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Leibniz Institute of Freshwater Ecology and Inland Fisheries

The effects of the German-Polish expansion of the Odra River on nutrient retention and water quality

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Groningen, 15/04/2024

Photo: Solvin Zankl

Fig..1 : Groynes along Waal river (NL), captured with Google Earth

Fig. 2: Buckling groynes on Reunion, captured with Google Earth

- Fig. 3: Groynes made of rockfill in England, Frake et al. (2013)

Fig. 4: Permeable groynes in Australia, Rutherfurd et al. (2007)

Contents

1

Study area

Study Area

Shares of the **neighboring countries**:

Poland: 89 %
Germany: 6 %
Czech Republic : 5 %

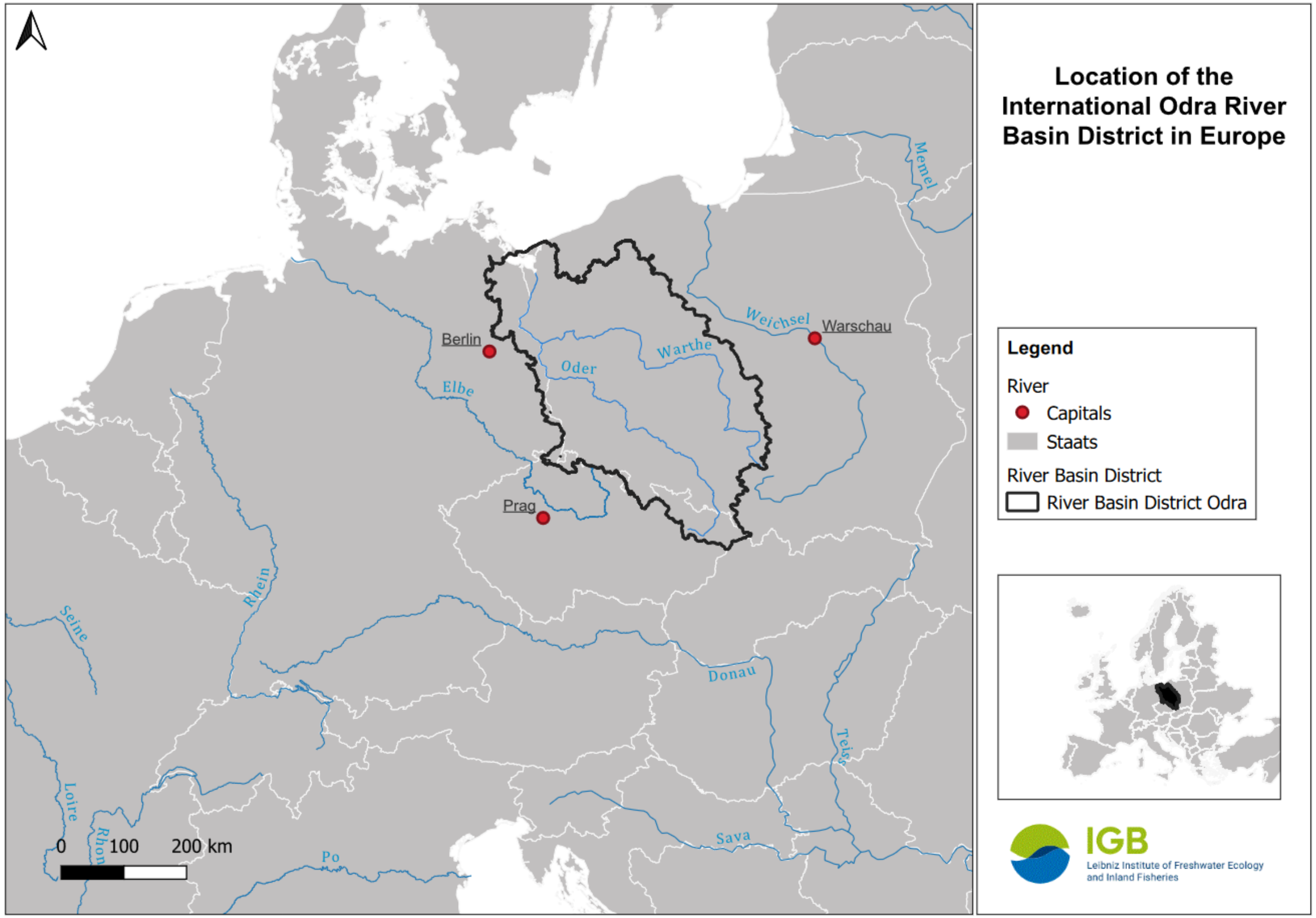
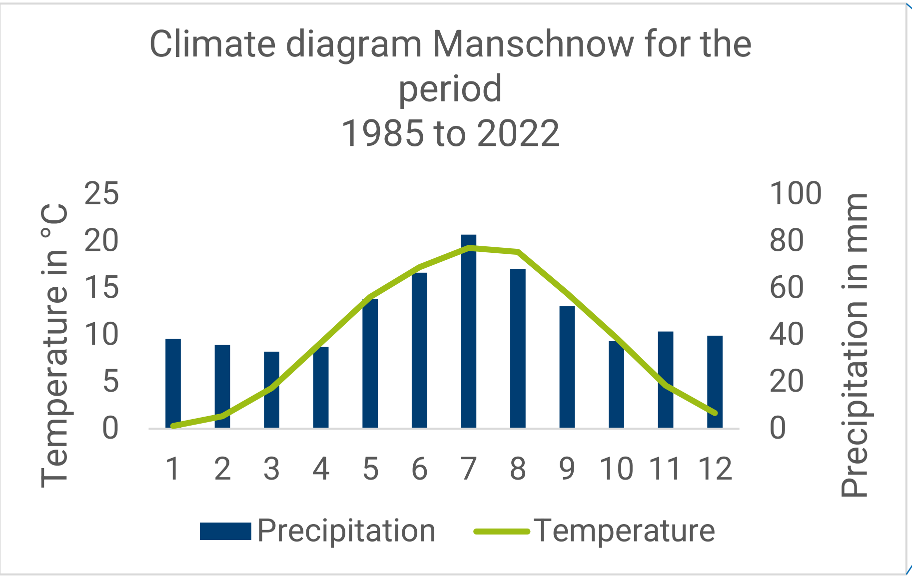


Fig. 5: Location of the interantional river basin district Odra in Europe

Study Area



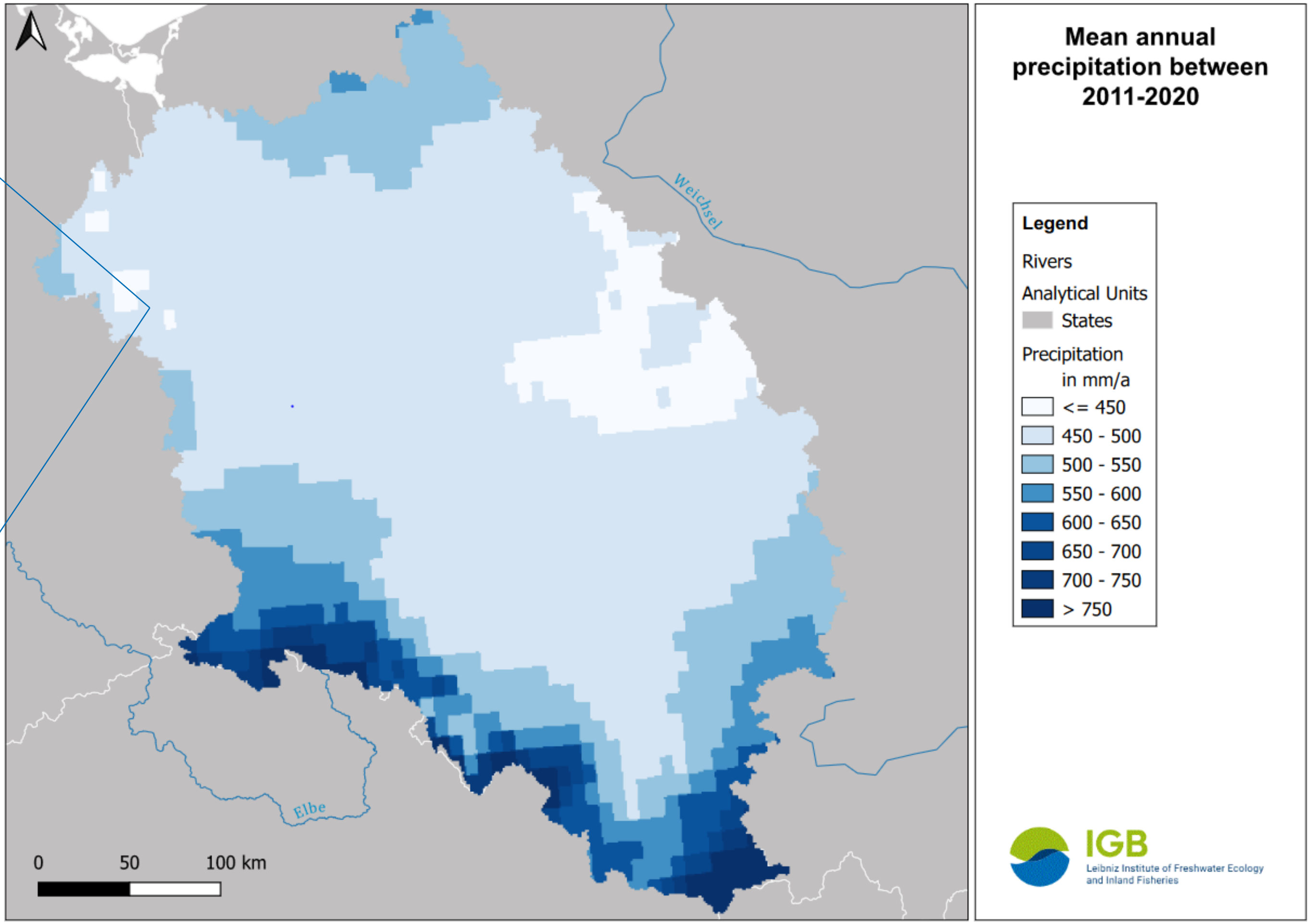


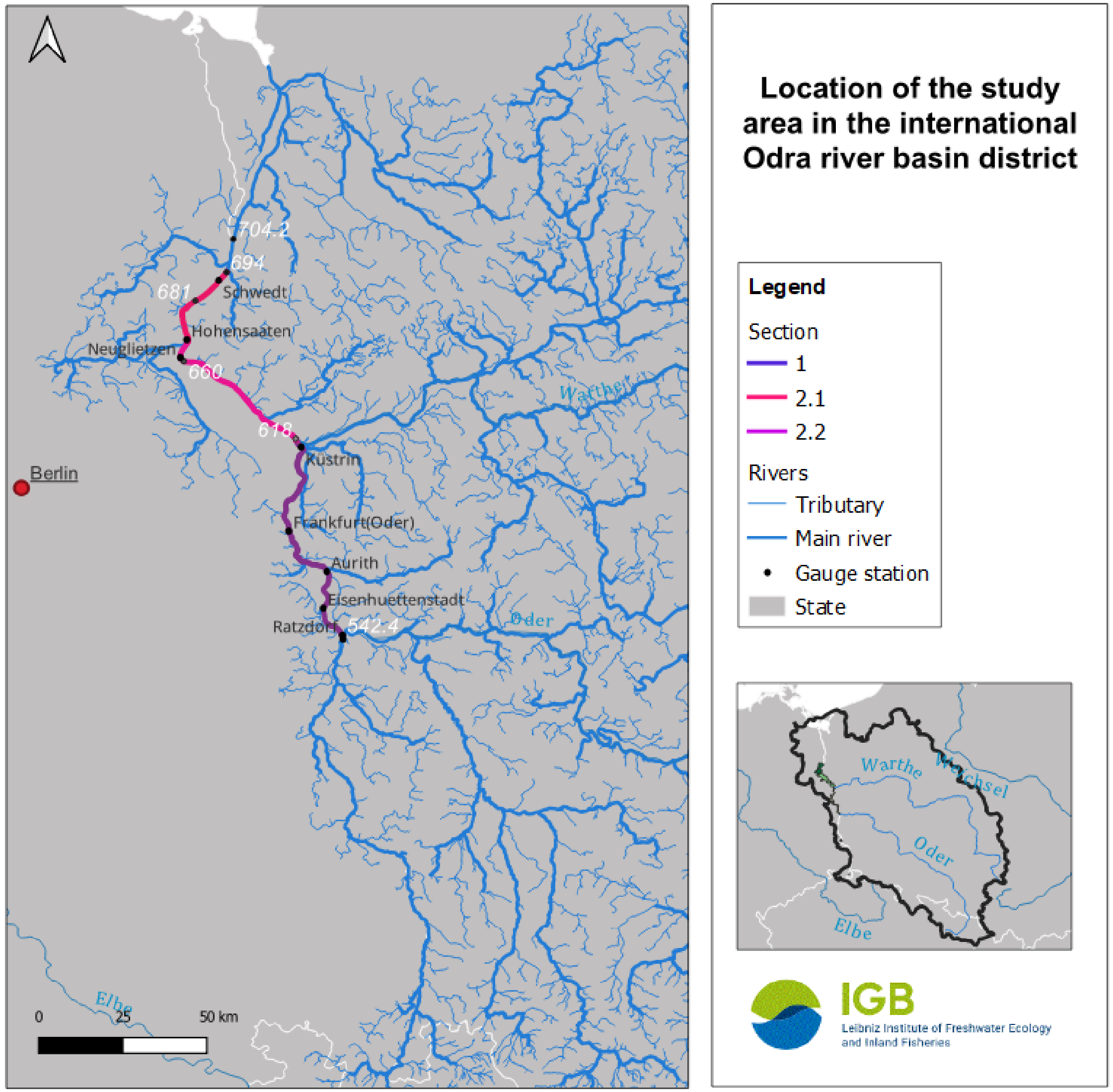
Fig. 6 & 7: Climate diagram & distribution of precipitation in the study area

Study Area

- Mean monthly calculations for the years **2011** to **2020**

- Derivation of the groyne field geometries based on the specifications of the Stream control concept (BAW, 2014)

Fig. 8: Location of the study area



Study area

- Average channel deepening from 1.60 m to 1.80 m
- Standardization of groynes spacing and length
- Maintenance of existing groynes
- Standardization of the groyne head distance

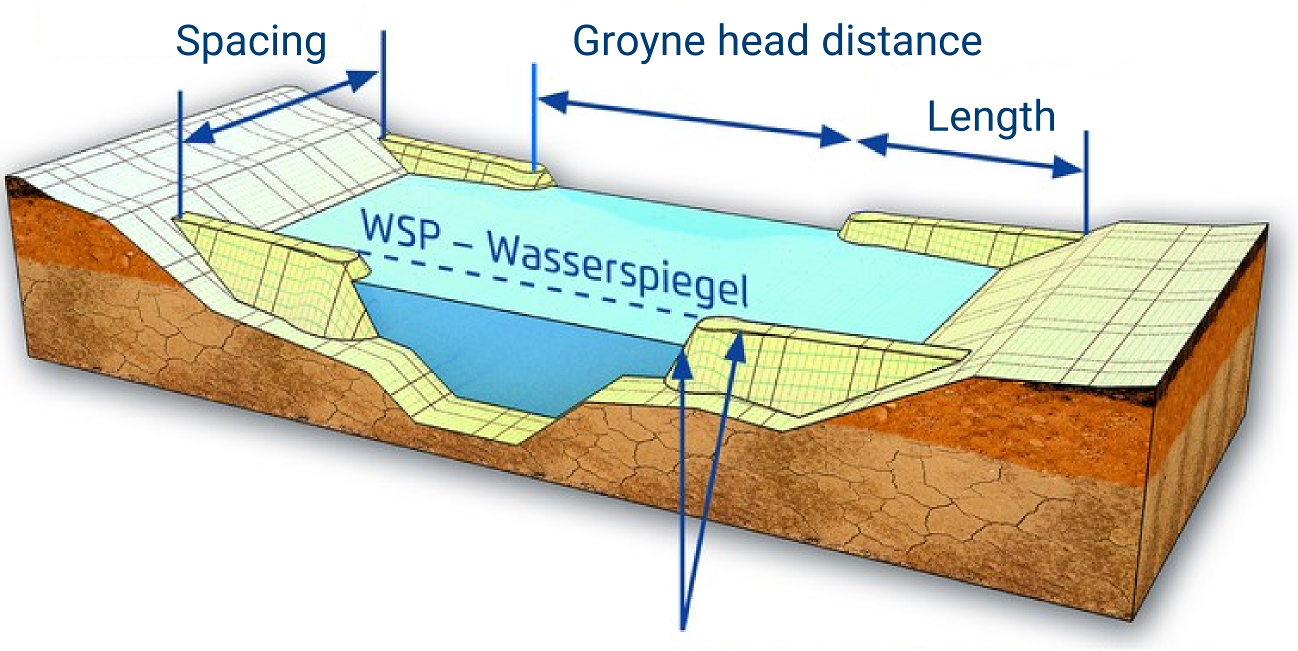


Fig. 9: Conceptual representation of hydraulic engineering measures (BAW, 2014)

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Methods

Material and methods

Hydrological transportation model	Water quality model	Nutrient flow model
Complex	**Less complex**	**Easy to use**
No consideration of groyne fields	Integrated groyne field approach	No consideration of hydraulic engineering measures to date

Material and methods

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SWAT (Soil & Water Assessment Tool)	QSim	moneris
Hydrological transportation model	Water quality model	Nutrient flow model
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Material and methods

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Material and methods

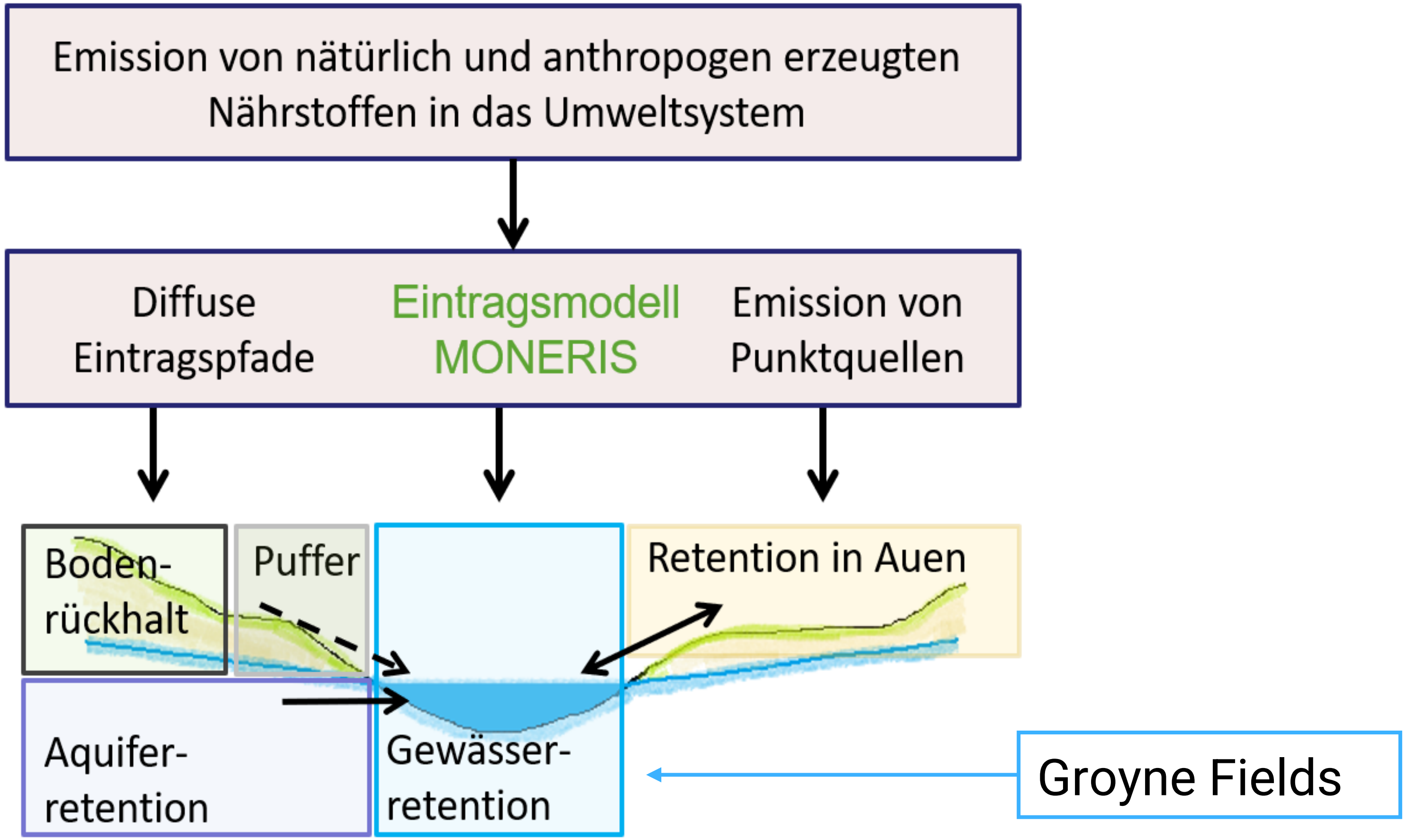

Abb. 11: Structure of MONERIS and classification of the work

(Venohr 2018)

Material and methods

Based on approaches according to BEHRENDT & OPITZ (2000), VENOHR (2006), VENOHR ET AL. (2011)

Retention approach

$$R_{HL} = (1 - \frac{1}{1 + k_{B1} \cdot HL^{k_{B2}}})$$

Modification of the approach to include the newly introduced groyne field factor (GFF)

R_{HL} = Retention of emissions [-]

$k_{B1,2}$ = Model parameters

HL = Hydraulic load [$m\ m^{-1}$]

Material and methods

Groyne field as a mixed reactor

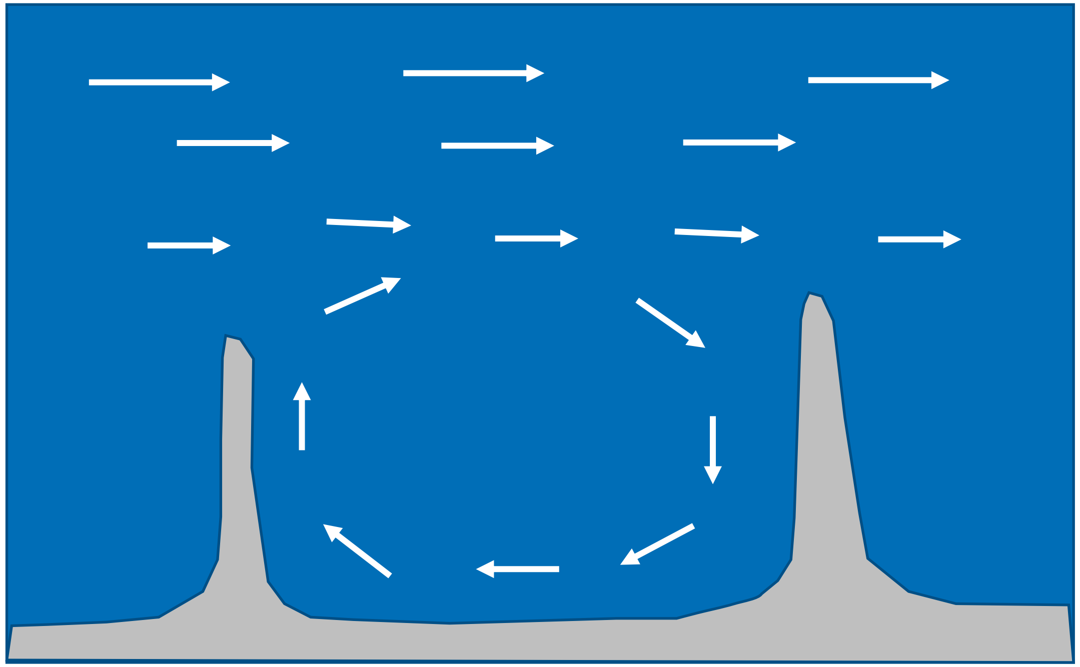

Fig. 12 : Flow in groyne fields according to Sukuhodolov (2002)

Modification of the approach to include the newly introduced groyne field factor (GFF)

Material and methods

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Calculation of residence time according to BAUMERT & DUWE (2006)

$$\tau_2 = \frac{\tau_2^0}{1 + Q/q_2}$$

Modification of the approach to include the newly introduced groyne field factor (GFF)

τ_2 = Average residence time in the groyne field [h]

τ_2^0 = 12 h

q_2 = 400 [m³/s]

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Material and methods

Calculation of residence time according to BAUMERT & DUWE (2006)

$$\tau_2 = \frac{\tau_2^0}{1 + Q/q_2}$$

$$Ex = \frac{(30 \cdot 24)}{\tau_2}$$

$$V_A = \frac{(V_{GF} \cdot Ex)}{(30 \cdot 24 \cdot 60 \cdot 60)}$$

$$\boldsymbol{GFF} = \frac{V_A}{Q_{tot}}$$

Ex = Average exchange rate [-]

V_{GF} = Groyne field volume [m^3]

GFF = Groyne field factor [-]

V_A = Exchange volume [m^3/a

Q_{tot} = Total discharge [m^3/a]

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Results

Results

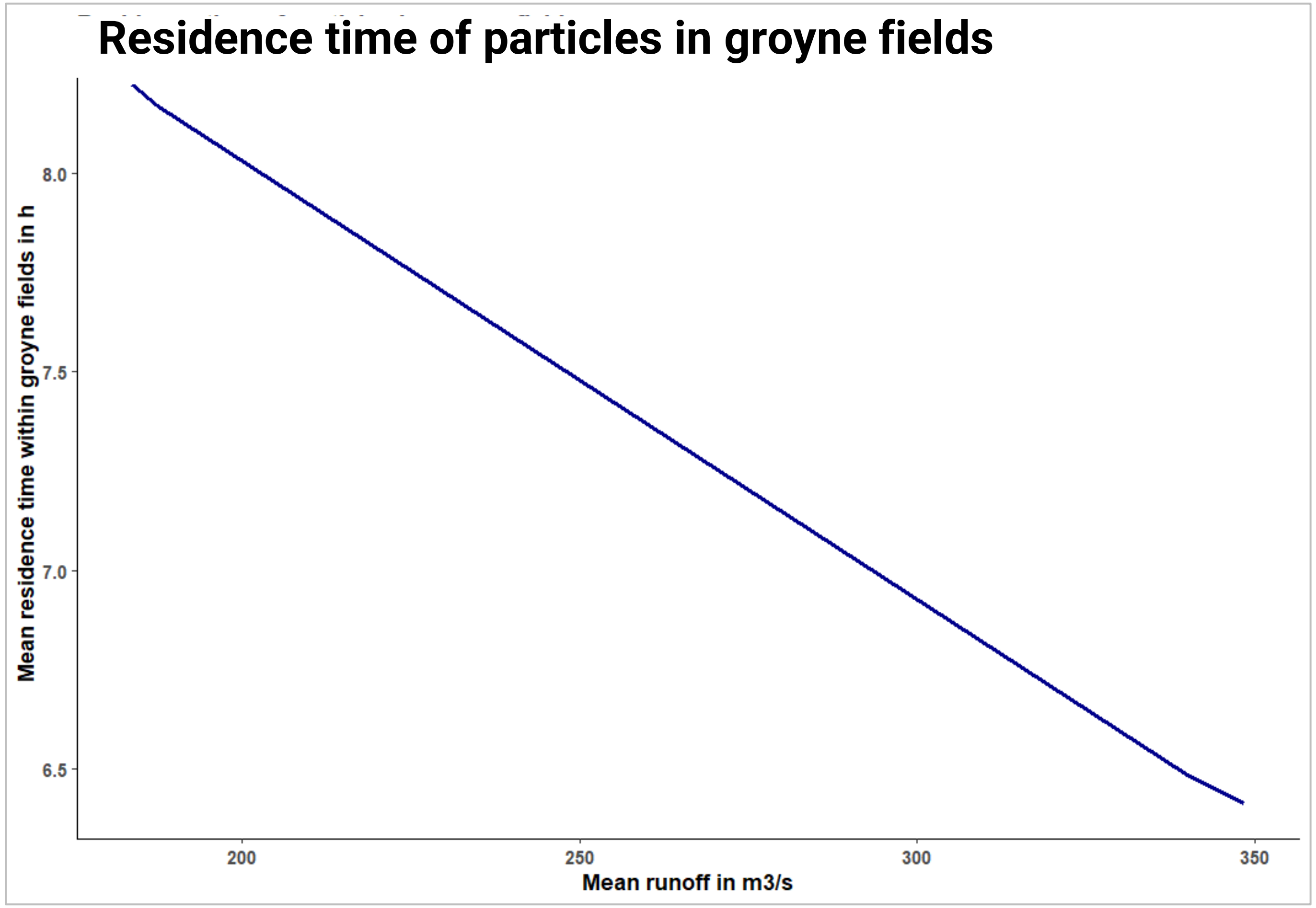
Residence Time

Winter: 4,6 - 6,7 h

Summr: 6,4 – 8,2 h

GFF ranges between 0,3 to 0,0029 %

HL in the groyne field is in the range of 1.900 to 10.200 m a^{-1}



Results

	N-Load	N-Retention	P-Load	P-Retention
Total input	66.073,50 (t/a)	(-)	3.197,52 (t/a)	(-)
Reference	65.339,94 (t/a)	1,11 %	3.187,74 (t/a)	0,30579 %
Groyne fields	65.324,16 (t/a)	1,134 %	3.187,73 (t/a)	0,30625 %

N-Retention: + 2,11 %

P-Retention: + 0,15 %

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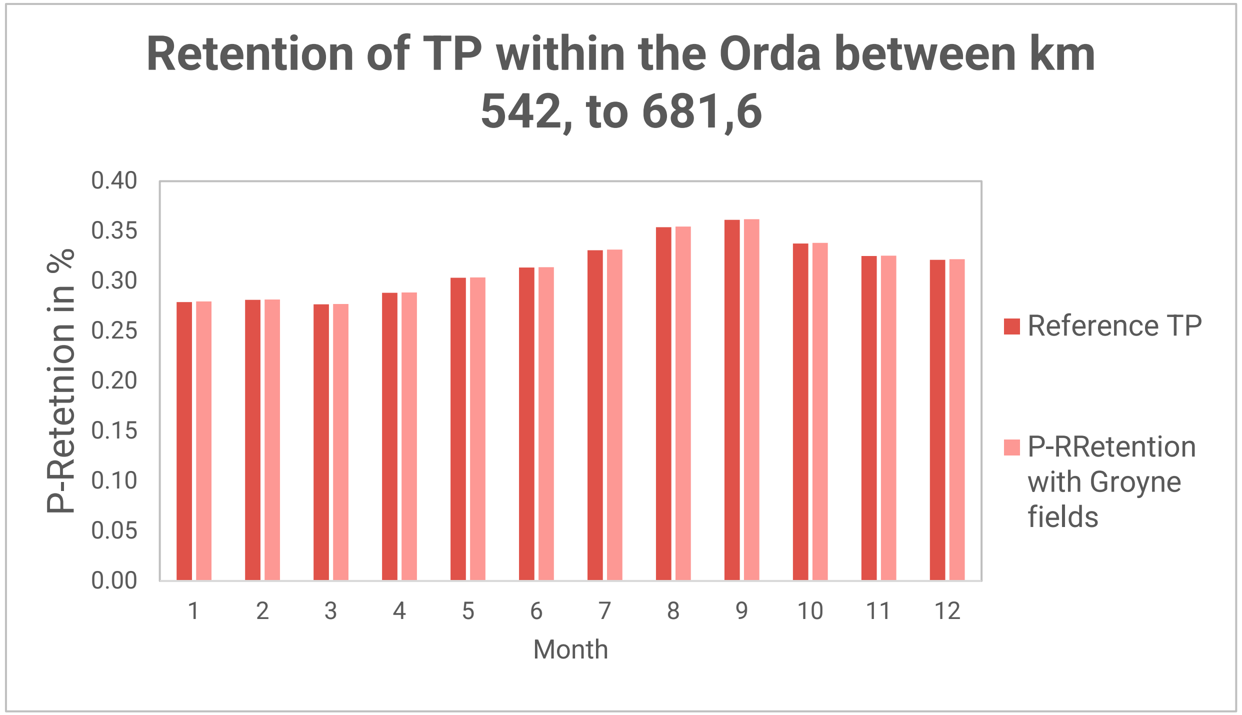

Fig. : Comparsion of in-stream TP-retention

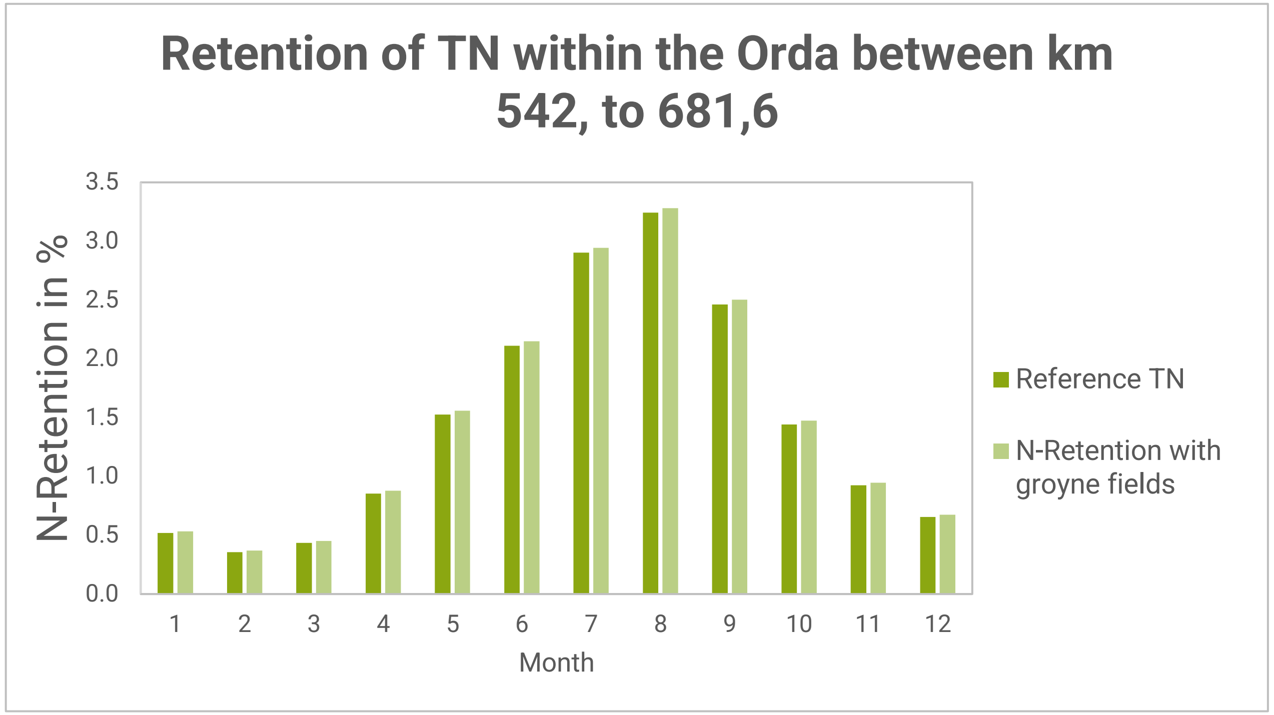

Fig. : Comparsion of in-stream TN-retention

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Discussion

Discussion

- **Minor changes in nutrient retention detectable**
    - No differences in nutrient loads documented by using QSim in the Middle Elbe (Schöl et al. 2006)
- **Retention capacity of groyne fields depending on:**
    - Level of nutrient inputs,
    - flow conditions,
    - water temperature,
    - plant growth (Gücker 2004, Sukhodolov et al. 2017, Pusch & Fischer 2006)

- **Occurrence of seasonal fluctuations in retention capacity**

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Conclusion

Conclusion

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- No major changes in nutrient retention and water quality recognizable due to expansion plans

- Nutrient retention is particularly dependent on inputs and environmental factors

- Further **need** of **nutrient reduction** in the Odra catchment area

Coupling groyne field approch with algae growth → Updating data records → Include other variables → Load validation

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Thank you very much for your attention!

If you have any questions, please contact:

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