Department of Hydraulic Engineering
and Environmental Recultivation

Warsaw University of Life Sciences - SGGW

# Nutrients and sediment transport in a small rural river

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# Introduction

1. One of the important topics of environmental protection in Poland is a problem of the nutrients estimation from small rural rivers. Small rural rivers are not monitored very often, so there is no frequent information about concentrations and discharges. Lack of this information causes problems with estimation of real loads.

2. The Department of Hydraulic Engineering and Environmental Recultivation of Warsaw University of Life Sciences, as a research institution, provides the complex investigation of environment changes and trends in a river catchment which is typical for the Mazovian Lowland.

3. This presentation includes some results of nutrient transport investigations in Zagożdżonka river.

# Basic research and model investigations carried on Zagożdżonka catchment and river:

-Runoff-rainfall-sediment transport modeling (SedimentGraphMOdel)

-Lag times of flood and sediment yields

-Suspended sediment transport during snowmelt floods

-Siltation of reservoirs (investigations and modeling)

-Investigations on suspended sediment grain size distribution changeability

- Investigations on sediment and nutrients transport at the catchment scale

# Zagożdżonka catchment

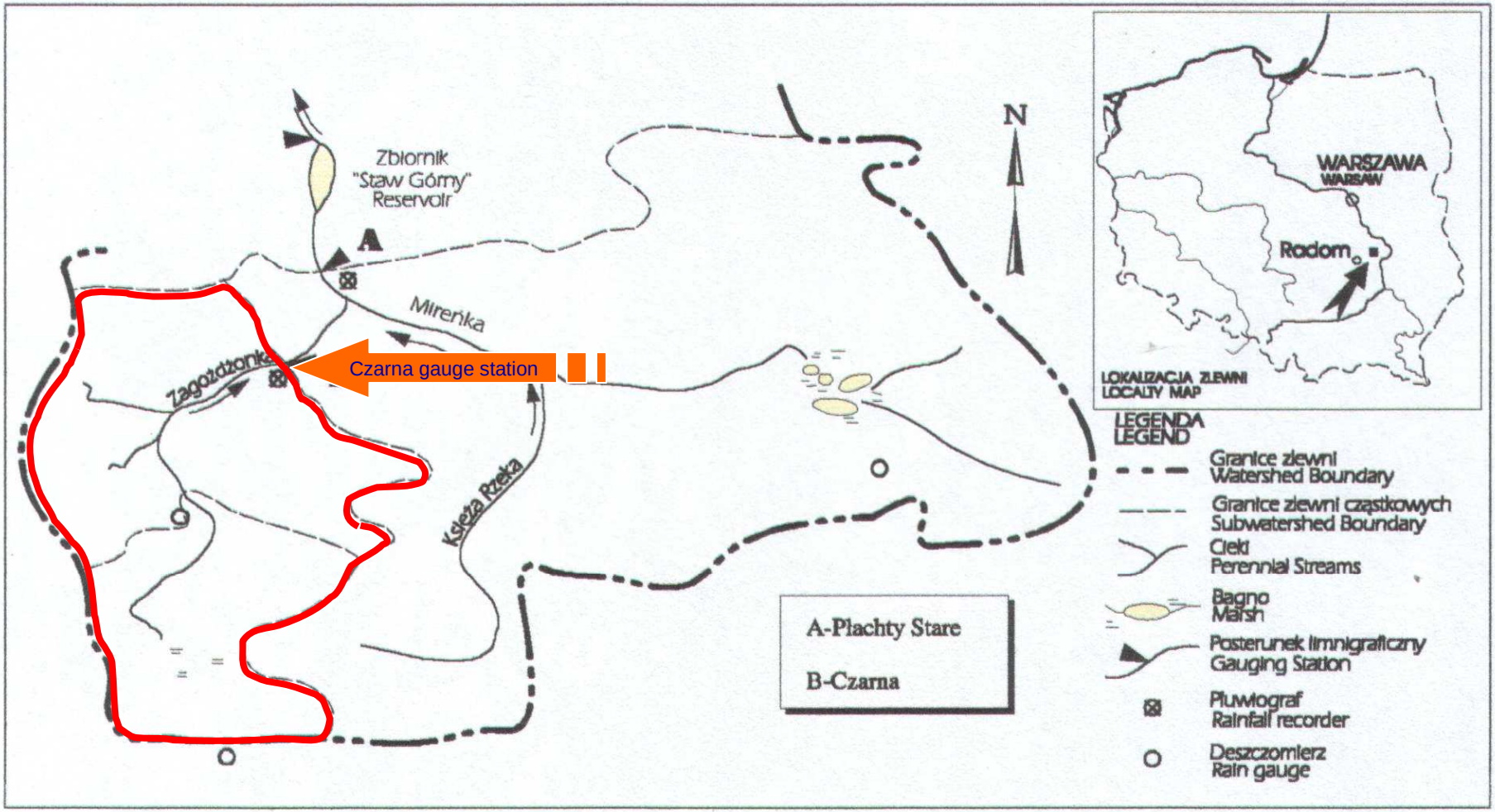



Figure 1. Locality map of Zagożdżonka watershed.

# Zagożdżonka River catchment

Basin area - 23.4 km$^2$

Absolute relief - 16.5 m

Average annual precipitation - 614 mm

Average annual runoff - 100 mm

Suspended sediment concentration

average- 14 mg/l

maximum observed - 219 mg/l

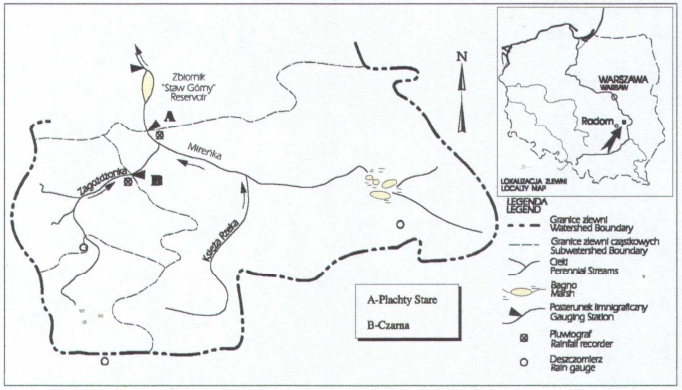
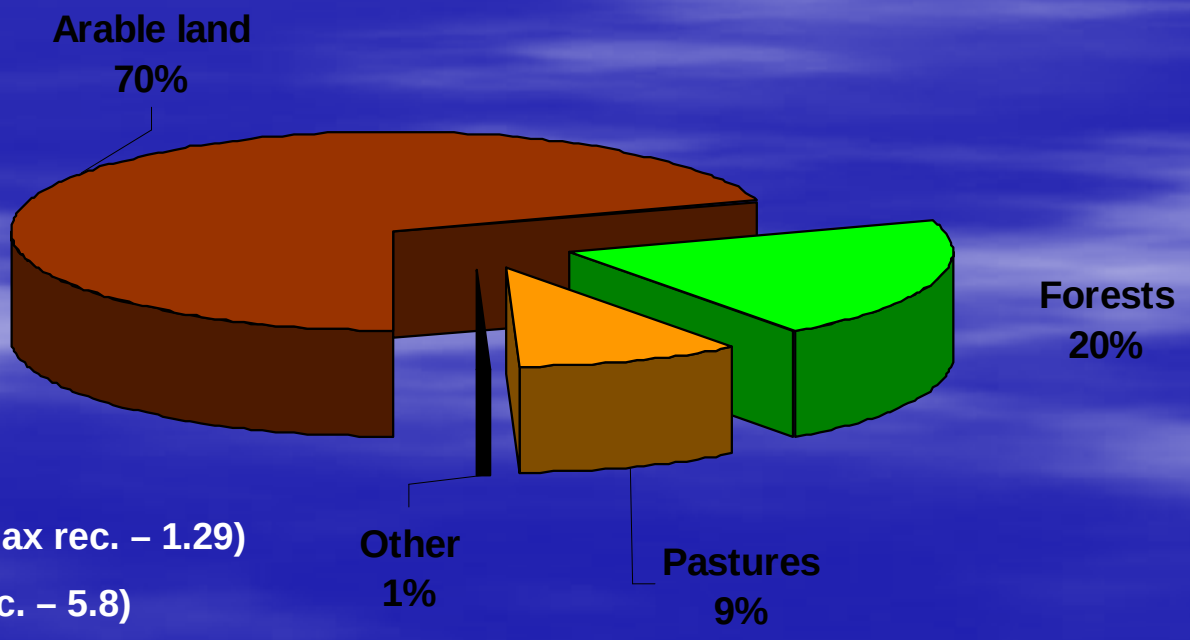


Figure 1. Locality map of Zagożdżonka watershed.

Soils:

90.7% - sandy soils,

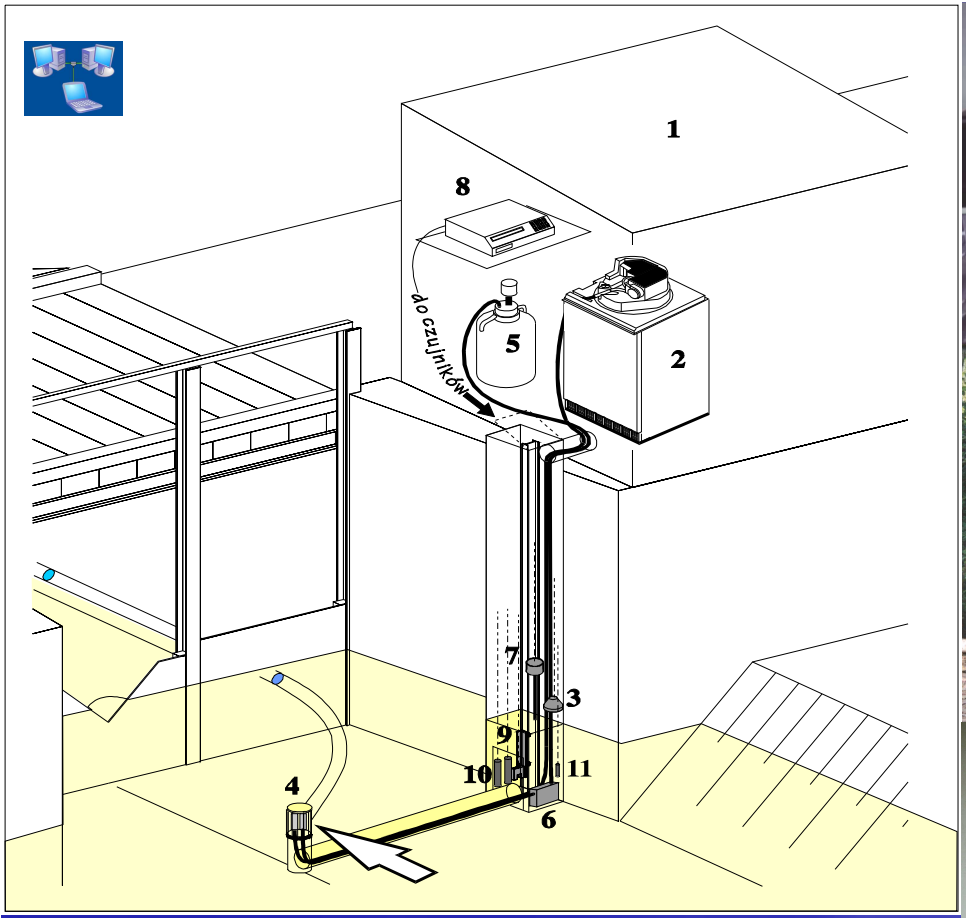
9.3% - peaty soils

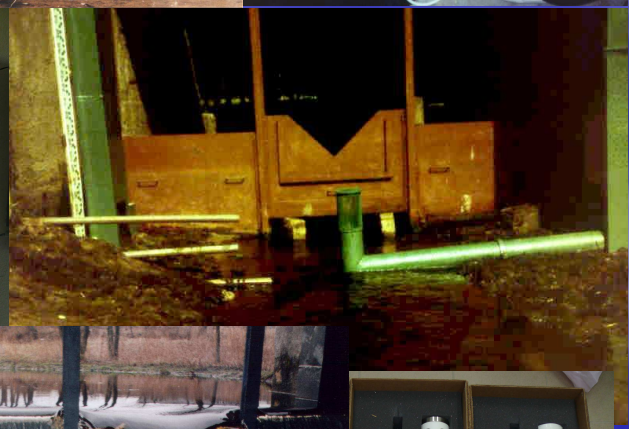



soluble phosphorus: 0.46 mg $PO_4$/l (max rec. – 1.29)

total phosphorus: 1.34 mg P/l (max rec. – 5.8)

Average fertilizers usage (kg/ha) N- 43, P-18, K-20





1-Electronic equipment place
2- automatic sampler SIGMA
3- level sensor for SIGMA sampler
4- intake nozzle
5- container with pressure switch
6- pump
7- floating pump switch
8- data logger
9- infra red turbidity sensor
10- water level sensor
11- water temperature sensor

# Comparison of annual average dissolved and total phosphorus concentrations and loads at Czarna station

Dissolved Phosphorus (P)

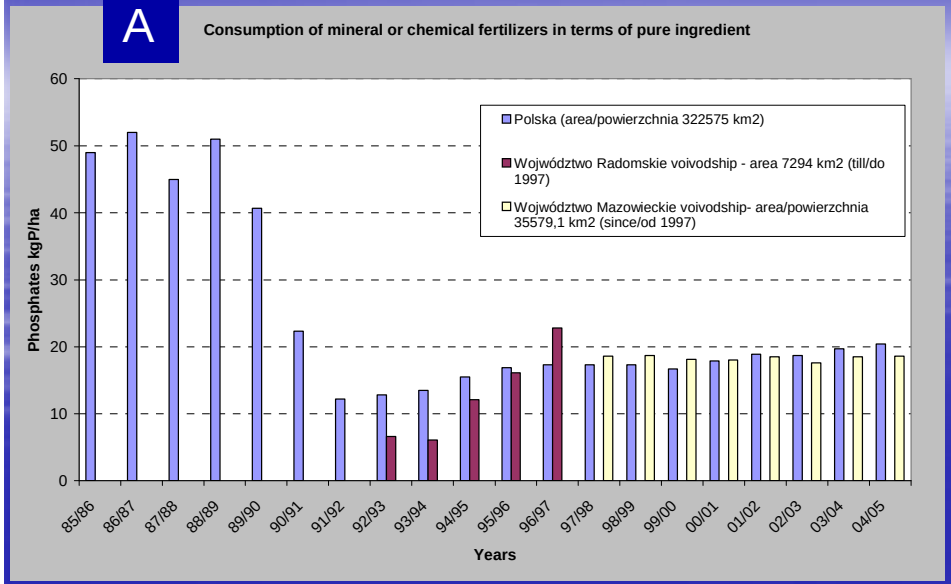
| year | NS | Average | Max | Min | Q | Load | Load |
|---|---|---|---|---|---|---|---|
| | | $mgP/dm^3$ | $mgP/dm^3$ | $mgP/dm^3$ | $m^3/s$ | kg/year | kg/year/ha |
| 1991 | 31 | 0,16 | 0,50 | 0,02 | 0,034 | 175 | 0,07 |
| 1992 | 52 | 0,13 | 0,64 | 0,04 | 0,033 | 132 | 0,06 |
| 1993 | 52 | 0,13 | 0,38 | 0,04 | 0,060 | 253 | 0,11 |
| 1994 | 49 | 0,16 | 0,42 | 0,05 | 0,060 | 309 | 0,13 |
| 1995 | 41 | 0,14 | 0,27 | 0,06 | 0,090 | 398 | 0,17 |
| Avarage | | 0,15 | | | 0,055 | 253 | 0,11 |
| 1999 | 52 | 0,14 | 0,45 | 0,03 | 0,107 | 473 | 0,20 |
| 2000 | 43 | 0,13 | 0,23 | 0,07 | 0,074 | 297 | 0,13 |
| Avarage | | 0,13 | | | 0,091 | 385 | 0,16 |
| 2008 | 35 | 0,09 | 0,20 | 0,04 | 0,055 | 158 | 0,07 |

Total Phosphorus (P)

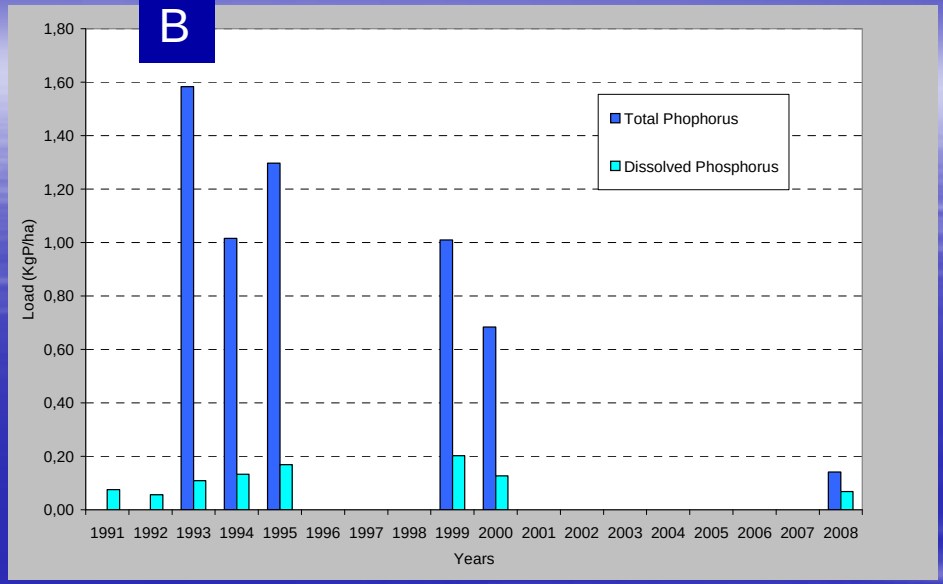
| year | NS | Average | Max | Min | Q | Load | Load |
|---|---|---|---|---|---|---|---|
| | | $mgP/dm^3$ | $mgP/dm^3$ | $mgP/dm^3$ | $m^3/s$ | kg/year | kg/year/ha |
| 1991 | | | | | | | |
| 1992 | | | | | | | |
| 1993 | 26 | 1,96 | 5,78 | 0,76 | 0,060 | 3705 | 1,58 |
| 1994 | 49 | 1,26 | 2,06 | 0,56 | 0,060 | 2377 | 1,02 |
| 1995 | 41 | 1,07 | 1,84 | 0,58 | 0,090 | 3034 | 1,30 |
| Avarage | | 1,43 | | | 0,070 | 3039 | 1,30 |
| 1999 | 52 | 0,70 | 2,64 | 0,07 | 0,107 | 2362 | 1,01 |
| 2000 | 43 | 0,69 | 1,68 | 0,18 | 0,074 | 1600 | 0,68 |
| Avarage | | 0,69 | | | 0,091 | 1981 | 0,85 |
| 2008 | 35 | 0,19 | 0,19 | 0,09 | 0,055 | 330 | 0,14 |

# Changeability of phosphorus

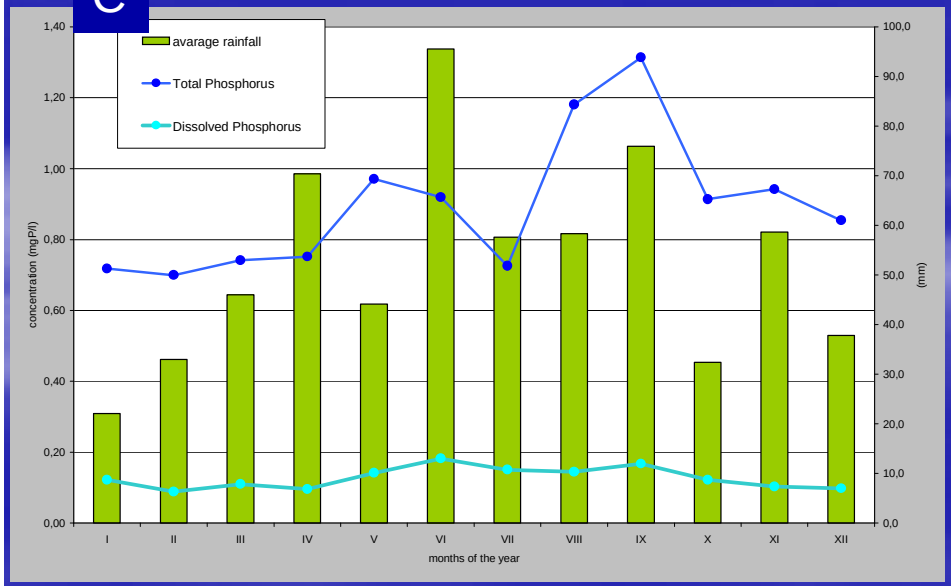
A




B




C




**A – Consumption of mineral and chemical fertilizers**

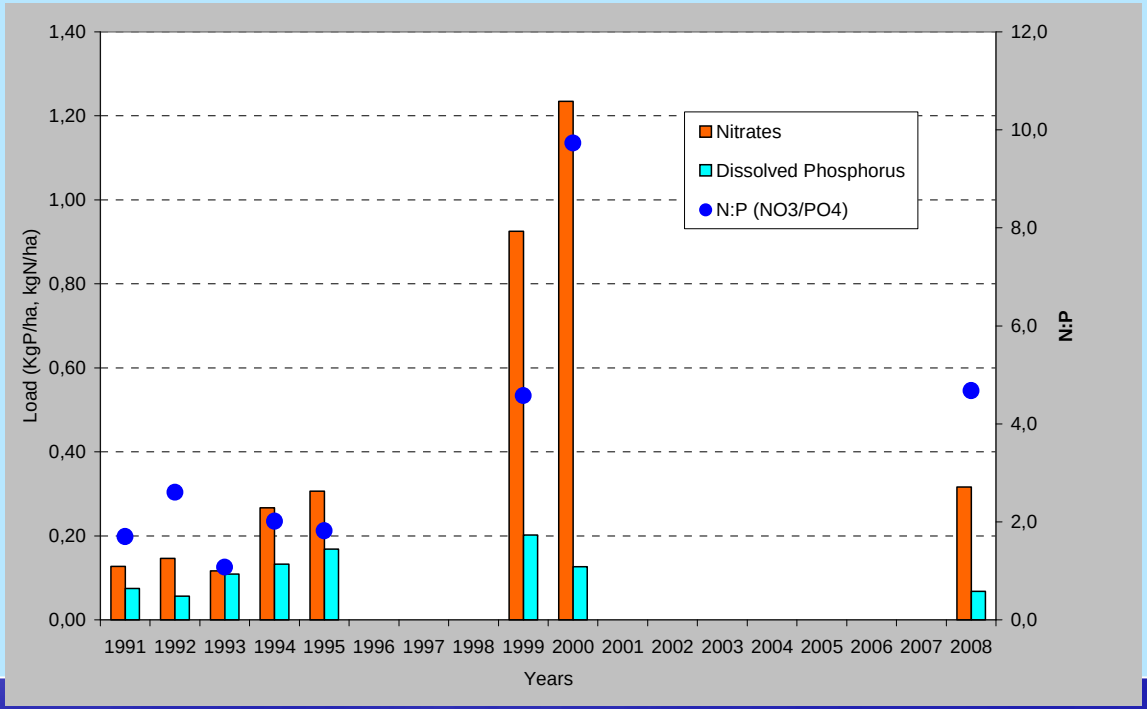
**B – Total and dissolved P loads**

**C – Monthly averages of total and dissolved P concentrations**

# Comparison of annual average nitrates concentrations and loads at Czarna

Nitrates N

| year | NS | Average | Max | Min | Q | Load | Load |
|---|---|---|---|---|---|---|---|
| | | mgN/dm$^3$ | mgN/dm$^3$ | mgN/dm$^3$ | m$^3$/s | kg/year | kg/year/ha |
| 1991 | 31 | 0,28 | 0,80 | 0,00 | 0,034 | 298 | 0,13 |
| 1992 | 52 | 0,33 | 1,64 | 0,02 | 0,033 | 343 | 0,15 |
| 1993 | 26 | 0,14 | 1,15 | 0,04 | 0,060 | 274 | 0,12 |
| 1994 | 49 | 0,33 | 1,18 | 0,03 | 0,060 | 624 | 0,27 |
| 1995 | 41 | 0,25 | 0,42 | 0,02 | 0,090 | 718 | 0,31 |
| Avarage | | 0,27 | | | 0,055 | 451 | 0,19 |
| 1999 | 52 | 0,64 | 1,50 | 0,02 | 0,107 | 2165 | 0,93 |
| 2000 | 43 | 1,24 | 5,74 | 0,09 | 0,074 | 2889 | 1,23 |
| Avarage | | 0,94 | | | 0,091 | 2527 | 1,08 |
| 2008 | 35 | 0,43 | 1,56 | 0,08 | 0,055 | 741 | 0,32 |



## Suspended sediment (SS) and phosphorus relations

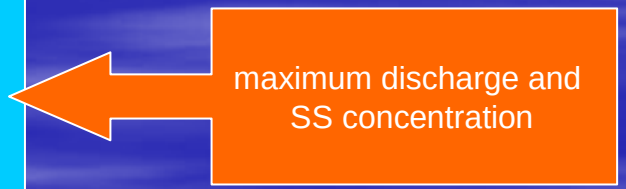
1. SS can be responsible for a significant amount of total phosphorus (TP) loads

2. The SS is transported mainly during runoff events, so it has a strong influence on phosphorus transport

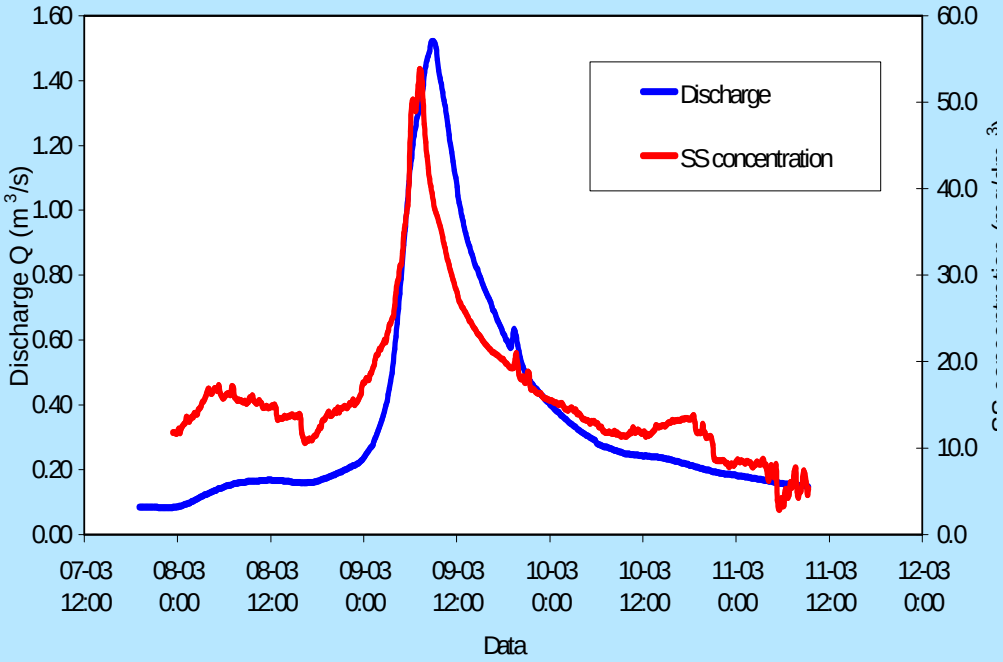
3. Some researches found an inverse relation between SS concentration and TPP concentration

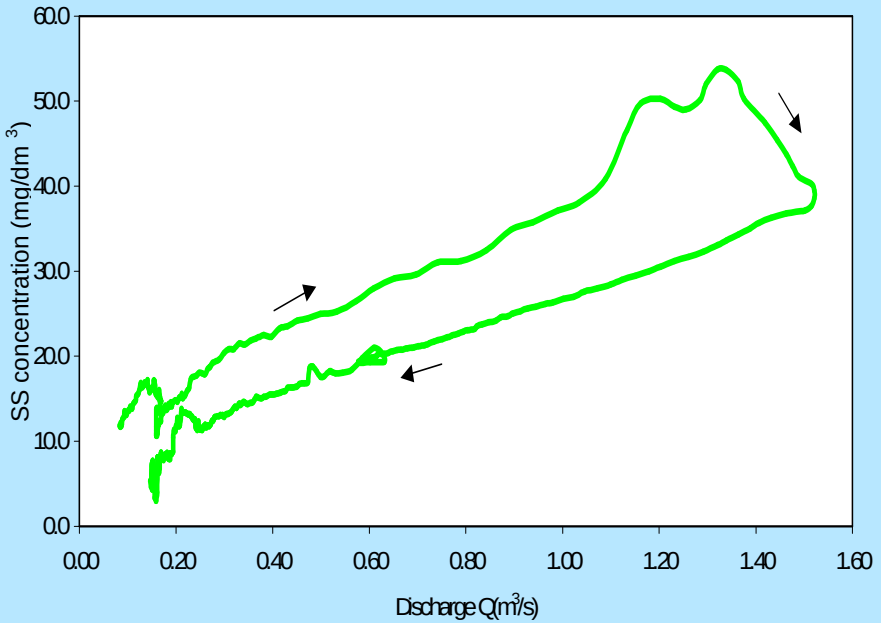
# Discharges and suspended sediment concentration

| Event | Rainfall (mm) | Runoff (mm) | Peak discharge ($m^3/s$) | Maximum SS concentration ($mg/dm^3$) |
|---|---|---|---|---|
| 1 | 15.8 | 0.45 | 0.27 | 31.5 |
| 2 | 23.0 | 0.64 | 0.34 | 32.3 |
| 3 | 26.8 | 1.14 | 0.26 | 16.3 |
| 4 | 10.3 | 0.58 | 0.24 | 23.4 |
| 5 | 19.2 | 3.25 | 1.50 | 53.7 |
| 6 | 11.1 | 0.56 | 0.34 | 23.8 |
| 7 | 48.5 | 1.72 | 0.69 | 37.4 |
| 8 | 36.9 | 1.19 | 0.35 | 33.5 |



# Discharges and suspended sediment concentration



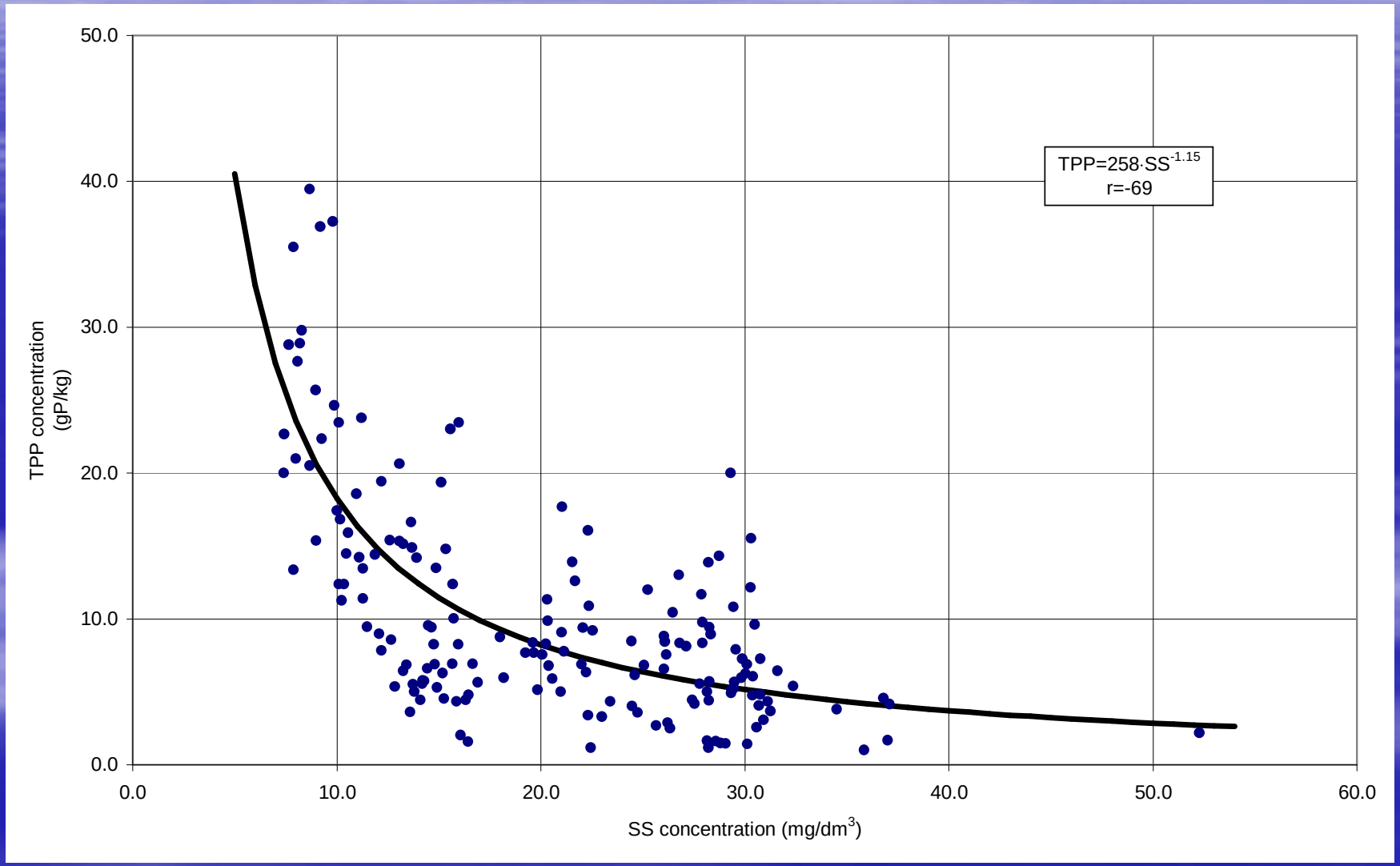



# Total phosphorus, Total soluble phosphorus

# Total particulate phosphorus

| Event | DP concentration ($mgPO_4/dm^3$) | | | TP concentration ($mgP/dm^3$) | | | TPP concentration (gP/kg) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Max | Avarage | Min | Max | Avarage | Min | Max | Avarage | Min |
| 1 | 0.40 | 0.23 | 0.25 | 0.54 | 0.31 | 0.12 | 9.5 | 4.5 | 1.2 |
| 2 | 0.76 | 0.64 | 0.53 | 1.05 | 0.53 | 0.31 | 19.8 | 9.3 | 4.1 |
| 3 | 0.91 | 0.70 | 0.46 | 1.18 | 0.65 | 0.18 | 39.1 | 20.5 | 2.0 |
| 4 | 1.60 | 0.70 | 0.39 | 0.98 | 0.52 | 0.22 | 17.1 | 7.9 | 1.2 |
| 5 | 0.65 | 0.36 | 0.22 | 0.48 | 0.33 | 0.20 | 16.5 | 7.7 | 2.2 |
| 6 | 0.44 | 0.37 | 0.31 | 0.82 | 0.25 | 0.13 | 17.5 | 7.1 | 3.6 |
| 7 | 0.82 | 0.73 | 0.59 | 0.64 | 0.44 | 0.24 | 11.2 | 5.4 | 1.0 |
| 8 | 0.35 | 0.19 | 0.11 | 0.67 | 0.48 | 0.31 | 28.6 | 16.0 | 4.7 |

# Relationship between Total Particulate Phosphorus and Suspended Sediment



# Summary

1. It seems that there is a reduction of total phosphorus loads in the Zagożdżonka river, however the reasons are not clear and will be difficult to find.

2. We did not notice a significant reduction when dissolved phosphorus and nitrates are take into consideration.

3. The phenomenon that the TPP concentration increases with decreasing of suspended sediment concentration has been confirmed in the Zagożdżonka river; however the relation is not very strong.

Thank You for Your attention

The International Association of Hydrological Sciences (IAHS)
The International Commission on Continental Erosion (ICCE)

**International Symposium on**

# Sediment dynamics for a changing future

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