Supplementary material

for

**Estimation of nutrient loads with the use of mass-balance and modelling approaches on the Wełna River catchment example (central Poland)**

Table S1 Input data for both methodologies.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Description | | | **Mass Balance Method** | **Modeling Method** |
| **Data source and resolution** | |
| monitoring data | Flow | | [IMGW-PIB. Daily flow data from 2017 for the Kowanówko calculation profile. https://danepubliczne.imgw.pl/](https://danepubliczne.imgw.pl/) | [IMGW-PIB. Daily flow data from the period of 18 years (2001-2018) for the calculation profiles of Pruśce and Kowanówko (Wełna) and Ryczywół (Flinta). https://danepubliczne.imgw.pl/](https://danepubliczne.imgw.pl/) |
| TN, TP | | [Chief Inspectorate of Environmental Protection: State Environmental Monitoring https://www.gios.gov.pl/pl/stan-srodowiska/monitoring-wod](https://www.gios.gov.pl/pl/stan-srodowiska/monitoring-wod) | [Chief Inspectorate of Environmental Protection: State Environmental Monitoring. TN and TP data from the period of 15 years (2001-2015) for the calculation profiles Oborniki and Rogoźno. https://www.gios.gov.pl/pl/stan-srodowiska/monitoring-wod](https://www.gios.gov.pl/pl/stan-srodowiska/monitoring-wod) |
| input data | Digital elevation model DEM | | - | Nation Protection IT System.-10m, 1:20000. https://isok.gov.pl/index.html |
| Hydrographic network | | [State Water Holding-Polish Waters: Map of the Hydrographic Division of Poland. https://isok.gov.pl/hydroportal.html](https://isok.gov.pl/hydroportal.html) | |
| Soil type | | State Water Holding - Polish Waters: "Identification of pressures in water regions and river basins districts. Part II: Development of database of anthropogenic pressures. | Soil-agricultural map, 1: 100 000, 2.5m - Institute of Soil Science and Plant Cultivation and a map of forest soils in the scale of 1: 10 000, 2.5m - Polish State Forests (31 soil classes) |
| Meteorological data | | - | [IMGW-PIB - air temperature, precipitation, humidity, wind speed and total radiation, for 250 stations located directly in the basin, and within 20 km from its borders. https://danepubliczne.imgw.pl/](https://danepubliczne.imgw.pl/) |
| Land use | Agricultural area (AGS) | EEA: Corine Land Cover (CLC 2018). https://land.copernicus.eu/pan-european/corine-land-cover | [Corine Land Cover (CLC 2012), Landsat 8 satellite images http://clc.gios.gov.pl/index.php/26-clc-2012, https://bdl.stat.gov.pl/BDL](https://bdl.stat.gov.pl/BDL) |
| Urban area |
| Forest area (MWS) |
| Municipal point sources (MWS) | | [State Water Holding - Polish Waters: National Program for Urban Waste Water Treatment - https://www.wody.gov.pl/nasze-dzialania/krajowy-program-oczyszczania-sciekow-komunalnych   Statistics Poland: Local Data Bank. https://bdl.stat.gov.pl/BDL](https://www.wody.gov.pl/nasze-dzialania/krajowy-program-oczyszczania-sciekow-komunalnych) | National Program for Urban Waste Water Treatment - https://www.wody.gov.pl/nasze-dzialania/krajowy-program-oczyszczania-sciekow-komunalnych, Central Statistical Office - https://bdl.stat.gov.pl/BDL, State Water Holding-Polish Waters |
| Industrial point sources (INS) | | Statistics Poland: Local Data Bank. https://bdl.stat.gov.pl/BDL |
| Fertilization | | [State Water Holding - Polish Waters: "Identification of pressures in water regions and river basins districts. Part II: Development of database of anthropogenic pressures.  Statistics Poland: Local Data Bank. https://bdl.stat.gov.pl/BDL](https://bdl.stat.gov.pl/BDL) | Local Data Bank of the Statistics Poland (GUS) - https://bdl.stat.gov.pl/BDL/start with regard to the consumption of mineral fertilizers and livestock (for natural fertilizers) together with agrotechnical activities carried out in the catchment area. |
| Municipal diffuse sources (SCS) | | [Population: Statistics Poland - https://bdl.stat.gov.pl/BDL,  Unit load in untreated wastewater: State Water Holding - Polish Waters: National Program for Urban Waste Water Treatment - https://www.wody.gov.pl/nasze-dzialania/krajowy-program-oczyszczania-sciekow-komunalnych](https://www.wody.gov.pl/nasze-dzialania/krajowy-program-oczyszczania-sciekow-komunalnych) | National Program for Urban Waste Water Treatment - https://www.wody.gov.pl/nasze-dzialania/krajowy-program-oczyszczania-sciekow-komunalnych, Central Statistical Office - https://bdl.stat.gov.pl/BDL, State Water Holding-Polish Waters |
| Natural background (NBS) | | Calculated based on total outflow from catchment and concentrations of nutrients adopted from Polish PLC-7 report (SWH PW, 2020b). | [Chief Inspectorate for Environmental Protection in Poland. TN and TP loads from natural transformation and transport processes, based on land use. https://www.gios.gov.pl/en/](https://www.gios.gov.pl/en/) |
| Atmospheric deposition (ATS) | | Chief Inspectorate for Environmental Protection: Precipitation Chemistry (TN and TP). https://powietrze.gios.gov.pl | Chief Inspectorate for Environmental Protection: Precipitation Chemistry (TN) and dry deposition. https://powietrze.gios.gov.pl |

Table S2 The Wełna River model calibration, verification and validation results.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Calculation profile** | **Parameter** | **R2** | **PBIAS** | **KGE** |
| **Calibration** | | | | |
| Flinta - Ryczywol | flow | 0.71 | -8 | 0.78 |
| Wełna - Prusce | 0.85 | -5 | 0.9 |
|  |  |  |  |  |
| Wełna - Oborniki | TN | 0.86 | -20 | 0.7 |
| TP | 0.60 | 30 | 0.53 |
| **Verification** | | | | |
| Flinta - Ryczywol | flow | 0.66 | 2 | 0.62 |
| Wełna - Prusce | 0.83 | 10 | 0.86 |
|  |  |  |  |  |
| Wełna - Oborniki | TN | 0.86 | 12.5 | 0.67 |
| TP | 0.38 | -25 | 0.21 |
| **Validation** | | | | |
| Wełna - Kowanowko | flow | 0.8 | 15 | 0.81 |
|  |  |  |  |  |
| Wełna - Rogoźno | TN | 0.9 | -14 | 0.51 |
| TP | 0.35 | 23 | 0.47 |

Table S3 Classification of value ranges for statistical measures used during calibration, verification, and validation, based on (Moriasi et al., 2015; Patil et al., 2015; Libera et al., 2018)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Performance Rating | **R2** | | | **PBIAS %** | | **KGE** |
| flow | TN | TP | flow | TN/TP | flow/TN/TP |
| very good | > 0.85 | > 0.7 | > 0.8 | < 5 | < 15 | >0.75 |
| good | 0.75<R2<0.85 | 0.6<R2<0.7 | 0.65<R2<0.8 | 5<PBIAS<10 | 15<PBIAS<20 | 0.5 - 0.75 |
| satisfactory | 0.6<R2<0.75 | 0.3<R2<0.6 | 0.40<R2<0.65 | 10<PBIAS<15 | 20<PBIAS<30 | 0 - 0.5 |
| unsatisfactory | < 0.6 | < 0.3 | < 0.4 | > 15 | > 30 | <0 |

# References

Moriasi, D. N., Gitau, M. W., Pai, N., Daggupati, P. 2015. Hydrologic and water quality models: Performance measures and evaluation criteria. *Transactions of the ASABE*, 58(6), 1763 – 1785. 10.13031/trans.58.10715

Patil, S. D., Stieglitz, M. 2015. Comparing spatial and temporal transferability of hydrological model parameters. *Journal of Hydrology*: 525, 409 – 417. https://doi.org/10.1016/j.jhydrol.2015.04.003

Libera, D. A., Sankarasubramanian, A. 2018. Multivariate bias corrections of mechanistic water quality model predictions. *Journal of Hydrology*: 564, 529 – 541. https://doi.org/10.1016/j.jhydrol.2018.07.043