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POTENTIAL REASONS FOR THE ECOLOGICAL CATASTROPHE OF THE ODER RIVER IN THE SUMMER OF 2022

*In July and August 2022, the largest ecological disaster in history occurred on the Oder River. The scale of the catastrophe resonated widely in Poland and Europe. Over 700 tons of dead fish have been caught. Several reasons can be considered as the main cause of the disaster, from extremely low flows lasting over 80 days to exceeding the pollutant loads. The biggest surprise was the presence of biological organisms *Prymnesium parvum* in the water, which secrete toxins during their death. In this work, one of the potential causes of the rapid deterioration of water quality is presented. Sedimentological conditions that could potentially occur on the Odra River from June to August 2022 are presented. The main groups of pollutants that may be released from sediments to waters are indicated.*

Keywords: ecological disaster, Odra River, sediment toxicity, hydrological drought..

Introduction. On July 26, 2022, information spread around Poland and its neighbor - Germany that dead fish appeared in the Oder river in Lipki, which, as it turned out later, reached Szczecin after 57 days (Fig. 1). At the very beginning of the catastrophe, an intensive search was undertaken for the "culprit" of this phenomenon, harmful to the environment and the human economy. This was to contribute to explaining the reasons for its creation, and then limiting its effects to full elimination, inclusive. So far, in almost every situation of this kind, sampling and chemical analysis of the Odra waters have been started, with simultaneous tracking of the pace of movement of the front of the dead fish zone (Fig. 1). According to the media reports, just two days after the disaster, the Provincial Inspectorate for Environmental Protection in Wrocław (WIOŚ), based on water samples taken in three places between Lipka and Oława (Fig. 1), assumed that a substance oxidative - which was determined on the basis of the high oxygenation of the Oder River. Two weeks after the appearance of the dead fish in the river (9.08), after the prosecutor was notified by the VIEP, it was reported that "so far no one has been detained, no charges have been filed against anyone". At the same time, in order to obtain information independent of Polish research units, chemical laboratories in Western countries were asked to conduct an impartial analysis of the contaminated waters of the Odra river - without the effect of explaining the cause of the disaster. The final version, which appeared on August 18, and which dominates to this day, is that the indirect cause of poisoning the waters of the river may be an invasive alga from the *Prymnesium parvum* haptophyte group, the so-called "golden algae". Their bloom, according to the Minister of Climate and Environment, may cause the appearance of toxins that kill fish and mussels, but they are not harmful to humans. The case of salty waters may result from their alimentation from reservoirs located above or the waste reservoir of KGHM Głogów - which, however, is not confirmed by Wody Polskie, which believes that these discharges took place in accordance with the applicable water and legal permit. At the same time, politicians on the airwaves emphasized that "natural causes are crucial here." Nevertheless, among specialists, the assurance that nature itself led to the mass extinction of fish in the Oder raises great doubts. At the request of the Government, a preliminary report of the team for the situation on the Oder was prepared in September 2022 (Kolada, 2022). According to the report, the cause of the disaster was most likely an intense bloom of *Prymnesium parvum* in the waters. The prerequisite for the formation of the bloom was the mere appearance of *Prymnesium parvum* in the Oder and the movement of algae from the foci of infection down the Oder River. The reason for the presence of algae can be considered:

(1) discharge of a toxic substance into the river by one of the workplaces, (2) possible natural causes, i.e. low water level combined with high temperature (increased concentration of pollutants already present in the river) and (3) discharge large amounts of industrial water. However, the above-mentioned report does not mention sediments, hence this topic will be the subject of our consideration.

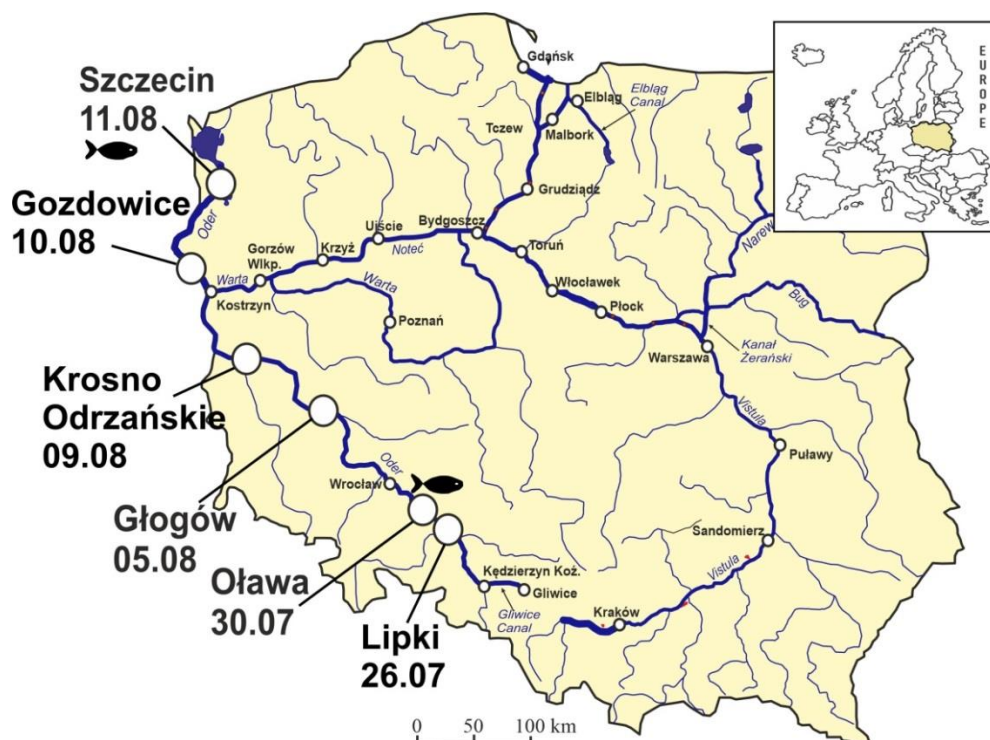


Fig. 1. Map of Poland with selected towns and dates where the appearance of dead fish was found in July and August 2022

Results . The phenomenon accompanying the ecological catastrophe of the Oder River in the summer of 2022 was the appearance of dead fish in its waters. The process of fish death (lethal threshold) is a physiological state in which the fish is still alive, but cannot return to active biological life, despite the removal of harmful physicochemical factors (Kujawa 1986). The death of fish may be caused by: low temperature (long-term icing of the surface of the water reservoir together with snow deposits prevents photosynthesis and oxygen production by aquatic plants - the so-called "winter fog" is created), high water temperature, lack of wind and low water level - then there is little dissolved oxygen and "Summer rush", and water poisoning or lack of oxygen (summer rush). It is usually a mass phenomenon, although in a limited area. The negative effects of oxygen depletion were probably intensified by the action of various toxic substances contained in the suspension accumulated at the bottom (e.g. alarming amounts of arsenic, mercury cadmium, as well as calcium, chlorides, sulphates were detected), because at low flows the concentration of pollutants in water increases (Giziński et al., 1986). However, the situation that took place on the Oder River in 2022 does not result from a shortage of oxygen in the water, but from its excess. The report prepared after the disaster shows that the examined bodies of the dead fish showed no clinical changes. The histopathological picture of all the examined fish showed acute damage to the organs most supplied with blood (Kolada 2022).

Initial investigations into the causes of the disaster do not include the study of bottom sediments of reservoirs on the upper Oder and those in the fields between groynes. The death of fish and fauna, mainly coastal, may be caused by chemical pollution of waters (dissolved sediment) and/or re-suspension of suspended sediment - but not by "clean" dragged sediment. Eliminating, among many factors affecting fish kills, chemical pollution of waters (this fact was not clearly defined in relation to the sediment dissolved in the Oder in the summer of 2022 - apart from the incidental appearance of *Prymnesium parvum*), is the only phenomenon among

fluvial processes that could have caused a catastrophe ecological, is the appearance of excess floating debris in the river. This phenomenon is schematically depicted in Figure 2 - situations a-e. The condition for inclusion of the suspension (A) deposited for many years at the bottom of the channel is its re-suspension caused by (B) lowering of the water table in the river to the level allowing it to emerge (hydrological drought - summer 2022), then drying as a result of evaporation (E) of the layer suspension formations (high air temperature - summer 2022) so that they are formed from a continuous layer (A) (e.g. the current of the San River), fragmented forms in the shape of polygons (B) (San and Biebrza) and with their further disintegration resulting from drying of the ground, intensified by the lowering of the water table, separate forms in the shape of "cup" are formed - very susceptible to fluvial transport (Fig. 2c). These forms, after evaporation of water (E), are loosely located on the alluvium and after condensation of long-term pollutants, they are so light that they deflate even with gusts of wind. In the case of the Odra River, this was not the case, because these forms were lifted by a water wave from torrential rainfall at the end of July in the Czech Republic and Southern Poland (Polish Waters message), and then incorporated into the channel process (Fig. 2d) and along with the rivers were fully resuspended (Fig. 2e, point 4 for the Rioni River - Georgia).

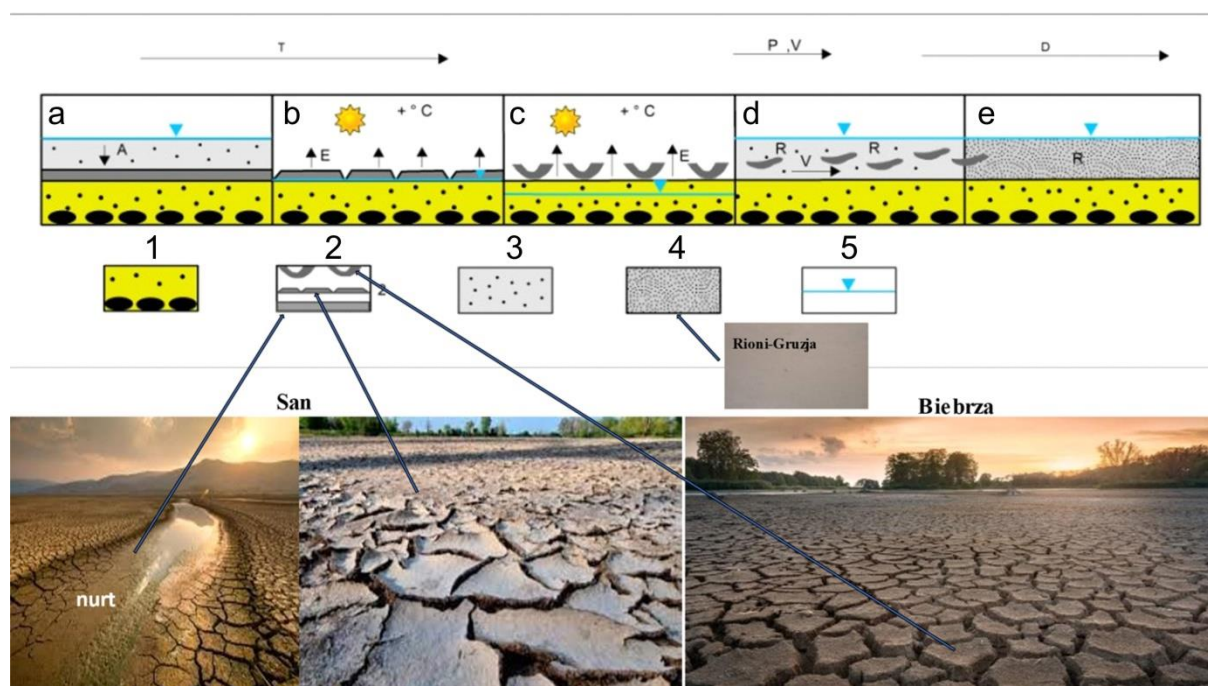


Fig. 2. Development stages of the Odra channel processes (higher out-of-current levels) in the summer of 2022 during: a - water levels preceding the drought / accumulation of fine-grained sediments (A), b - hydrological drought with the water table at the contact of sandy alluvium / drying of sediments and c - below alluvial top/beginning of detachment of sediments from the bottom, d - phase of water level rise, flooding of dried sediments and inclusion of dried polygon-shaped (B) or "cup-shaped" forms (C) into the trough process, e - full resuspension of suspension formations; supplemented with photographs of the bottom of the San and Biebrza riverbed during the drought in the summer of 2022 with forms depicting the drying process of the mud-clay layer in the shape of "bowls". Explanations: 1 – river alluvia, boulders at the bottom; 2 – silt-clay formations (former suspension) in three stages of development during: (C) detachment from the bottom and (D) transport; 3 – suspension transport; 4 - suspension dissolved (in resuspension) - (R) in a catastrophic amount (killing fish); 5 - water level in the river: E - evaporation, T - time, P - precipitation, V - water flow, D - distance.

Discussion. This sudden process in time and on a relatively long section of the river (which is why it is elusive and difficult to determine, which results from the current ignorance about the cause of the disaster), became the reason for the huge saturation of the water with a toxic suspension, which released suffocation and lack of oxygen on an unprecedented scale. In the water, and thus the tragedy of the fish being killed. The process, which was deadly for fish, started in Lipka on the Oder on June 26, along with the runoff of post-rain waters (possibly and reservoir waters) successively flooding these areas of the channel bottom in the form of a wave, moved downstream until reaching the Oder delta zone, i.e. August 11, 2022 in Szczecin (Fig.

1). It should be added that the phenomenon described above may occur in places where silt-clay formations (originally suspended rubble) are emerging and subject to drying, because in the current zone they are compact and resistant to erosion (Fig. 2, San current).

For a full explanation of the process of pollution of the Oder waters in the summer of 2022, presented in Figure 2, it should be stated that both the lack of field documentation of the phenomenon of disintegration of silt-clay formations (there is no information or photographic documentation on this subject - which was done, among others, on the river San, Biebrza - Fig. 2), as well as tests of water for suspension downstream to Szczecin, because almost exclusively the focus was on chemical contamination of water. On the other hand, the situation C presented in Fig. 2 was developed theoretically from field observations, the so-called post-rain requirements, after which the forms in the shape of "cup" remain. Regardless of the lack of documentation of these forms in the Oder, phase B, supported by photographs of the San and the Biebrza (Fig. 2), could result in the resuspension of suspension formations accumulated over many years, but in the case of these rivers this phenomenon has not been found (lack of information), because it should be presumed that they were not completely dried and detached from the alluvial substrate, which would have enabled them to be later included in the fluvial transport. Finally, it should be added that the process of re-suspension of silt-clay formations (killing of fish), which is harmful to the environment, also has its positive effects, because the Odra river bed will be free of polluted sediments for a long time (the scale of the phenomenon is unknown). In order to make this information credible, research should be carried out - to what extent and on what sections of the Oder River is "cleaned" after this ecological disaster. In addition, it should be noted that fish kill occurring in lakes and retention reservoirs has little to do with the process of suspension resuspension, as it occurs almost exclusively in rivers. The chemical composition of bottom sediments accumulated in reservoirs or ponds depends on the properties of pollutants reaching the waters of the reservoir and on environmental factors. Sediment contamination with toxic compounds is a serious problem for aquatic ecosystems. In the case of strongly flowing reservoirs, e.g. during floods, the previously deposited sediments are displaced (Achrem, Gierszewski, 2007). This may cause the release of toxic substances accumulated in them and secondary water pollution. The research shows that it is the suspended rubble that is the "carrier" of the most dangerous pollutants. Many publications draw attention to the negative role played by suspensions and impurities adsorbed on them, mainly heavy metals, in the aquatic environment (Barbusiński et al. 2012). Studies on the content of heavy metals in suspensions in the Oder basin have been described in many studies (Barbusiński et al., 2012; Adamiec, Helios-Rybicka, 2002a, Adamiec, Helios-Rybicka, 2002b; Helios-Rybicka et al., 2005). They showed heavy metal contamination of suspensions in rivers flowing through areas heavily anthropogenically transformed. Heavy metals transported in the aquatic environment are subject to, among others, adsorption processes by clay minerals and organic matter, which means that they can be transported further in the form of a river suspension, and under favorable conditions, subject to sedimentation (Brekhovskikh et al., 2001). Therefore, dam reservoirs are places of particularly intensive accumulation of suspended solids. Hydrological conditions, including, above all, the reduction of the water flow velocity on the section of the river dammed up by the dam, are an important factor influencing the diversification of the concentration of heavy metals in the sediments of the reservoir (Leńczowska-Baranek 1996). A particularly large accumulation of toxic substances, including heavy metals, occurs in the sediments of reservoirs formed on heavily polluted rivers, such as the Oder.

Conclusions.

1. Lack of confirmation of contamination of the Oder waters by dissolved sediment (chemical compounds mainly from denudation, fields and industrial and municipal sewage) in the summer of 2022 indicates that the cause of the ecological disaster (killing of fish) is the excessive supply of suspension from the resuspension of toxic sediments accumulated over many years silt-clay.

2. The process of activating suspension sediments accumulated on the bottom of the channel (outside the current zone) in rivers is possible only when they are dry, i.e. during hydrological drought (water table below the sediments) and high air temperature.

3. The dried sediments are light, detached from the substrate (alluvial), which makes it easier to collect them and move them downstream when water returns (precipitation, water discharge from the reservoir, etc.).

4. Along with the transport of sediment sheets in the form of polygons (ultimately "cups"), they are resuspended, resulting in a strong concentration of suspension in water and chemical pollution, oxygen limitation, which, together with the accompanying suffocation, causes the death of fish.

5. However, such a catastrophic situation in the transport of the Odra debris results in a positive fact - cleaning the bed from toxic sediments accumulated over many years, which may indicate that this process will not be repeated so quickly in time.

6. The environmentally catastrophic situation of the Oder River should not be related to the frequent killing of fish in lakes and artificial water reservoirs - unless such a process takes place with the participation of humans, as was the case on the Włocławski Reservoir in May 1986.

References

1. Achrem E., Gierszewski P., 2007. Zbiornik Włocławski, Inspekcja Ochrony Środowiska, Bydgoszcz, s.146.
2. Adamiec E., 2004. Rola zawiesiny w zanieczyszczeniu metalami śladowymi rzeki Odry. Akademia Górniczo-Hutnicza w Krakowie., s. 82.
3. Adamiec E., Helios-Rybicka E., 2002a. Distribution of pollutants in the Odra River system. Part IV. Heavy metal distribution in water of the upper and middle Odra River, 1998– 2000. Polish Journal of Environmental Studies 2002, Vol. 11, No. 6, pp. 669–673.
4. Adamiec E., Helios-Rybicka E., 2002b. Distribution of pollutants in the Odra River system. Part V. Metals content in the suspended matter and sediments of the Odra River system and recommendations for river chemical monitoring. Polish Journal of Environmental Studies 2002, Vol. 11, No. 6, pp. 675–688.
5. Babiński Z., 2002. Wpływ zapór na procesy korytowe rzek aluwialnych ze szczególnym uwzględnieniem Zbiornika Włocławskiego, Wyd. Akademii Bydgoskiej im. Kazimierza Wielkiego, Bydgoszcz, 185 s.
6. Barbusiński K., Nocoń W., Nocoń K., Kernert J., 2012. Rola zawiesin w transporcie metali ciężkich w wodach powierzchniowych na przykładzie Kłodnicy, Ochrona Środowiska, Vol. 33, Nr 1, 2011, s. 13-17.
7. Brekhovskikh V.F., Volkova Z.V., Kocharyan A.G. 2001. Heavy Metals in the Ivan'kovo Reservoir Bottom Sediments. Water Resources, 28, 3: 278–287
8. Giziński A. i in., 1986. Raport wstępny z wyników badań przeprowadzonych w celu ustalenia przyczyn masowego śnięcia ryb i innych organizmów w Zbiorniku Włocławskim [Preliminary report on the results of tests carried out to determine the causes of mass deaths of fish and other organisms in the Włocławek Reservoir], Toruń, pp. 1–3
9. Kolada A. (red), 2022. Wstępny raportu zespołu ds. sytuacji na Odrze, Instytut Ochrony Środowiska-Państwowy Instytut Badawczy <https://ios.edu.pl/wp-content/uploads/2022/10/Wstepny-raport-zespołu-ds.-sytuacji-na-rzece-Odrze.pdf>
10. Leńczowska-Baranek J., 1996. The Łączany Weir as a geochemical barrier in the migration of heavy metals. Applied Geochemistry, 11: 223–228
11. Kujawa S. 1986. Tlen w wodzie. Magazyn Akwarium, nr 5, D.Firlej Sp.k..
12. Teisseyre A. K., 1986. Fluvial processes on the wet Miskowice Fan. P. II. Sediment transport, with special reference to the August 1977 flood. Procesy fluwialne na „mokrym” stożku Miskowic. Cz. II. Transport osadu ze szczególnym uwzględnieniem powodzi w sierpniu 1977 roku. Geol. Sudet., 21, 2: 1-45.

Потенційні причини екологічної катастрофи річки Одер влітку 2022 року

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У липні та серпні 2022 року на річці Одер сталася найбільша в історії екологічна катастрофа. Масштаби катастрофи викликали широкий резонанс у Польщі та Європі. Виловлено понад 700 тонн мертвої риби. Кілька причин можна вважати основною причиною катастрофи, від надзвичайно низького стоку, що тривав понад 80 днів, до перевищення впливу забруднюючих речовин. Найбільше здивування викликала наявність у воді біологічних організмів *Prymnesium parvum*, які під час загибелі виділяють токсини. У цій роботі показано одну з потенційних причин швидкого погіршення якості води. Засвідчено седиментологічні умови, які потенційно можуть виникнути на річці Одра з червня по серпень 2022 року. Вказано основні групи забруднюючих речовин, які можуть надходити з донних відкладів у воду річки.

Ключові слова: екологічна катастрофа, річка Одра, токсичність наносів, гідрологічна посуха.

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