1,000 tonnes of fish were lost. The immediate cause of their death was a toxin-producing (planktonic) brackish water alga, scientifically known as *Prymnesium parvum*, which was able to grow *en masse* due to high salinity, high solar radiation, and low water flow.

The unicellular alga *Prymnesium parvum* belongs to the algae group of haptophytes. It is often referred to as ”golden alga” in publications, although this name is also used as a collective term for other groups of algae with similar pigmentation. At present, many questions relating to this alga, in particular its growth dynamics and toxicity, have not yet been scientifically clarified or completely understood. As part of the special investigation programme ODER~SO, several sub-projects dedicated to research on *Prymnesium* and its effects on other aquatic organisms are conducted at the Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB). Amongst others, the work is aimed at developing an early warning system for mass developments of *Prymnesium*. The special investigation programme is supported by the Federal Agency for Nature Conservation (BfN) with funding from the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV).

This IGB Fact Sheet summarises the current state of scientific knowledge on the toxic alga *Prymnesium parvum* in the Oder River.

Description: What is *Prymnesium parvum*?

- *Prymnesium parvum is* a **unicellular microalga** that is 5 to 10 micrometres (µm) long and 4 to 7 µm wide.
- Using its two flagella of equal length, the alga can **actively move through** water. It also has a holding organ, the so-called haptonema, with which it can attach itself to prey organisms and other surfaces.
- There are **at least 40 genetically distinct strains** of *Prymnesium parvum*, which have different amounts of genetic material and produce specific toxins. The name "*Prymnesium parvum" is* therefore a collective term for very different strains or types of the genus *Prymnesium*. The genotype of *Prymnesium* that led to the devastating damage in the Oder River in the summer of 2022 belongs to the so-called B-type.
- As is typical for plants, *Prymnesium* can feed **autotrophically**, i.e. by photosynthesis. However, this microalga can also feed on organic material (heterotrophically), in particular on other organisms. It is known that *Prymnesium* increasingly feeds **heterotrophically** when there is a lack of the nutrients nitrogen and phosphorus.

Distribution: Where does *Prymnesium parvum* occur?

- The alga is found **worldwide in brackish waters**, where mass developments with fish kills are regularly reported. It therefore belongs to the ecological group of brackish water algae. However, *Prymnesium* can also be found in the ocean and in fresh water, albeit in much lower concentrations. Occurrences have been documented in Europe, North America, South America, Australia and Asia. Prior to the environmental catastrophe in the Oder, *Prymnesium* had already caused massive fish kills on several occasions in highly saline reservoirs in the south of the USA, among other places.
- **The alga was already native to Europe** before it was first found *en masse* in the Oder in 2022. Toxic mass developments have occurred in Norwegian fjords, for example, but also in the increasingly saline River Thurne, England, and the Jasmund Bay (Jasmunder Bodden). However, unlike the Oder, these waters have a naturally high salt content. The only known mass development in a natural freshwater body outside the Oder river system has occurred in an industrially polluted river in the north-east of the USA.
- **Mass developments of planktonic algae** require favourable growth conditions for several weeks. In free-flowing rivers that are not artificially dammed, mass developments are impossible, as the water in the rivers has usually already reached the sea by this time.
- During the **environmental disaster in the summer of 2022,** the algae grew *en masse* in the Oder to more than 100 million cells per litre of river water, particularly in the Gliwice Canal and neighbouring reservoirs.
- Since then, ***Prymnesium*** has become established **in the Oder system**. After the start of field surveys by IGB as part of the ODER~SO project in March 2023, *Prymnesium* was detected in low concentrations in the Oder, but the alga has not mass-proliferated since then. The **maximum density** in the section of river investigated in summer 2023 was only about one hundredth of the density in August 2022. Even if such *Prymnesium* concentrations are too low to cause mass mortality of fish or mussels, they may have a major impact on the growth and fitness of other organisms such as zooplankton.

- In the summer of 2023, *Prymnesium* cells were also detected in individual samples from the **waters of the Spree-Havel system**, albeit at low densities. These corresponded to only around one thousandth of the algae density measured in the Oder in August 2022. Accordingly, no negative effects were observed there.
- *Prymnesium* can, for example, pass unnoticed from one body of water to another via water birds, on boats, rubber boots or through fishing gear such as fishing rods or landing nets. It can even spread in aerosols, the smallest suspended particles in the air, due to their tiny size. The same applies to *Prymnesium* as to all microalgae: **It can spread everywhere, but it cannot grow *en masse* under all conditions.**

Growth conditions: How does mass development of *Prymnesium parvum* occur?

- According to current research, the rate at which *Prymnesium* can grow depends on at least **six factors**: the **water retention time**, the **salinity**, the **light availability**, the **water temperature**, the presence of **algae viruses** and the **levels of nutrients** such as nitrogen and phosphorus in the water. More precise parameters for the growth of the algae are still being researched.
- *Prymnesium* tolerates **salinity levels** between 0.5 PSU (unit of measurement: Practical Salinity Unit) and 30 PSU. In laboratory tests, it cannot grow at a salinity of over 34 PSU, which is typically found in the open sea. According to previous studies at IGB, the strain from the Oder grows best at 2–5 PSU, while the salinity of the Oder without discharges would be below 0.5 PSU.
- Depending on the salinity of the water, the alga will grow particularly quickly at **water temperatures** between 20 °C and 30 °C. However, many mass developments with toxin formation have already been observed at water temperatures between 7 °C and 15 °C, where growth takes longer.
- Under ideal conditions, such as high salinity, plenty of light, warm water and sufficiently high levels of nitrogen and phosphorus, *Prymnesium* grows very rapidly: the algae then only need a few days to **double their biomass.** Such conditions favour the mass development of the algae.
- **Mass developments of *Prymnesium*** have so far been documented in lakes and reservoirs with a salinity of 0.74–20 PSU, and in rivers with a salinity of 0.9–3 PSU. *Prymnesium* can proliferate in areas with calm flow such as reservoirs, but also to a lesser extent in free-flowing river sections. The **water residence time or flow rate plays a key role** in the growth and spread of the algae.

Toxicity: What makes *Prymnesium parvum* so dangerous?

- Under certain conditions, *Prymnesium* produces **cytotoxins**, so-called prymnesins, which damage or kill competing algae species, predators and other animals. *Prymnesium* benefits from the nutrients that are then released.

- The **prymnesins** destroy the gills of aquatic organisms and then enter their blood and internal organs, which they decompose. **Fish** die from lack of oxygen and circulatory failure after the toxin has destroyed their red blood cells.
- These toxins also kill **mussels** and gill-breathing **aquatic snails**. Little is known about how different groups of **zooplankton** – i.e. small animal organisms floating in the water – react to prymnesins, but this is being investigated. According to current knowledge, *Prymnesium* concentrations as low as 1 million cells/litre can already have negative effects on the growth and reproduction of zooplankton. Similarly, very little research been performed on **amphibian larvae.**
- The question of the exact conditions under which the algae produce and release their **toxin** is the subject of ongoing research. Among other things, scientists are investigating possible correlations with the density of the *Prymnesium* bloom or the number of predators present. The influence of the nutrient levels or a sudden change in the salinity of the water is also being investigated.
- It is already clear that **the environmental conditions for the growth of the *prymnesium parvum* are different from those under which they become toxic.**

Countermeasures: How can toxic *Prymnesium* blooms in the Oder and other waters be prevented or contained?

- **Natural predators** of *Prymnesium* – as of all planktonic algae – include predatory protozoa, rotifers, water fleas and mussels. In addition, parasites such as fungi or viruses can decimate a *Prymnesium* bloom. However, under favourable conditions, including suitable salt concentrations, *Prymnesium* will reproduce much faster than algae cells die, resulting in mass development.
- Therefore, the **most effective precautionary measure** against further *Prymnesium* mass developments in the Oder would be to **reduce the salinity of the river** to a level that is less favourable for the brackish water alga *Prymnesium* – especially during the summer months. A **threshold value** for this does not yet exist, but is to be proposed on the basis of new studies.
- Reducing **concentrations of the plant nutrients phosphorus and nitrogen** in the Oder River, which are mainly discharged via inadequately treated wastewater and through agriculture, would also reduce the risk of further *Prymnesium* mass developments, but this cannot be achieved in the short term.
- The use of **hydrogen peroxide** and the precipitant **ferric chloride** to combat the mass development of *Prymnesium* was tested in Poland after the Oder disaster. According to reports, these measures can reduce *Prymnesium* density locally. However, IGB does not expect this to have a lasting effect, especially as it is not possible to combat the problem in flowing water due to the large quantities of chemicals required, and would have negative side effects on other aquatic organisms.
- Like all algal blooms, those of *Prymnesium* require a long **water residence time** to develop. Algal blooms therefore occur in stagnant or slow-flowing tributaries and reservoirs. Combating them locally and not releasing them into the Oder can prevent disasters, but it does not eliminate their causes.

- *Prymnesium* and **algae monitoring** in general, either by remote sensing and/or by taking samples in bodies of water, enables earlier warnings. However, the countermeasures and response options are limited.
- In the event of toxic riverine disasters, **riparian and floodplain waters play** an important role as refugial and recolonisation habitats for riverine fauna. They provide fish fauna and other mobile organisms with access to refugia, spawning and nursery areas. Deepening the river bed through **engineering measures** counteracts lateral connectivity and contact with the tributaries is lost, especially during periods of low water in summer.
- **Deepening the Oder for navigation** additionally impairs the river's ability to clean itself by reducing the contact surfaces with the sediment. As a result, the Oder would become less resilient to pollution disasters and the effects of climate change. Near-natural or restored water bodies can cope better with future challenges. Purely technical solutions are expensive and inflexible. In contrast, the **use of nature-based solutions can** achieve considerable **synergies between the protection and use** of watercourses and their floodplains.

The special investigation programme ODER~SO

In the special investigation programme ODER~SO, scientists are investigating the course of the environmental disaster in the Oder in the summer of 2022, the current state of the river, and precautionary measures and resilience factors for the protection of the ecosystem. The Federal Agency for Nature Conservation (BfN) supports ODER~SO with funding from the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV). In addition to the Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB), other scientific partners involved in the project are the Brandenburg University of Technology Cottbus-Senftenberg (BTU), the Helmholtz Centre for Environmental Research GmbH (UFZ) Magdeburg, Potsdam Institute of Inland Fisheries (IfB) and the University of Duisburg-Essen (UDE).

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Links to databases

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https://www.marinespecies.org/aphia.php?p=taxdetails&id=160564#distributions

https://www.gbif.org/species/7513065

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