Chapter 6
Vistula Lagoon as Potential Object of Accumulated Environmental Harm

A. V. Minashkina and S. V. Kondratenko

Abstract The initial list of HELCOM hot spots in the Kaliningrad Region included 10 objects. There are now 7 objects left with the Vistula Lagoon among them. Numerous rivers of the Kaliningrad Region enter the bay, including the largest Pregolya River. Until 2019, the largest landfill that lacked a system for protecting the aquatic environment from the resulting leachate was located on the coast of the bay. Different chemical pollutants entered the Vistula Lagoon and accumulated in water, bottom sediments and hydrobionts, posing a threat to the ecosystem of the Vistula Lagoon, to residents of the Kaliningrad Region and numerous tourists. Detailed long-term monitoring of the content of nutrients in the water of the bay has been performed, yet the chemical pollution of the bay is studied poorly. The data on the content of organic and inorganic substances in fish and bottom sediments have become available only recently. It was established that pollutants that entered numerous landfills could enter the soil and then, through dips in impermeable soils, aquifers that discharge (release) into the Vistula Lagoon. In this regard, it is proposed to give it the status of an "object of accumulated ecological harm", the definition of which recently appeared in the Federal Law "On Environmental Protection". This status will allow a more detailed study of the bay in terms of its environmental safety.

Keywords Vistula Lagoon · Chemical pollution · Ecological monitoring · Heavy metals · Object of accumulated ecological harm

A. V. Minashkina · S. V. Kondratenko (✉)
Kaliningrad State Technical University, Sovetsky prospect 1, 236022 Kaliningrad, Russian Federation
e-mail: kondrat@klgtu.ru

A. G. Arkhipov (ed.), *Sustainable Fisheries and Aquaculture: Challenges and Prospects for the Blue Bioeconomy*, Environmental Science and Engineering, https://doi.org/10.1007/978-3-031-08284-9_6

Fig. 6.1 Location of the Vistula Lagoon. *Source* yandex.ru/maps/

6.1 Introduction

6.1.1 Vistula Lagoon is Hot Spot No. 73 in the HELCOM List

In June 2019, at the 56th meeting of the delegations of the HELCOM member states, hot spots No. 67 (Wastewater treatment plant in Kaliningrad) and No. 69 (Pulp and paper mill Zepruss) were excluded from the general list of hot spots (HELCOM, n.d.). Earlier, No. 68 (Darita pulp and paper mill) was excluded from this list. It contains seven more objects located in the Kaliningrad region, including two bays—Curonian and Vistula.

The Vistula Lagoon (Fig. 6.1) was included in the list of HELCOM hot spots due to the lack of effective resource management plans for these unique natural objects. Moreover, most of the Kaliningrad hot spots are directly related to the Vistula Lagoon. Some of them, as already mentioned, have officially ceased to be "hot", and some of them are close to losing this status.

However, tendencies in attitudes towards the natural systems of the Kaliningrad Region require not only a formal approach—whether they are included in the list or not, whether there are management plans for them or not. Due to sanctions and closure of many tourist destinations abroad, natural complexes of the Kaliningrad Region have become extremely popular in terms of tourism and recreation. The Vistula Lagoon is among these. Another important feature of the bay is its fish stocks popular with both professional and amateur fishermen.

In this case, we propose to consider the Vistula Lagoon as a water body exposed to long-turn chemical pollution from its catchment area posing a danger to both aquatic organisms and humans. In 2016, the Federal Law of the Russian Federation 7-FZ On

Environmental Protection introduced the concept of "accumulated ecological harm" and its definition: this is harm to the environment caused by past economic and other activities, where the obligation to eliminate the harm has not been met or has not been fully implemented.

The aim of this paper was to substantiate the inclusion of the Vistula Lagoon in the list of objects of accumulated ecological harm.

6.2 Materials and Methods

The paper employed articles and other available publications, which report data on the ecological status of the Vistula Lagoon and primarily information on the potential danger of chemicals accumulated in different environments of the bay to human.

6.3 Results

Municipal landfills are one of the main sources of water pollution. The largest landfill in the Kaliningrad Region was reclaimed in 2019. Two more municipal landfills are currently being prepared for reclamation. In 2005, there were 161 waste disposal sites in the Kaliningrad Region (Ministry of Natural Resources and Environment of the Kaliningrad Region 2018). By 2011, the number of landfills for disposal of household and industrial waste had reduced to 31 (Ministry of Natural Resources and Environment of the Kaliningrad Region 2012), and to date, the number of landfills used in the region has decreased to 4, of which only 2 are supplied with drainage water collection and purification systems.

The period of the reducing number of officially used landfills was accompanied by appearance of unauthorized landfills. For example, in 2011, 230 unauthorized landfills were discovered (Ministry of Natural Resources and Environment of the Kaliningrad Region 2012).

Another significant long-term source of water pollution in the Kaliningrad Region was household and industrial wastewater from settlements. The wastewater pollutants could enter the water bodies of the region.

At the beginning of the twentieth century, an intensive bloom of blue-green algae was periodically observed in the Vistula Lagoon, and both hydrobiologists and sanitary hygienists were aware of this fact. During these periods, fish deaths, diseases and deaths among the population consuming water from the bay were recorded. The disease was named Haff disease in honor of Frisches-Haff Bay (now Vistula Bay). At that time, the pollution of the estuary and urban parts of the Pregolya River attained the level threatening the life of aquatic organisms (Ezhova 2013).

Intensive algal bloom in the bay was also facilitated by the supply of nutrients from its catchment area involved in active agricultural activities. Since then, the list of leached nutrients has been extended by a variety of chemicals used in crop and

livestock production, as well as pollutants from wastewater and filtration waters of the landfill.

Long-term regular monitoring of the influx of nutrients into the Vistula Lagoon and its aftereffects have been performed by the Atlantic branch of the Federal State Budgetary Scientific Institution VNIRO (AtlantNIRO), and its results are presented in numerous reports and reviews (Aleksandrov 2011, 2018; Aleksandrov et al. 2017). They state that the content of gross nitrogen and phosphorus over most of the years of the monitoring period, on average for the Russian water area, corresponded to the potentially hypertrophic level of the bay ecosystem.

These facts indicate intense eutrophication of the Vistula Lagoon. However, no systematic studies of other forms of chemical pollution in the bay have been performed until recently. Such studies have become more regular and their results have become available to the scientific community only in the last 15 years.

One of the main nutrient suppliers to the bay is the Pregolya River, as its basin makes up 65% of the catchment area of the Vistula Lagoon (Russian part of the bay) (Ejdel'man et al. 2020). The ecological status of the bay and the Pregolya was assessed based on the parameters of hydrochemical monitoring and meteorological reports obtained for 2013–2019. The actual content of chemical substances in the studied water objects was compared with the standards for the content of these substances in water bodies of fishery significance—maximum permissible concentrations (MPCr-x). During the entire monitoring period, annual excess of MPCr-x was recorded for ammonium ions, nitrite ions, chloride ions, iron, copper, sulfates, phenols, and formaldehyde.

The content of heavy metals in bottom sediments was of the greatest interest among researchers who investigated chemical pollution of the bay.

Arsenic contents in bottom sediments of the Vistula Lagoon have been determined (Emel'yanov and Kravcov 2007). In the 0–3 cm sedimentary layer, from 3 to 57 mg/kg of arsenic was found, and in the silt column of 5–66 cm, the arsenic content ranged from 9 to 133 mg/kg.

The mercury content in bottom sediments of some parts of the Vistula Lagoon was reported in the review prepared based on fragmentary data obtained for the period of 2000–2019 (Bogdanov et al. 2020b). Mercury content ranged from 0.008 to 0.216 mg/kg.

In individual cases (Pahomova et al. 2004), in the coastal Vistula Lagoon and in its central part, flows of dissolved inorganic metals (Fe II and III, Mn, Pb, Cu) and those associated with the organic matter of marine water (Fe, Mn, Pb, Cu) were studied at the water–bottom interface. Among other things, it was found that at the stations in the Primorskaya Bay located closer to the coast the metal fluxes are 2–fourfold higher than those at the station located closer to the bay center.

According to the Geology and Licensing Division of the Department for Subsoil Use of the Northwestern Federal District for the Kaliningrad Region (Efimenko and Sokolov 2015), over 350 water-consuming enterprises extract and use underground fresh and mineral waters for drinking, industrial and commercial purposes. The utility and drinking water system, which supplies the population of about 950 thousand

people in the Kaliningrad Region with water, employs mainly 4 aquifers: upper intermoraine Moscow-Valdai, lower intermoraine Oka-Dnieper, Neogene-Paleogene and Upper Cretaceous. It is believed that the region is reliably provided with groundwater resources.

It is well known that surface waters can interact with groundwater with various degree of intensity. Extensive work has recently been done to assess this interaction in the Kaliningrad Region (Mihnevich 2011). As a result, three zones were identified in the region in terms of the degree of protection of the Moscow-Valdai aquifer (the most exploited) depending on the thickness of the upper aquiclude.

Hydrogeological (lithological) windows—local areas characterized by the absence or small thickness of the upper aquiclude, its increased permeability, and an insignificant water pressure in the Moscow-Valdai aquifer—provide interaction of different groundwater and surface water aquifers. Hydrogeological windows serve as pathways for pollutant spread in groundwater. To the greatest extent, hydrogeological windows are typical of the valleys of large rivers, for example, the Pregolya River.

The paper reports that there are 12 sanctioned (at the time of the study) landfills in the territory of the unprotected aquifers. Groundwater in 15 unauthorized landfills is not protected.

Another aftereffect of the influx of pollutants from land into groundwater aquifers is their subsequent migration (submarine discharge) to the Baltic Sea (Mihnevich et al. 2020). A special effect on the concentration of many heavy metals of submarine discharge is observed in small closed (semi-closed) water areas, namely gulfs and bays. In a number of such cases, the influx of metals such as cadmium, cobalt, zinc and chromium from the groundwater discharge can account for 80–90% of the river flow.

In (Bogdanov et al. 2020a), the ecological status of the Vistula Lagoon is assessed by the content of oil products in bottom sediments in three different zones of the bay. In conclusion the authors state that the ecological status of the investigated area of the Kaliningrad Bay is currently quite satisfactory in terms of the content of oil products in bottom sediments.

Studies are underway to investigate the aftereffects of chemical pollution of the aquatic environment by economic activities for aquatic organisms and human health.

It was found that in perch, roach and pike perch caught in the Curonian and Vistula Lagoons, the total PAH content does not exceed 11 μg/kg, while in bream, its content attains up to 14.6 μg/kg (Shenderyuk et al. 2011).

In general, all the most extensively studied pollutants of natural waters fall into three groups (Petrosyan 2010): priority organic toxicants, priority organometallic toxicants, and priority heavy metals.

In turn, priority organic toxicants include 13 groups of organic compounds with a wide range of chemical stresses: bioaccumulation in fatty tissues and in trophic chains, carcinogenesis, damage to the central nervous, endocrine systems, immune and reproductive systems, skin damage, toxic effects on fish etc.

Priority organometallic toxicants include derivatives of tin, mercury and lead. Chemical stresses of these compounds entail damage to the central nervous system, brain and liver, and cancer of the respiratory and digestive tracts.

Priority heavy metals in aquatic ecosystems include 12 metals with a wide range of chemical stresses.

Recent epidemiological developments draw our attention to the property of some metals that affects living organisms—mutagenesis, the ability to provoke new mutations. There are few studies on mutagenesis, therefore we can only state that metals in the aquatic environment can affect evolutionary processes at all levels of the organization of living matter, including viruses, bacteria, etc.

6.4 Discussion

Some of the promising economic activities in the Kaliningrad Region are fishing and fish processing, transport, and tourism. All these activities are somehow related to water, including water resources of the Vistula Lagoon.

In the Russian part of the Vistula Lagoon, more than 4 thousand tons of fish have been harvested in recent years, and the catch was represented by about ten fish species (herring prevail) (Shibaev 2020).

Water tourism, including sports tourism (sport fishing), is considered promising (Lekarkina 2017) due to the unique geographical position of the Kaliningrad Region. The Kaliningrad Region has a dense network of waterways, exits to the Baltic Sea and two bays. The development of cruise tourism and travelling by inland waterways is advantageous for the Kaliningrad Region.

The study of the Vistula Lagoon and associated waterways is highly potential for development of both water tourism and transportation of goods in the bay basin (Chubarenko et al. 2015). There are 19 small ports and harbors in the Polish and Russian waters of the bay.

A number of authors (Belova et al. 2016) believe that ecotourism is of a particularly high potential for development of tourist and recreational activities on the shores of the Vistula Lagoon, which combine efficiency of economic activities and high quality of the natural potential.

With regard to the uniqueness of most water bodies in the Kaliningrad Region, other authors suggest that plans for economic development of the region should include a management element referred to as ecological marketing of the territory (EMT, which indicates the priority of the environmental aspect in any business project implemented in the Kaliningrad Region (Kolosovskij 2017).

6.5 Conclusion

The Vistula Lagoon has been under long-term intense chemical exposure (at least for the last hundred years) caused by various chemicals entering it from the catchment area. Sources of chemical substances entering the aquatic environment are wastewater from settlements, industrial and agricultural enterprises and landfills. Chemicals enter the bay through surface runoff and groundwater (air transport is difficult to assess). In bottom sediments of the bay, high concentrations of various chemical compounds (primarily metals) pose a potential danger to aquatic organisms and humans. The bay is in high demand for economic activities, therefore, it is necessary to ensure its environmental safety, in particular, to reduce its chemical pollution and assess the potential danger to aquatic organisms and population of the region posed by chemical pollutants accumulated in the bay ecosystem.

The results of assessing the object of accumulated ecological harm should be sent to the Federal Government, which may include (or refuse) the object in the State Register (Decree of the Government of the Russian Federation of April 13, 2017 No. 445 On approval of the regulations for maintaining the State Register of objects of accumulated environmental harm). Objects included in the register are provided with state financial support for works aimed at elimination of the accumulated harm (Decree of the Government of the Russian Federation of May 4, 2018 No. 542 On approval of the regulations for organizing works to eliminate accumulated ecological harm), namely:

(1) adequate inspections of the facility, including engineering surveys;
(2) development of the project to eliminate the accumulated harm;
(3) agreement and approval of the project;
(4) works to eliminate the accumulated harm;
(5) control and acceptance of the work aimed at elimination of the accumulated harm.

References

Aleksandrov SV (2011) Current ecological state and pollution of the Curonian and Vistula bays of the Baltic Sea. Water: chemistry and ecology, 11, 3–9 (in Russian)

Aleksandrov SV (2018) Spatial changes in hydrochemical parameters in the Vistula Lagoon in 2014–2016. Works of AtlantNIRO, 2 1(5)), 5–21 (in Russian)

Aleksandrov SV, Vahrusheva SA, Mal'fanov IL, Trenina NE (2017) Spatial changes in hydrochemical parameters and water salinity in the Vistula Lagoon in 2010–2013. Works of AtlantNIRO. New series 1(3):5–21 (in Russian)

Belova AV, Fedina-ZHurbina IV (2016) Opportunities for the development of ecotourism in the Kaliningrad region (with an emphasis on the pilot area of the Russian part of the territory adjacent to the Vistula (Kaliningrad) and Curonian bays). Bulletin of the Baltic Federal University. I. Kant. Series: Natural and Medical Sciences 1:64–74 (in Russian)

Bogdanov NA, Bass OV, Savostina OA, and Chugaevich VYa (2020a) The ecological state of the kaliningrad bay by the variability of the content of oil products in bottom sediments. In V. I. Osipov

Proceedings from Sergeev's readings: geoecological aspects of implementation of the national project "Ecology". Dialogue of generations. Moscow, Russia: Peoples' Friendship University of Russia (in Russian)

Bogdanov NA, Ermolaev BV, Bass OV, Paranina AN (2020b) Mercury in bottom sediments of the water area and at river mouths: Kaliningrad Bay. Geosphere Research 2:76–82

Chubarenko BV, Shvankovska B, Fedorova GM, Gricenko VA (Eds.). (2015). Catalog of small ports and harbors of the Kaliningrad /Vistula Lagoon/. Moscow, Russia: Ex-libris. 188 p.

Efimenko AV, Sokolov AV (2015) Condition and rational use of groundwater resources in the Kaliningrad region. In K.V. Tylik (eds.) Proceedings from III BMF WBAEWB: Water bioresources, aquaculture and ecology of water bodies. Kaliningrad, Russia: Kaliningrad State Technical University (in Russian)

Ejdel'man YAV, Koroleva YuV, Golubeva YUV (2020) Comprehensive assessment of pollution of the Pregolya River and the water area of the Kaliningrad Bay. International Research Journal 6–2(96):74–78

Emel'yanov EM, Kravcov VA (2007) Reasons for increased arsenic concentrations in the Baltic Sea and Vistula Lagoon. Geochemistry 8:871–888 (in Russian)

Ezhova EE (ed.) (2013) Biological communities of the pregolya river (vistula gulf, baltic sea). Kaliningrad, Russia: Smartbooks. 246 p (in Russian)

HELCOM Hot Spots: two Kaliningrad pollution sites get wiped off the list at key HELCOM meeting. (n.d.). Retrieved from https://helcom.fi/helcom-hot-spots-two-kaliningrad-pollution-sites-get-wiped-off-the-list-at-key-helcom-meeting/

Kolosovskij AM (2017) On some aspects of environmental marketing of water resources in the Kaliningrad region. In Kostrikova N.A. (Eds.). Proceedings from V IBMF: V International Baltic Maritime Forum. Kaliningrad, Russia: Separate structural subdivision "Baltic State Academy of Fishing Fleet" of the Federal State Budgetary Educational Institution of Higher Professional Education "Kaliningrad State Technical University" (in Russian)

Lekarkina NK (2017) Overview of investment opportunities in the Kaliningrad region. Analysis of the most promising industries for investment. Economic scientific journal: Investment assessment, 2–1, (6), 55–80 (in Russian)

Mihnevich GS (2011) Geoecological assessment of the natural protection of groundwater from pollution (on the example of the system of the upper intermoraine aquifer of the Kaliningrad region). Dissertation of Candidate of Geographical Sciences. Immanuel Kant Baltic Federal University, Kaliningrad, Russia (in Russian)

Mihnevich GS, Krechik VA, Krek AV, Danchenkov AR (2020) Transport of heavy metals with underground runoff to the baltic sea. Proceedings from VIII IBMF: Materials of the VIII International Baltic Maritime Forum: in 6 volumes, 157–163 (in Russian)

Ministry of Natural Resources and Environment of the Kaliningrad Region (2018) Order of Natural Resources and Environment of the Kaliningrad Region "On Approval of the Territorial Scheme for Waste Management, Including Solid Municipal Waste, in the Kaliningrad Region" (March 28, 2018 No 145). Kaliningrad, Russia (in Russian)

Ministry of Natural Resources and Environment of the Kaliningrad Region (2012) Report "on the ecological situation in the Kaliningrad region in 2011". Kaliningrad, Russia. 203 p (in Russian)

Pahomova SV, MYu Kononec, YUdin MV, Vershinin AV, Rozanov AG (2004) Study of dissolved forms of metals across the water-bottom interface in the Vistula Lagoon of the Baltic Sea. Oceanology 44(4):516–523 (in Russian)

Petrosyan VS (2010) Natural and drinking water: chemical safety issues. RANS Bulletin 10(3):50–55 (in Russian)

Shenderyuk VV, Chernysheva NL, Baholdina LP, Dubova OL, Strygina OA (eds.) (2011) Assessment of the level of pollution of the water resources of the Baltic Sea and the waters of its sea and bays with polycyclic aromatic hydrocarbons. In AV Ivanov (eds.) proceedings from IX ISC : proceedings of the IX International Scientific Conference "Innovations in science and education—2011". Kaliningrad, Russia: Kaliningrad State Technical University (in Russian)

Shibaev SV (2020) Fishing intensity in the Russian part of the Vistula Lagoon. Fishing Issues 21(1):41–52 (in Russian)