FACT SHEET: Oder River Basin

The Oder River Basin has a drainage area of 118,938 km^2, most of which in Poland. The Oder River originates from the Barania Góra Mountains in the Czech Republic, forms the border between Poland and Germany, then drains through the eastern lowlands of Poland to the Baltic Sea near Gdańska. The population of the basin is close to 16 million inhabitants (2015) and 50.4% of the basin is agricultural cropland. Table 1 presents the main characteristics of the basin.

Figure 1. Oder River drainage basin.

Table 1. Oder River Basin characteristics

Oder
COUNTRIES: CZECH REPUBLICK, GERMANY, POLAND
Pedo-climate: Continental region and zone
Drainage Area 118,938 km^2
Maximum altitude: 1580 m
Annual average rainfall 641 mm/year
Main land uses: Agriculture 50.4%; Forest 41.8%, and Urban 6.5%
Population in 2015: 15,815,498
River length 855 km
Strahler Order – 8
Discharge at outlet 710.8 m^3/s
Outlet coordinates: 52° 13' 32" N, 16° 21' 60" E

The many economic activities that include heavy industry (chemical and petrochemical, power-generating), intensive agriculture and forestry, urban activities, and tourism pose heavy pressure to the basin water bodies.

Agriculture and water in the Oder Basin

The agricultural pressure to water resources is significant throughout Poland. According to Polish CSO data, an average of 75.5 kg N/ha/y of nitrogen fertilizers and 24.3 kg N/ha/y of phosphorus was used in Poland in 2014, which resulted in the consumption of 1,098.4 thousand tons of nitrogen fertilizers and 341.1 thousand tons of phosphate fertilizers. In the Polish basins, fertilization over the optimum, particularly in soils with low humus content, have been associated with nitrogen pollution (Dresler et al., 2011). Greenhouse soilless culture is also a source of pollution as well as high livestock density farms (Bres, 2009; Kupiec, 2019).

Groundwater pressures result from water abstraction, agricultural activities, mining, and urban activities especially contamination from waste water treatment plants. Dragon (2006) investigated about 1000 km^2 of the Wielkopolska Burried Valley (WBV), a semi-confined aquifer formed of multilayers of glacial and fluvioglacial deposits in the northern part of the basin. Lithology is dominated by sand in upper part and sand and gravel in deeper portions (Dragon, 2016). Agriculture is mainly in eastern study area, east of the line of Grodzisk Wilekopolski, Opalenica and Pniewy, whereas the central region is a recharge area and the western region is forested. Dragon (2013) reported concentrations of nitrate and ammonium exceeding regulations in the recharge area of the aquifer. Domestic waste contamination, possibly from septic leakage, was identified as an important problem. Agricultural contamination was found to occur mainly from livestock farms, and linked to over-fertilization in inorganic and organic forms. Zones of high vulnerability are located where the aquifer is less than 25 m thick, and below intense farming and emissions from uncollected domestic waste in rural land.

In the decade from 2000 to 2009, the concentrations of nitrate, ammonia, chloride and sulfate increased (Dragon, 2012), indicating intensification of anthropogenic contamination. The recharge zone of the aquifer was studied in Gragon (2013), Dragon et al. (2016) and Dragon (2016). The upper aquifer water is recent, whereas the discharge zones of the WBV had a residence time greater than 1000 years (Dragon and Gorski, 2015). The groundwater quality of the aquifer is highly influenced by the recharge water, which is extremely vulnerable to nitrate pollution (Dragon, 2013). Large differences of nitrate concentrations were observed between the shallow and deeper parts of the flow system. Presence nitrogen gas (N_2) suggested that denitrification is taking place. Recharge water contamination was related to agricultural activities: isotopic data showed that the main source of nitrate in the groundwater is manure, followed by other fertilizers and spreading sewage on land (Dragon et al., 2016). The contamination spreads to the deeper parts of the aquifer is accelerated by groundwater extraction, which occurs near urbanized areas (Dragon, 2008), as water pumping creates a depression cone that facilitates the migration of contaminants. Generalized maps of groundwater chemistry identified hot spots of contamination (Dragon and Gorski, 2015). Even though policies have been put in place to protect groundwater, the expected positive impact in improvements in groundwater quality is still to be seen (Dragon, 2016).

Kaspercryk et al. (2016) studied two catchments in lower Silesia region of Poland to assess the impact of mineral fertilizers on shallow aquifers. Two catchments were selected: the Cicha Woda, a left tributary of the Oder river, and the Sąsiecznica, a left tributary of the Barycz river. Two aquifers were investigated at Cicha Woda, the Quaternary aquifer and the Negogene aquifer and one at Sąsiecznica, the Quaternary aquifer. Cicha Woda is identified as Nitrate Vulnerable Zone (NVZ). Measured nitrate concentrations in the Cicha Woda ranged from 0.08 to 142.12 mg NO_3^-/L in the Quaternary aquifer, and from 0.01 to 0.39 mg NO_3^-/L in the Neogene aquifer. In the Sąsiecznica Quaternary aquifer, nitrate concentration ranged from 2.6 to 137.65 mg NO_3^-/L. High concentrations of ammonium, potassium and phosphate were also detected. The major source of pollution was identified in the intensive agriculture.

The study of Lawniczak et al. (2016) took place at the Wielkopolska National Park (WPN) and its buffer zone in central-west Poland, which are protected under Natura 2000 as Special Protection Areas. The area is approximately 15 km from Poznań City, on the left bank of Warta River. Groundwater and surface water sampling took place in 16 catchments in spring and summer 2012, and put in relation with fertilization and crop production. Groundwater contamination of nitrogen and phosphorus were extensively observed. Nitrogen concentrations were higher in agricultural areas than under forest land, particularly in spring, after winter freezing when nitrogen fertilizers are applied on bare soils. Nitrogen leaching was large where fertilization amounts exceeded crop uptake, which was sub-optimal also due to concurrent shortages in phosphorus and potassium availability.

Massmann et al. (2004) and Merz et al. (2005) analyzed redox processes in the river recharged aquifer of the Oderbruch polder, next to Oder river in north-eastern Germany. The Oderbruch polder is 800 km^2 large, about 50 km NE from Berlin. The water of the Oder river infiltrates in the polder, but is already reduced by the time it reaches the aquifer below an alluvial loamy top layer of the polder. The process is driven by organic matter degradation. Nitrates and oxygen are reduced by organic matter, pyrite oxidation, carbonate dissolution and precipitation, iron and manganese reduction and sulfate reduction. Denitrification keeps nitrogen in groundwater level low, but the oxidation of geogenic pyrite causes the release of large sulfate amount in the groundwater. Interestingly, denitrification can be associated with nitrous oxide production (a powerful greenhouse gas) in suboptimal conditions, but this intermediate product is not studied. Exfiltration interrupted by dry phases cause the accumulation of iron and manganese in the sediments, affecting the natural function of the soil. The authors concluded that intensive agriculture and drainage impacted significantly the polder, and advocated improving water management strategies to improve ecological conditions of the region.

Impact on coastal areas

From 1995 to 2008 nitrogen and phosphorus deliveries by the Oder river to the sea have reduced, but phosphorus load has reduced more than nitrogen (Kowalkowski et al., 2012). This imbalanced reduction in nutrient loads at the sea is still insufficient to halt coastal episodic eutrophication crisis (Kudryavtseva et al., 2019; Berthold et al., 2018). Coastal eutrophication takes various forms with development of harmful algal blooms (HAB), with accumulation of mucilaginous algae or dinoflagellates Pseudo-Nitzschia, and mostly Cyanobacteria for the Baltic Sea, possibly producing toxic substances and leading to hypoxia. Besides nutrient inputs, coastal eutrophication depends on many factors linked to the morphology and hydrological pattern of the receiving water body – flushing rate or residence time, temperature and light conditions, wind, etc., all varying seasonally and interannually (Friedland et al., 2019; Berthold et al., 2018).

The impacts of agricultural activities to water bodies in the Oder River Basin and coastal zone can be clearly seen from the studies presented here. Nutrient excess in surface and groundwater are related to agricultural activities. Parts of the aquifers have significant capacity for denitrification (e.g. Oderbruch polder). Nevertheless, all these systems are affected by agricultural pollution regardless their capacity to buffer it. Ultimately, despite improvements in recent years, nutrient deliveries at the outlets are still too high to prevent eutrophication episodes.

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