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Lessons From the Oder Environmental Disaster

In the summer of 2022, an environmental disaster unfolded on the Oder River. Though the disaster was caused by humans, it was the river's natural ecosystem that paid the heaviest price.

Shore of the Szczecin Lagoon (the town of Stepnica) in September 2022. The exposed shores with decomposing vegetation and algae demonstrate the high concentration of nutrients in the water

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For thousands of years, the peoples inhabiting the Oder basin have altered the river in various ways through their activity. Anthropologists could presumably undertake an in-depth analysis of how humans have interacted with the Oder over the ages. Initial deforestation certainly played a role in effecting gradual changes in the river's hydrological cycle. Since the dawn of civilization, people have been eager to colonize and alter fertile lands situated in river valleys, turning them into farmland and pastures. Logs could be conveniently moved downstream using river currents, so channels were straightened to speed up the transport. This held true not only for the Oder itself, but also for most of its tributaries. To date, no one has estimated the scale of alterations made to the rivers making the Oder basin, but the Oder itself is estimated to have lost about 20% of its length. Hydromorphological alterations throughout the Oder's drainage basin caused water to flow towards the Baltic Sea faster than before, especially during the periods of heavy rainfall or spring thaw. The resultant flooding prompted efforts to erect embankments, thereby further altering the river's shape. Intensive urbanization and industrialization, which began in the eighteenth century, resulted in the construction of groynes in the midstream and downstream segments of the Oder and dams in its upstream sections.

Every shortened and altered kilometer of the river (including all of its tributaries) further reduced its capacity for water retention and self-purification. The latter term, "self-purification," refers to all the natural processes in the circulation of chemical elements and matter that involve living organisms and lead to the removal of certain chemicals from the water or their accumulation in the tissues of organisms. Rivers have a very good capacity for self-purification as long as their natural hydromorphological elements (meanders, oxbow lakes, point bars, and so on) are preserved. Over many years of human activity, however, both the Oder and its drainage basin have undergone significant alterations, ultimately detracting irreversibly from the river's resilience.

Water quality

As human population figures grew, a greater amount of biogenic elements came to be introduced into the river through sewage. These serve as nutrients for algae and vascular plants. With the riverbanks severely altered, however, plants cannot grow, so a considerable portion of these nutrients ends up being harnessed by microscopic autotrophs. Several centuries ago, additional substances started to enter the Oder's water, alongside nitrogen and phosphorus compounds. The list of substances that find their way into the water is very long and includes plant protection products, pharmaceuticals, hydrocarbons, and heavy metals. There's an old saying: "the dose makes the poison." This holds true, for instance, even for table salt, whose lethal dose for humans is roughly 1.5 g per kilogram of body weight. The reference to salt here is no coincidence. In the upstream segments of the Oder, huge amounts of salt enter the water and are not accumulated by the organisms that live in the river, nor can they be removed through self-purification. At times, we observe a salinity of 1.5 grams per liter of water in the midstream sections of the Oder, and even considerably higher levels in its tributaries, where saline waters are directly discharged. River ecosystems are more resistant to salt than humans – under such conditions, many species can survive, and certain salt-tolerant organisms can even thrive – but rivers, too, have their limits.

During the communist era in Poland, significantly greater quantities of agricultural biogenic compounds made their way into river water. In the early 1990s, there was an almost fourfold decrease in the use of phosphate fertilizers per hectare of cropland. In addition, the absence of efficient wastewater treatment facilities had played a considerable role in increasing the amount of nutrients in river water, prior to the country's transition to democracy. Despite significant progress in wastewater treatment made over the past 30 years, pollutant concentrations remain very high. In addition, vast amounts of organic and inorganic matter that have accumulated on the bottom of the

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The Oder River near the village of Kaleńsko

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The Oder River at the town of Słubice in August 2022, after the peak of fish die-offs. Dead fish were visible on the banks

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river for decades remain unutilized by living organisms. Every year, these bottom sediments therefore provide a secondary supply of biogenic elements.

The ecosystem

Climate change is already causing heat waves and unpredictable events, and climatologists believe that this is but a prelude to more severe consequences. They are warning that prolonged drought periods and short torrential rains will become more frequent. Such circumstances will do nothing to bolster the stability of aquatic ecosystems. Consequently, we will witness significant fluctuations in river levels, alternating between drastic drops and periods of potential flooding. Dry soil has lower absorption compared to moist soil, resulting in faster water runoff over parched ground. This further compounds the problem of heavy rainfall. Adding to these concerns, vast areas of landscape with paved surfaces and consequently fast runoff during heavy rain completely eliminate the soil's natural water storage capacity. Such highly variable hydrological conditions in the river are not favorable for the health of river ecosystems.

In such conditions, these ecosystems are often subjected to a variety of stressors, not only chemical and physical ones, as mentioned earlier, but also biological stressors. Important chemical factors determining the composition of species in a river include the above-mentioned level of salinity, which creates favorable conditions for salt-tolerant species (marine or estuarine ones), and high temperature, which is a physical factor favoring exotic species. To date, numerous non-native species have been discovered in the Oder River. This biological factor (non-native invasive species) outcompetes the native flora and fauna. Under the burden of all these stressors, the Oder ecosystem may become non-functional, potentially leading to the death of the animals inhabiting it.

Environmental disaster

The catastrophic situation that the Oder River faced in the summer of 2022 resulted from the culmination of a number of adverse events, including significant human influence. Firstly, the year 2022 was unusual in terms of record-low water levels, resulting from climate change in conjunction with ineffective water management in the Oder's drainage basin (this happened not only in the Oder, but also in other rivers in Europe). This, in turn, caused the chemical compounds entering the Oder to remain in high concentrations. One of the key factors was salt – coupled with high temperatures, it hampered the growth of

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The discharge canal for heated water from the Dolna Odra power plant

algae typical of a large lowland river, creating instead an ecological niche favoring salt-tolerant species and those that prefer warm waters. An algal species called *Prymnesium parvum* came to be introduced into the Oder, where it thrived under favorable growth conditions. This particular species produces a toxin called prymnesin, which can be lethal to gill-breathing fish and mollusks. Osmotic stress increases the level of toxicity of this haptophyte. As it drifted in the highly saline water of the Oder, however, *Prymnesium parvum* was exposed to stress from freshwater inputs from Oder tributaries. The largest of the Oder's freshwater tributaries is the Warta, where salinity is on average two or three times lower than in the Oder. This may have triggered the release of toxins by the algal cells, which explains why we observed a mass mortality event involving fish and mollusks in the portion of the Oder downstream from the confluence with the Warta.

The disaster culminated in the river's deoxygenated downstream section, collecting large amounts of decaying bodies of uncollected fish and mollusks. Consequently, the Oder waters near Szczecin became nearly completely deoxygenated. According to the estimates of the Leibniz Institute in Berlin, this led to the death of 50% of fish in terms of biomass and 60% of large bivalves. As such, the disaster of summer 2022 significantly weakened the Oder's ecosystem. The absence of large bivalves to filter the water and the absence of larger fish has made it difficult for the ecosystem to recover to its pre-disaster condition.

A lesson for the future

The 2022 environmental disaster on the Oder River can, therefore, be attributed to a multitude of factors that have accumulated over centuries of human activity. Generally speaking, we humans neglected to consider the well-being of the riverine ecosystem on par with our own. We failed to prevent excessive water pollution, land and water channel alterations, or the rampant emissions of greenhouse gases. In recent years, environmental science has increasingly recognized the importance of "ecosystem services." Such services have proved to hold substantial value, and the present authors are of the opinion that most of them are indeed priceless. As a society, we have failed to find ways to force those who excessively exploit the environment to compensate for these losses. Without acknowledging this need and taking appropriate steps based on scientific knowledge, we are unfortunately highly likely to soon witness more environmental disasters similar the one that devastated the Oder River in 2022. ■

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