



Efficacy of source control, use-related, and end-of-pipe legislation quantified for a 64-year river water quality trajectory of phosphorus loading

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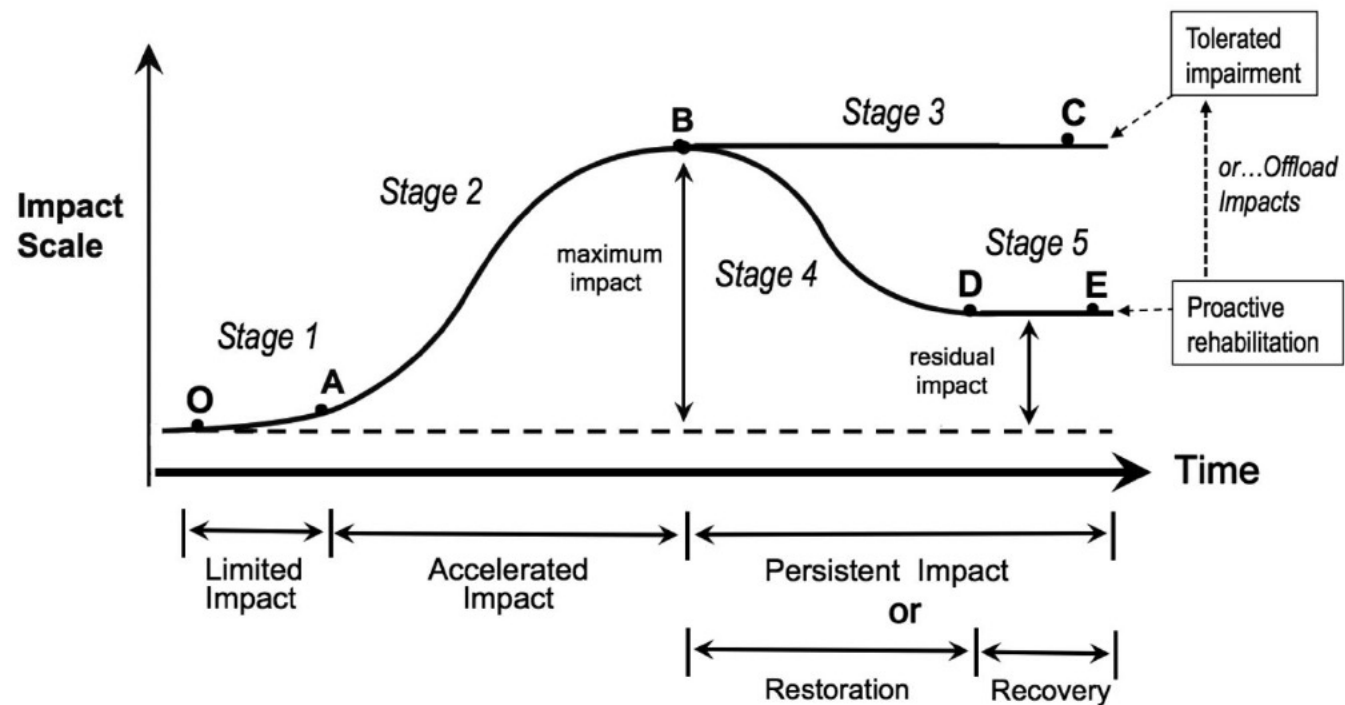
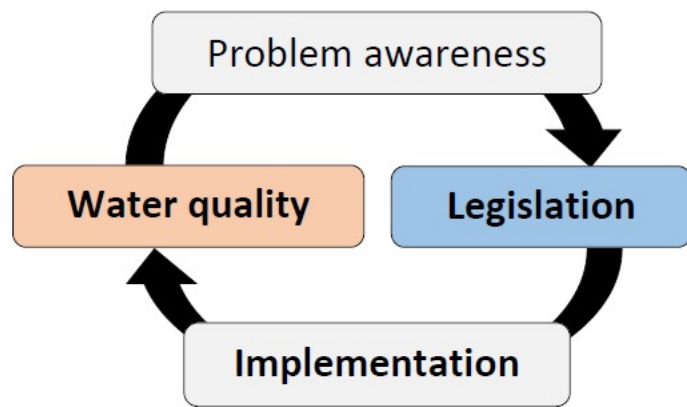
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Approach and key questions

- What's the relationship between mitigation measures, including legislative interventions, and their long-term effects on water quality?

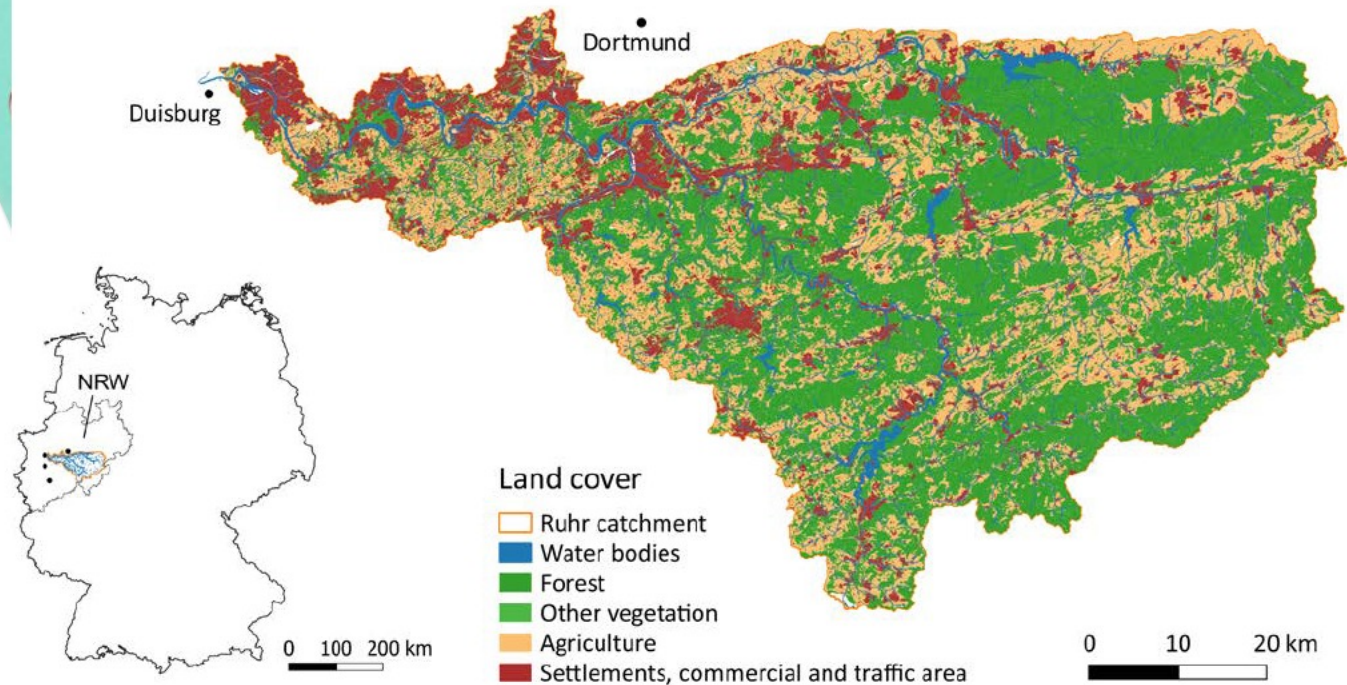


A Heuristic Model or Typology of Water System Impacts and Societal Response to Water-Related Environmental Stress. Source: Vörösmarty, C. J., Meybeck, M., & Pastore, C. L. (2015). Impair-then-Repair: A Brief History & Global-Scale Hypothesis Regarding Human-Water Interactions in the Anthropocene. *Daedalus*, 144(3), 94–109. https://doi.org/10.1162/DAED_a_00345

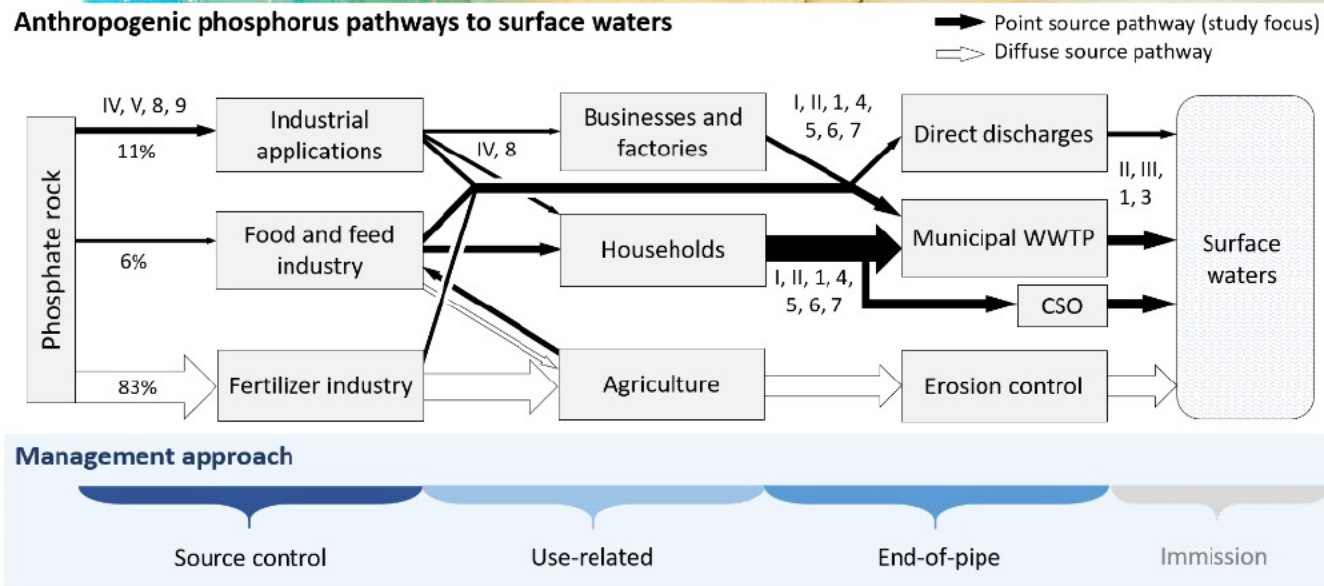


Approach and key questions

- Phosphorus (P)
- Legislative approaches towards P management classified in
 - source control,
 - use-related, and
 - end-of-pipe
- Point and diffuse sources
- Ruhr catchment

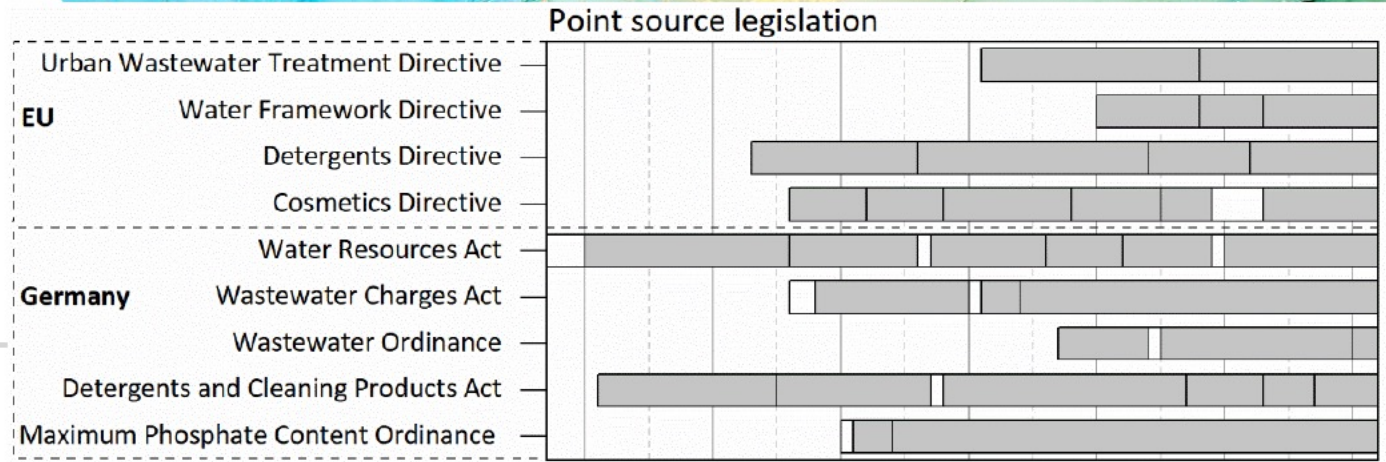


Anthropogenic phosphorus pathways to surface waters



Results and discussion

Point sources

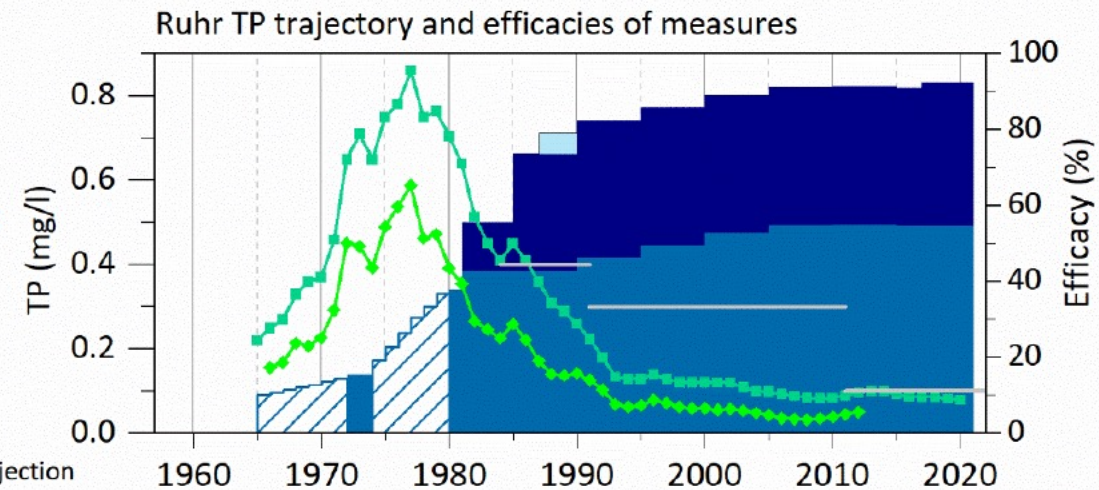


····· relevant revision
 - - - - date of enforcement
 - - - - adoption of legislation

River water quality
 — TP
 — TP attributed to WWTPs
 — water quality limit

Efficacy

 use-related
 source control
 end-of-pipe
 end-of-pipe historical projection



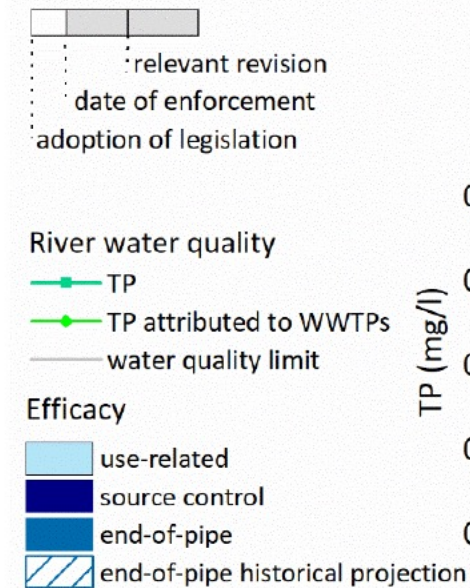
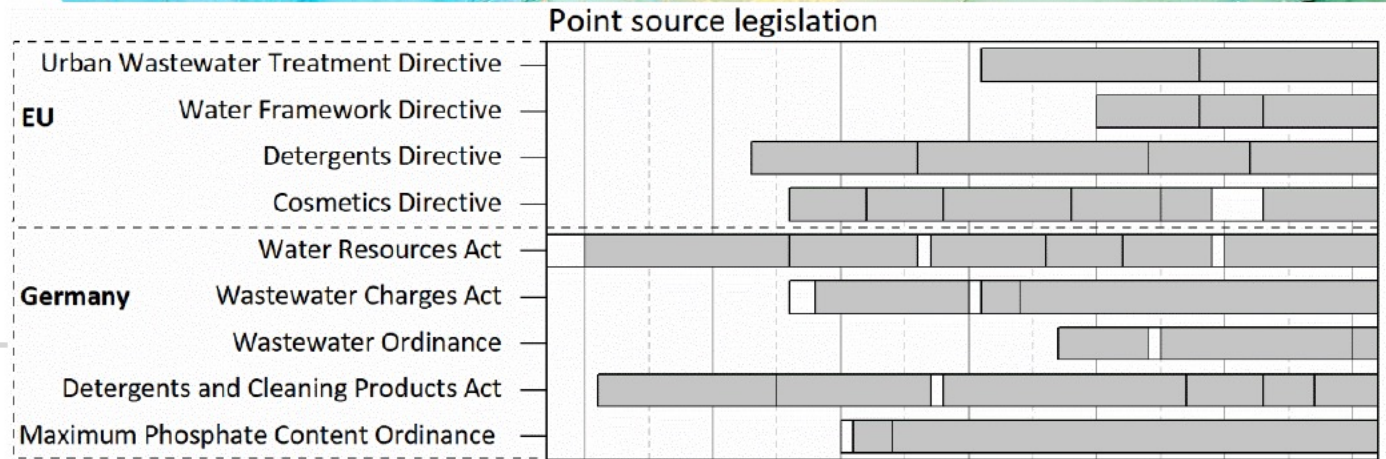
Point source legislation on EU and national levels (upper panel) and total phosphorus (TP) concentration trajectory, as well as the share attributed to wastewater treatment plant (WWTP) effluents, at the outlet of the river with efficacies of measures in the Ruhr river (lower panel).

Results and discussion

Point sources

Most effective: combination of end-of-pipe and source control legislation

- source control: effective way to curb TP inputs to surface waters quickly early-on
- end-of-pipe legislation: necessary complementary measure
- efficacy almost doubled between 1980 and late 1980s (introduction of biological treatment stages and the first source control measure)



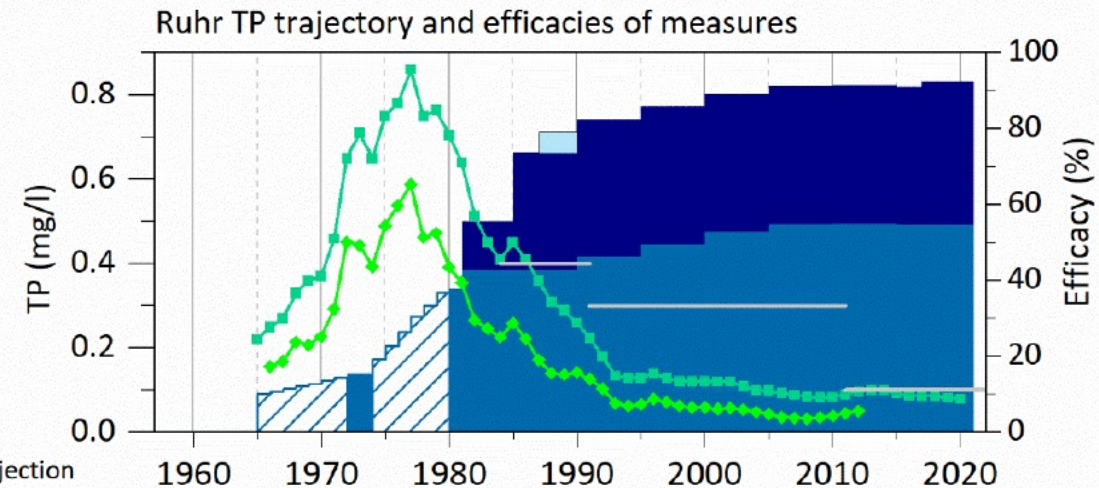
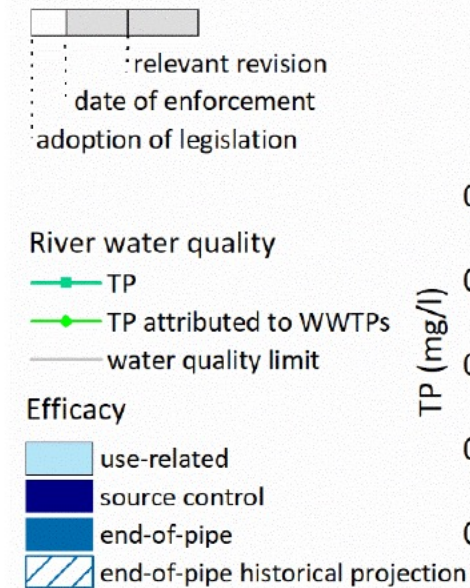
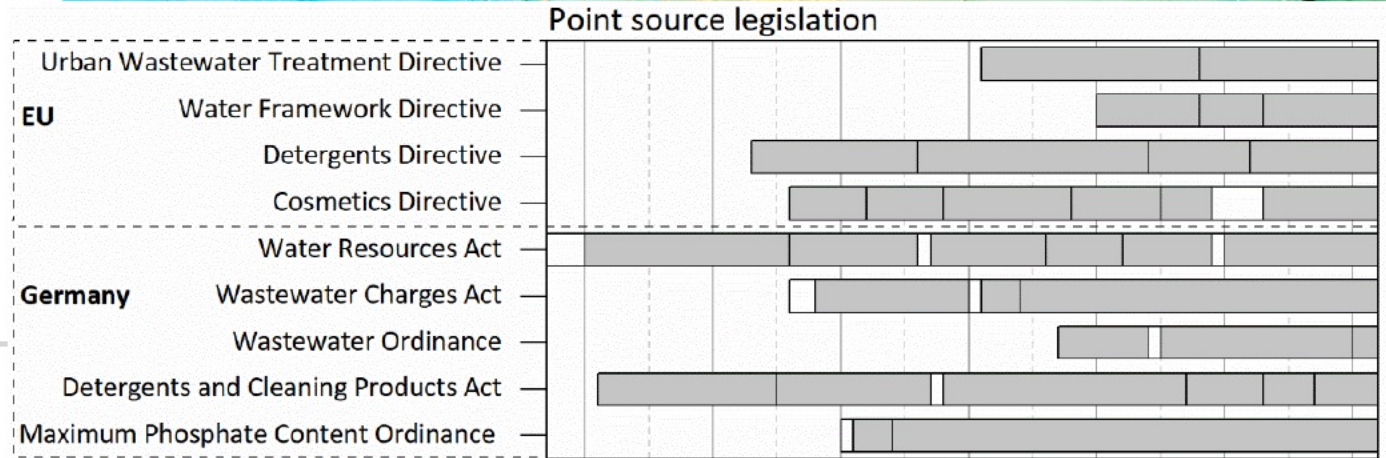
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Results and discussion

Point sources

Implementation challenges and time lags

- End-of-pipe implementation initially slow
- Source-control: decade-long delay between recognition of the problem and legislative measures

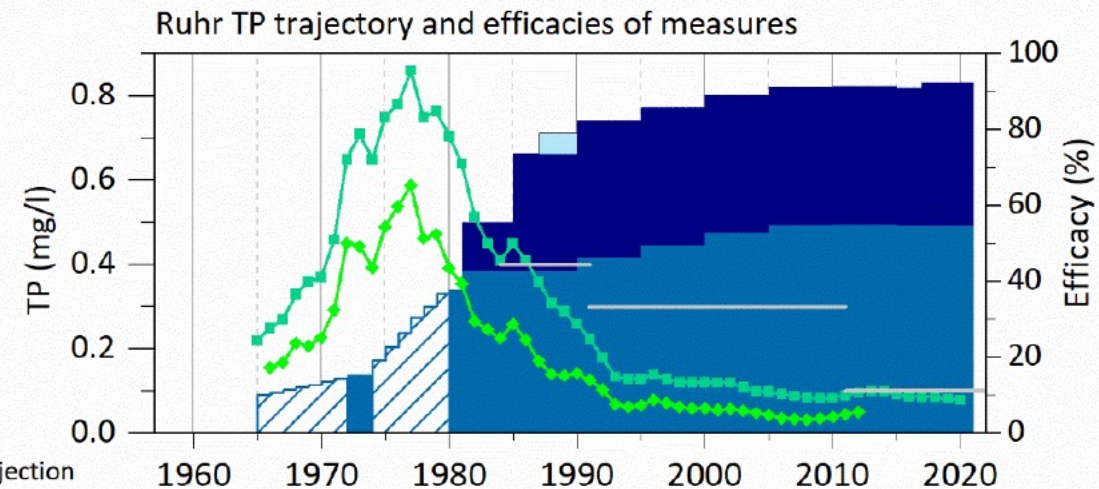
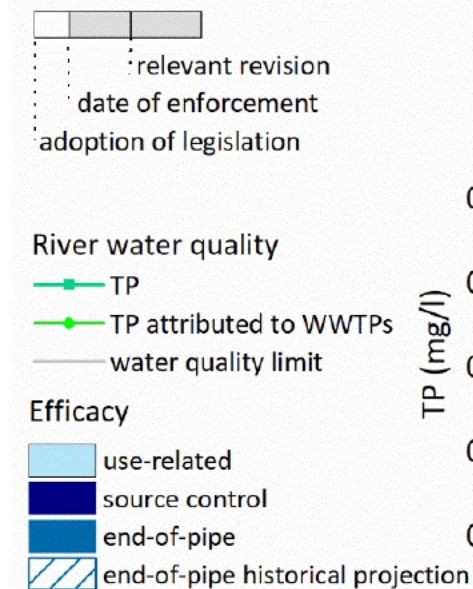
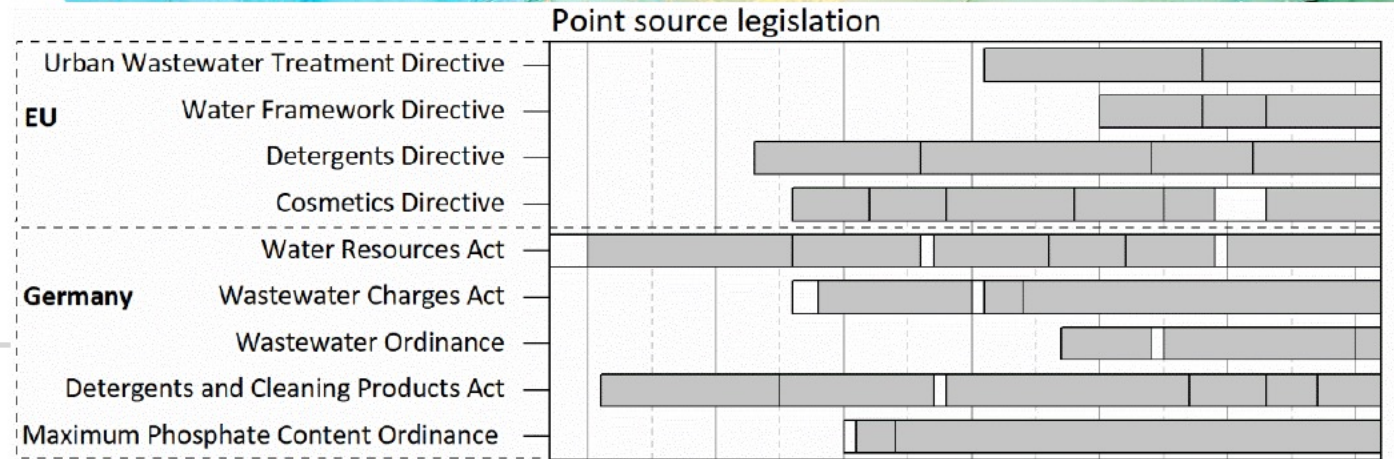


Point source legislation on EU and national levels (upper panel) and total phosphorus (TP) concentration trajectory, as well as the share attributed to wastewater treatment plant (WWTP) effluents, at the outlet of the river with efficacies of measures in the Ruhr river (lower panel).

Results and discussion

Point sources

- Local interests, actors, and monitoring make a difference
- continuous monitoring in WWTP influents necessary to identify changes in inputs, f.ex. for emerging contaminants

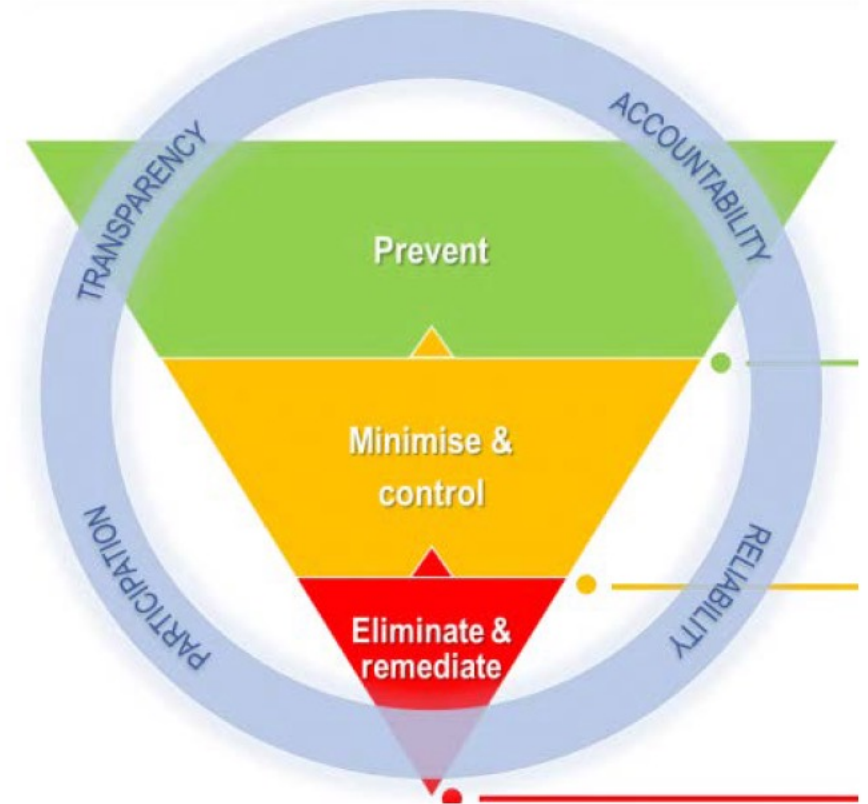


Point source legislation on EU and national levels (upper panel) and total phosphorus (TP) concentration trajectory, as well as the share attributed to wastewater treatment plant (WWTP) effluents, at the outlet of the river with efficacies of measures in the Ruhr river (lower panel).

Outlook

- Source control and, where needed, use-related measures should be prioritized, because they are the most cost- and time-saving approach to manage water quality
- Applicability to other substances?

The Zero Pollution Hierachy

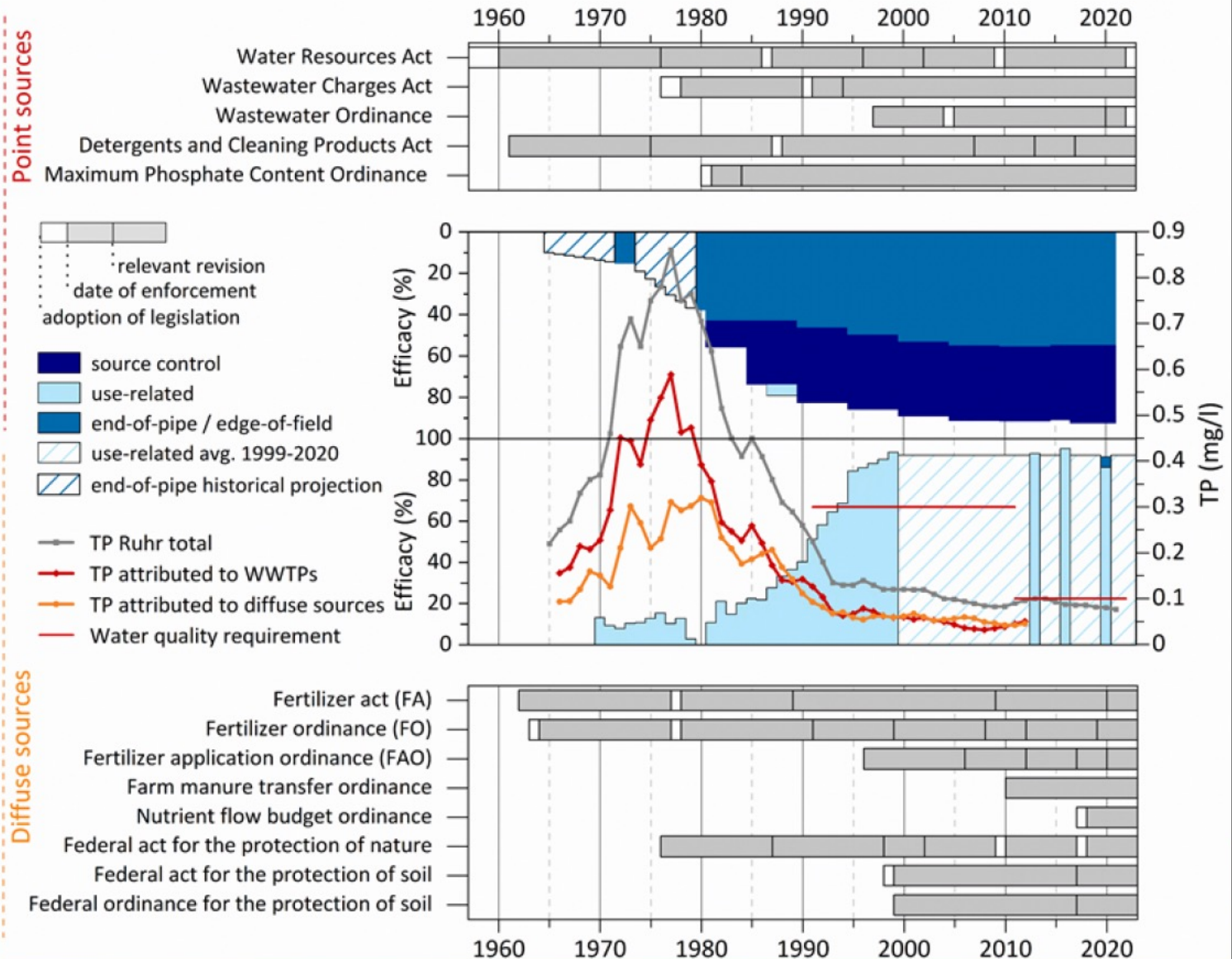


Source: The European Commission (2021): Pathway to a Healthy Planet for All EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil'. COM(2021) 400 final. [Link](#)

Outlook

➤ What about diffuse sources?

Phosphorus (P) legislation, efficacies of measures, and Ruhr total phosphorus (TP) trajectory



Thank you!
Questions?

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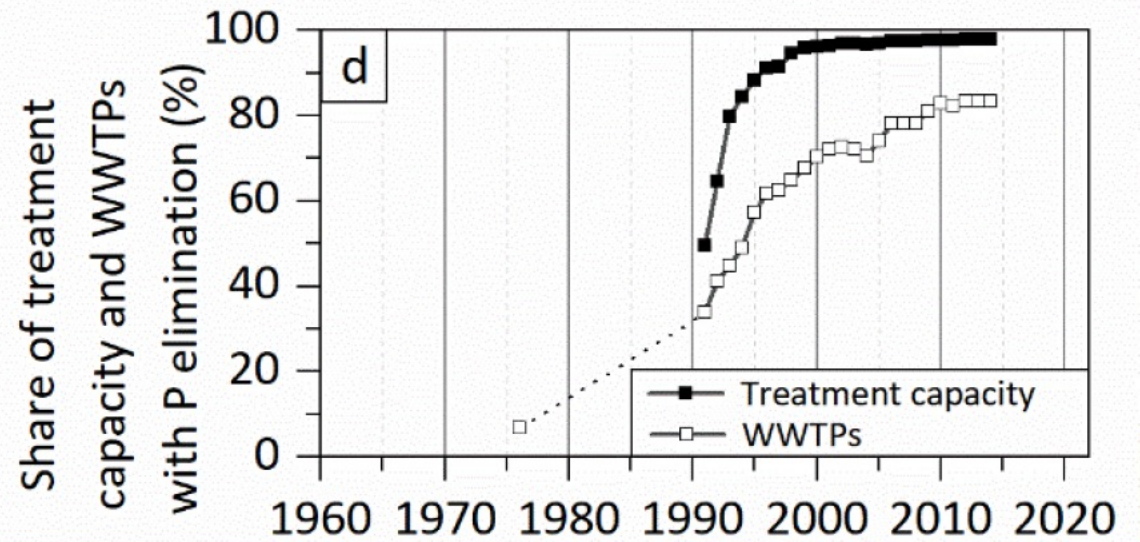
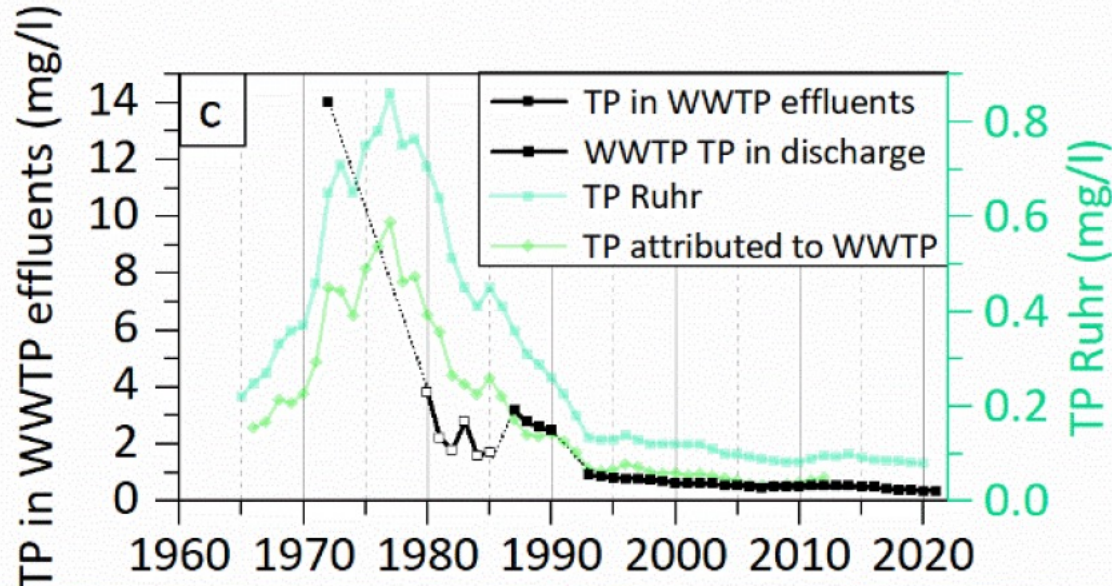
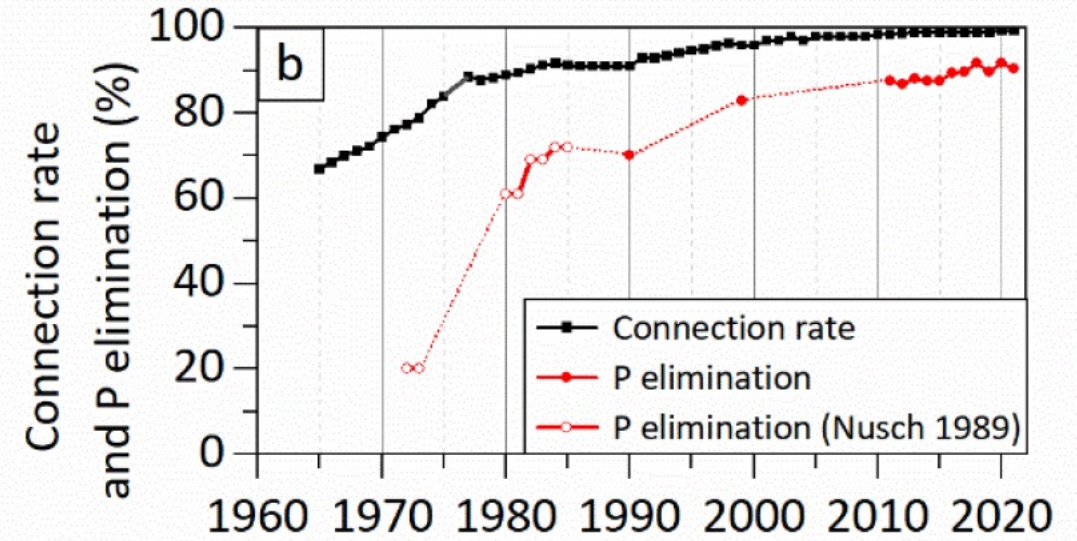
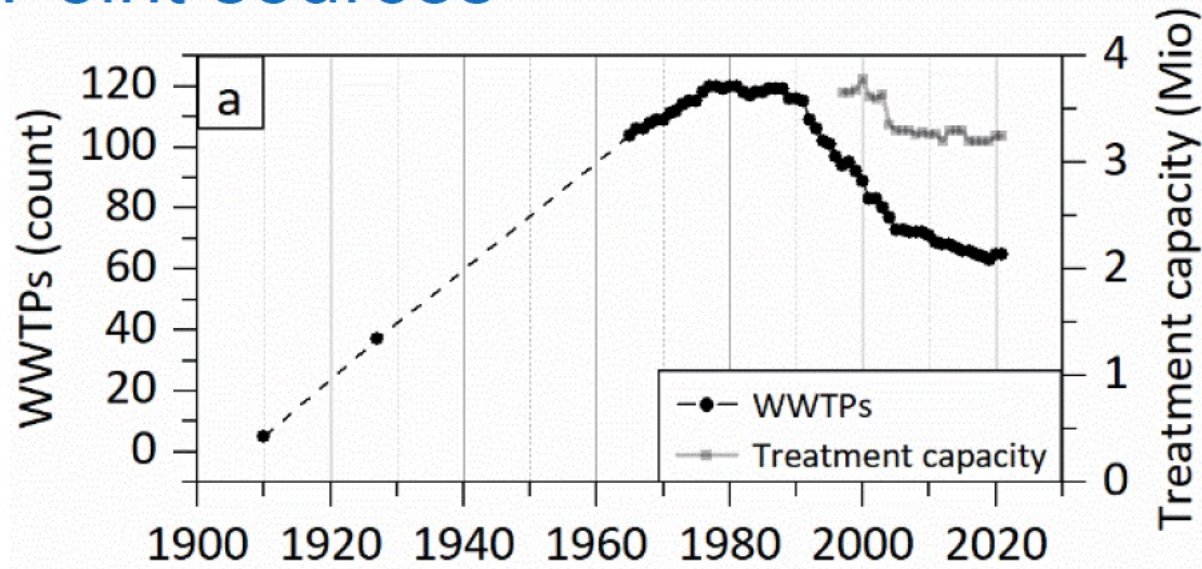


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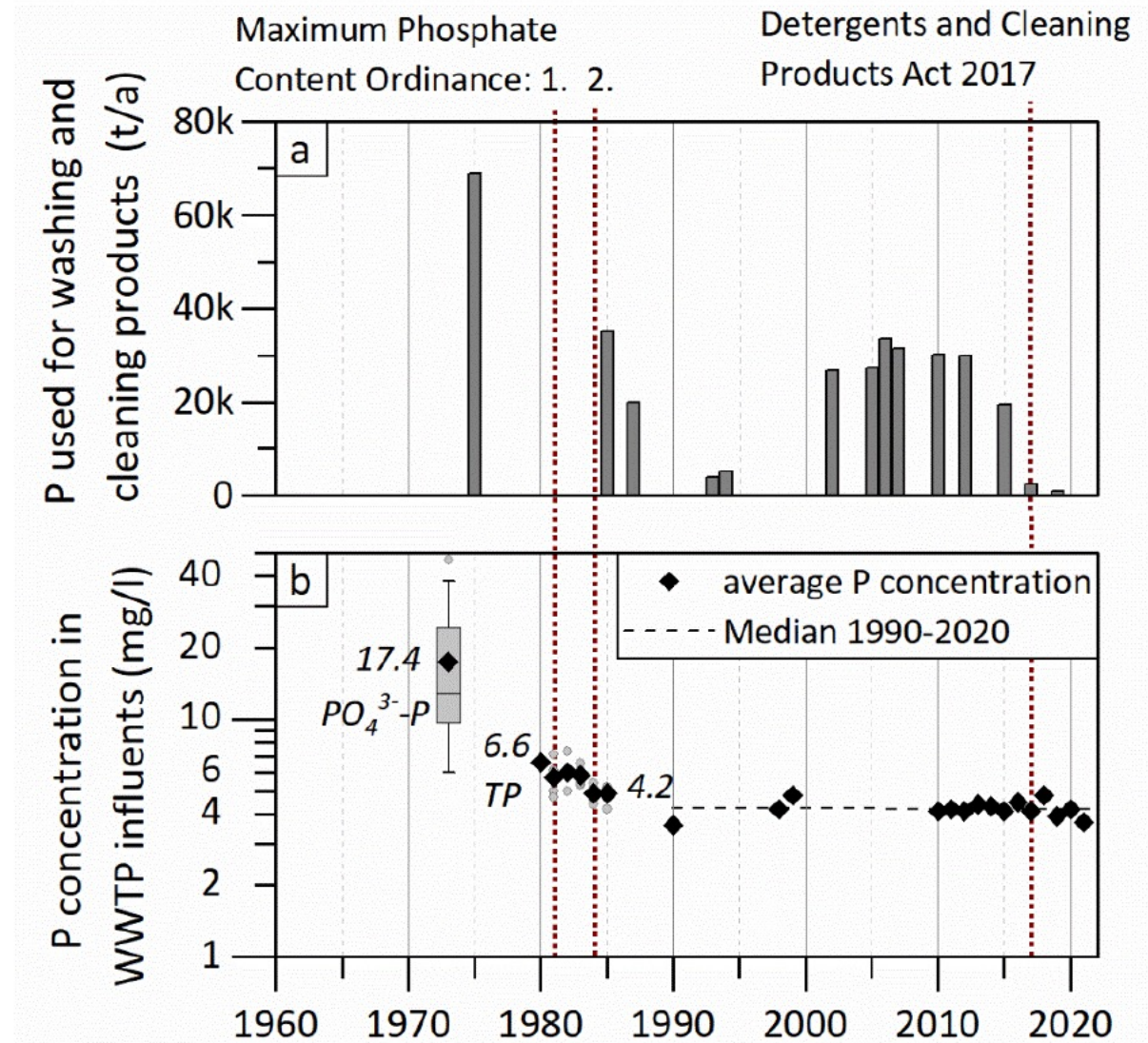
Results and discussion

Point sources



Results and discussion

Point sources



a) P used for washing and cleaning products; b) P concentration in the Ruhrverband's WWTP influents