Eawag
Swiss Federal Institute of Aquatic Science and Technology

eawag aquatic research

Pesticides in Swiss waters – an ongoing challenge



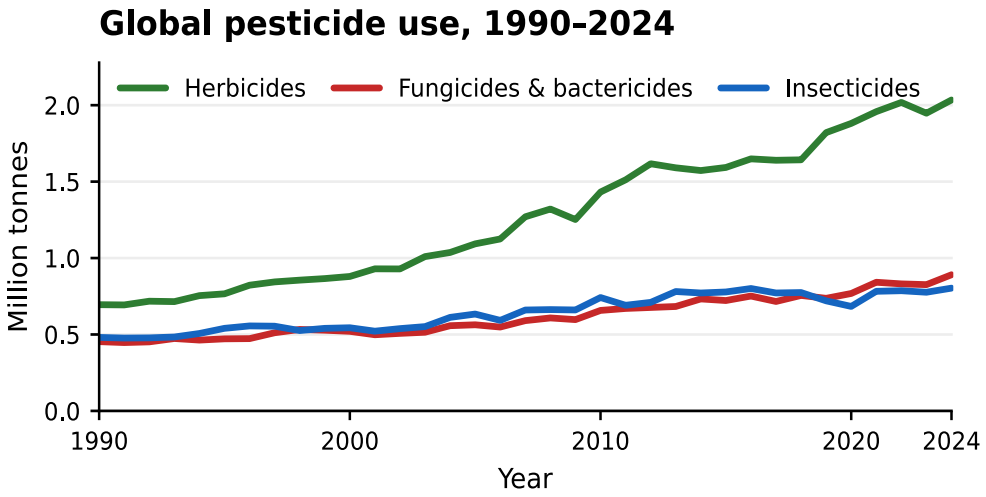
Juliane Hollender, Heinz Singer
Environmental Chemistry, Eawag

Swiss EurEau Water Summit
21. October 2026

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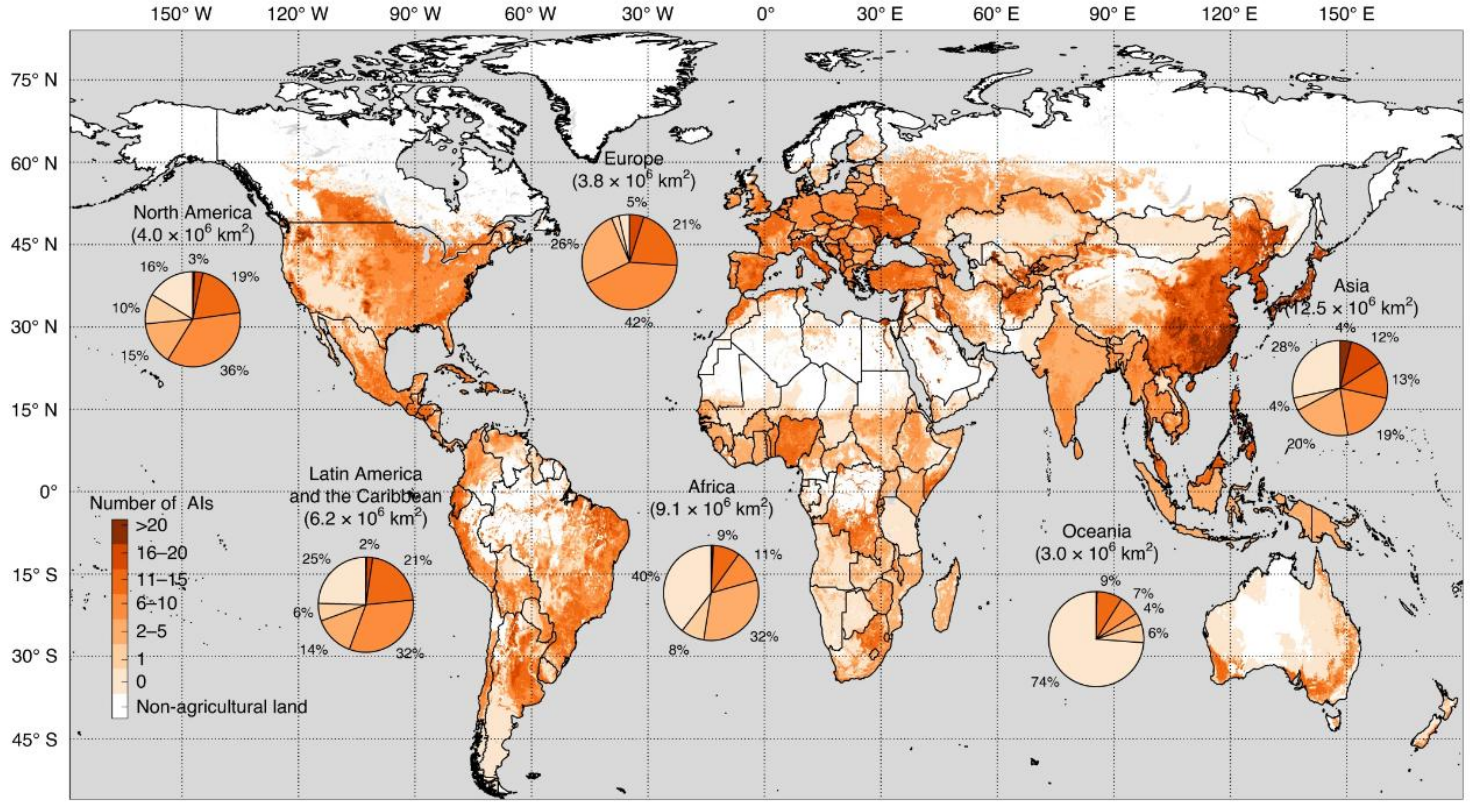
Global pesticides use

- 3.9 million tonnes in 2024 (>50% increase since 1990)



Source: FAO, FAOSTAT Pesticides Use (1990–2024)

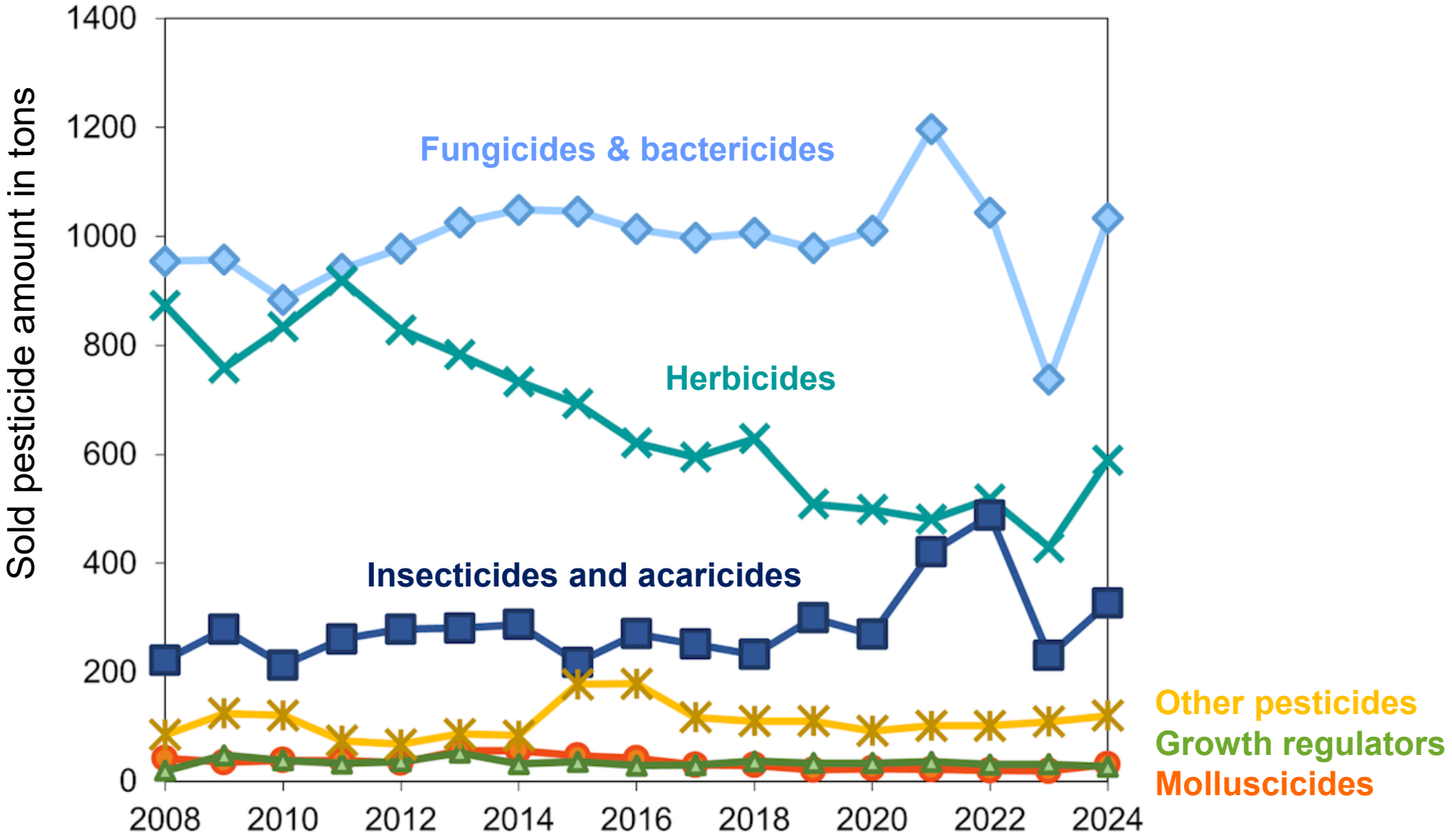
- Number of Active Ingredients (AI) with PEC > PNEC
- 62 % of the EU agricultural land at high risk of pesticide pollution



The map has a spatial resolution of 5 arcmin, which is approximately 10 km × 10 km at the Equator. The pie charts represent the fraction of agricultural land contaminated by different numbers of AIs in each region, and the values in parentheses above the pie charts denote the total agricultural land in that region.

Tang et al., 2021, Nature Geoscience, Doi.org/10.1038/s41561-00712-5

Pesticide consumption over time in Switzerland



https://www.blw.admin.ch/

Input pathways of pesticides into aquatic systems

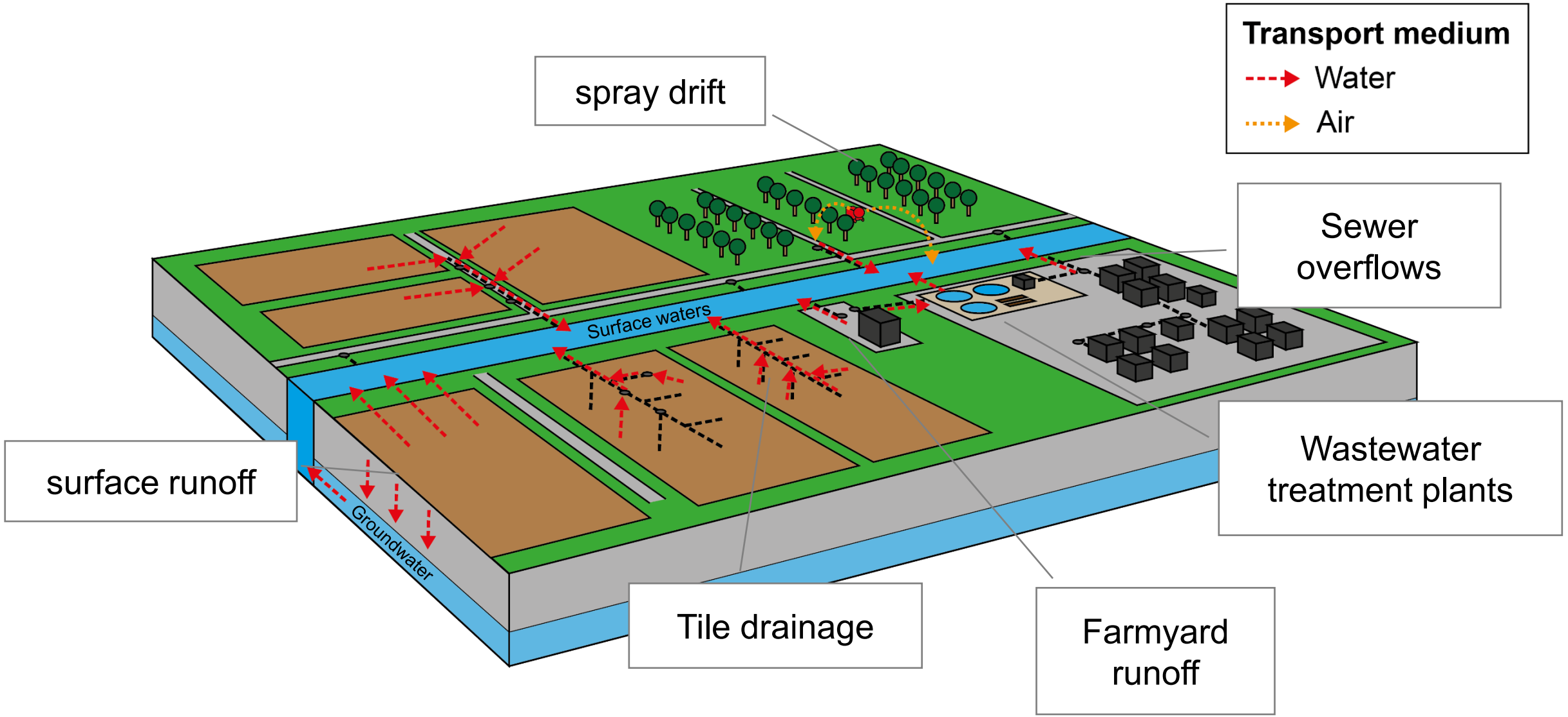
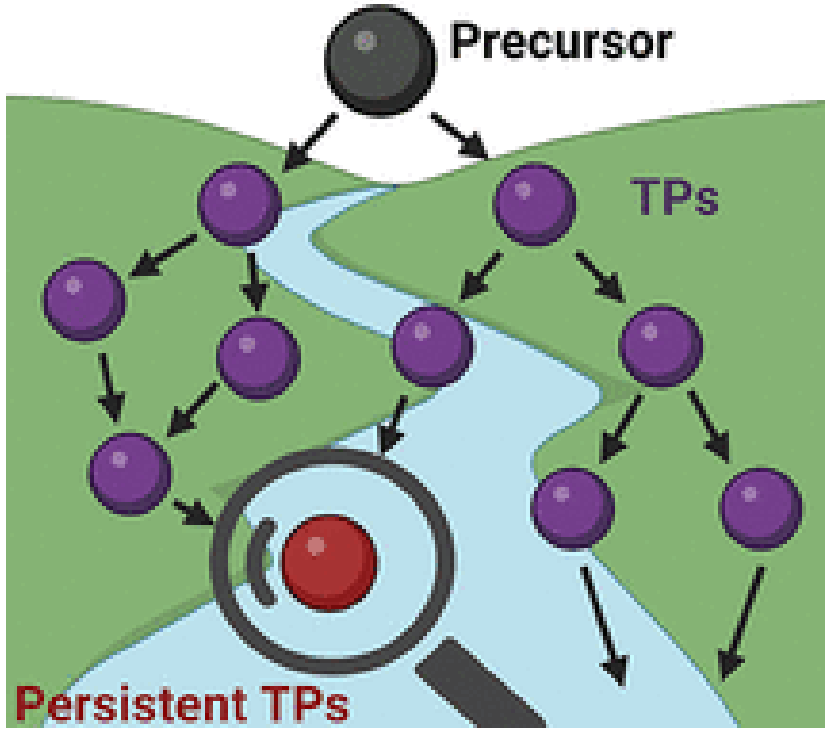


Figure: Urs Schönenberger, Eawag

Transformation of pesticides

- Various abiotic and biotic transformations in soil, water and air
- Formation of transformation products (TPs)
- Lack of TP prediction specificity
- Lack of TP reference standards
- TPs are often more mobile than parent compounds
- Mobile and persistent transformation products reach groundwater



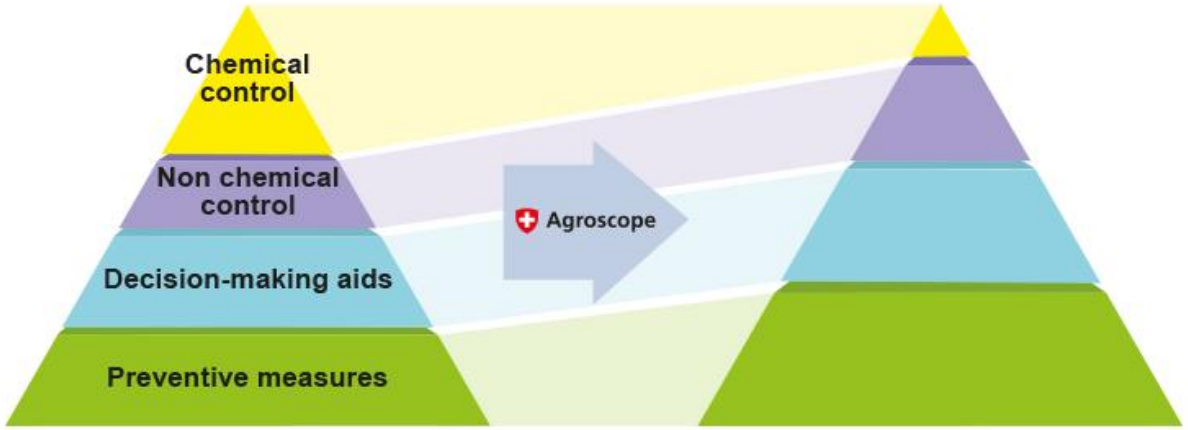
Zahn et al., EST& 2024; https://doi.org/10.1021/acs.est.4c00125

Pesticide regulation in Switzerland versus EU

- **Registration** EU & CH: Authorization of plant protection products: Regulation (EC 1107/2009)
- **Food** EU & CH: Pesticide residues in food and animal feed (EC 396/2005)
- **Drinking water** directive EU & CH: Limit value of 0.1 µg/l for pesticides and relevant transformation products, 0.5 µg/l for sum of pesticides
- **Surface water** EU: WFD & river-basin specific pollutants; CH: water protection act with since 2016 EQS derived according to EU TGD, currently 19 pesticides with 0.00003 µg/L (cypermethrin) – 6.4 µg/L (MCPA), for all other pesticides 0.1 µg/l, 5-7 additional pesticides under discussion

Risk reduction

- EU Directive 2009/128/EC on the **sustainable use** of pesticides.
- **Swiss Pesticide Action Plan** (2017): Risk reduction by **50% in 2027** in comparison to 2012-2015

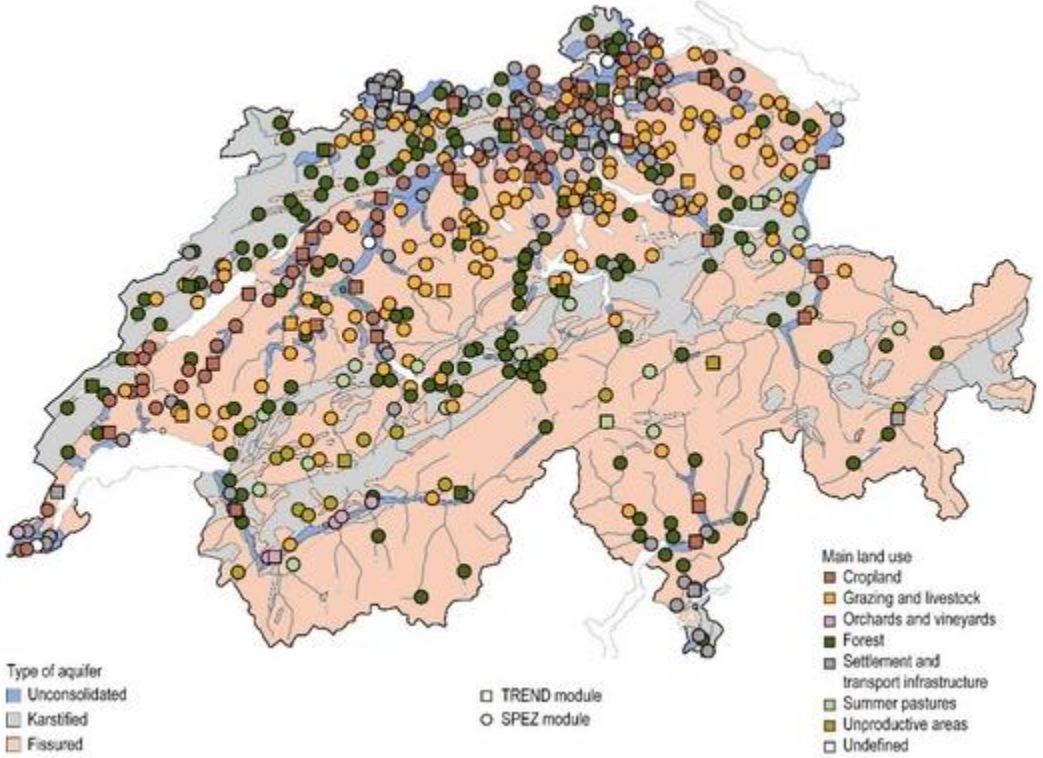


National Monitoring Programs in collaboration with cantons

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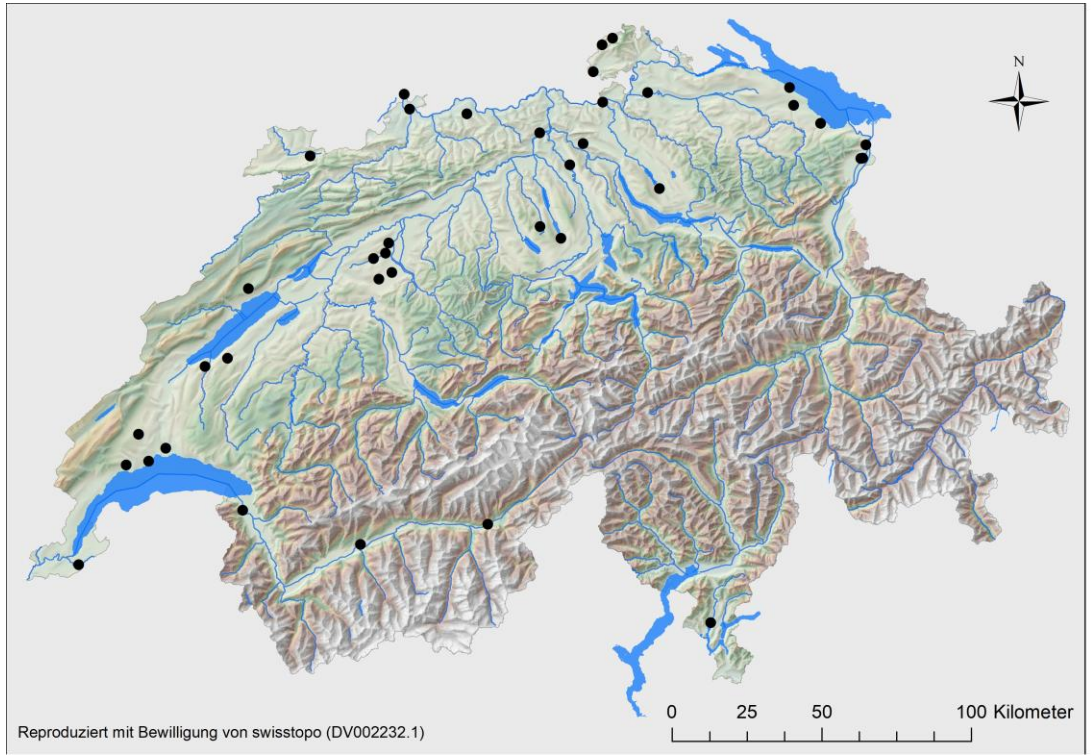
Groundwater - NAQUA

- Since 2002 with 500 monitoring stations, different land-use
- Contaminants monitored up to 4 x per year
- 70-80 pesticides, pesticide transformation products, pharmaceuticals, industrial compounds
- Pilote programs



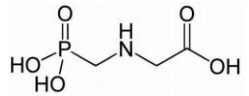
Surface water - NAWA

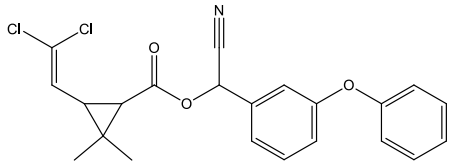
- since 2018 also micropollutants
- 38 rivers of different size, 14d-composite samples (<0.1 m^3/s to > 50 m^3/s), different land use
- 55 pesticides, 23 pharmaceuticals, 4 others, 20 PFAS from 2027, HRMS stored in NTSuisse
- Pilote programs

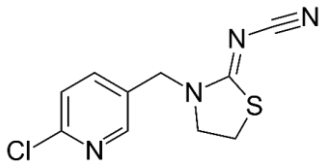


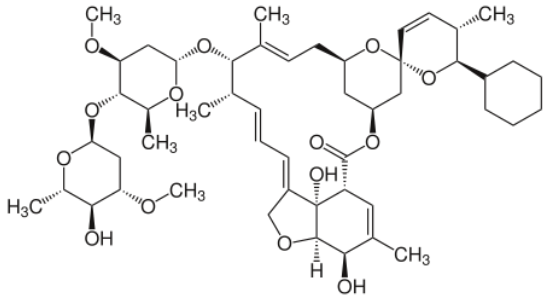
Monitoring challenges

- **Large variety of properties** (molecular weight, logKow, speciation) – not one analytics fits all
- **Diffuse input pathways** into waterbodies need appropriate sampling design to capture dynamics and different sources
- **Transformation** in the environment to **many** transformation products





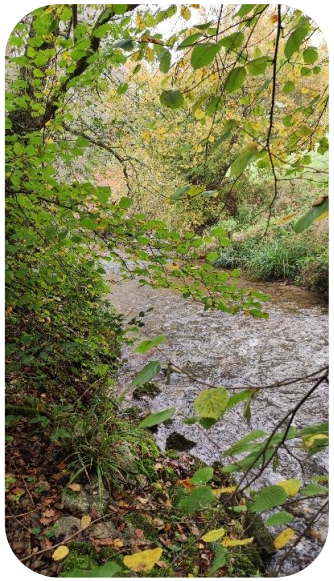


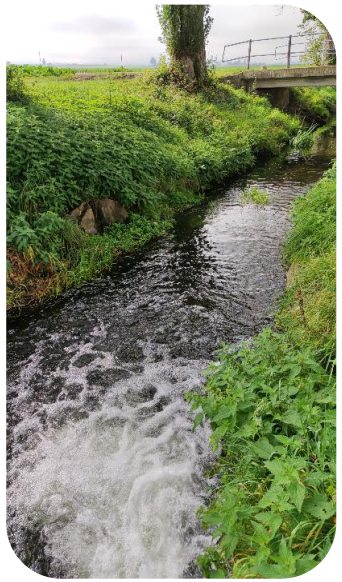


Special monitoring programs of Eawag with Federal Office for the Environment

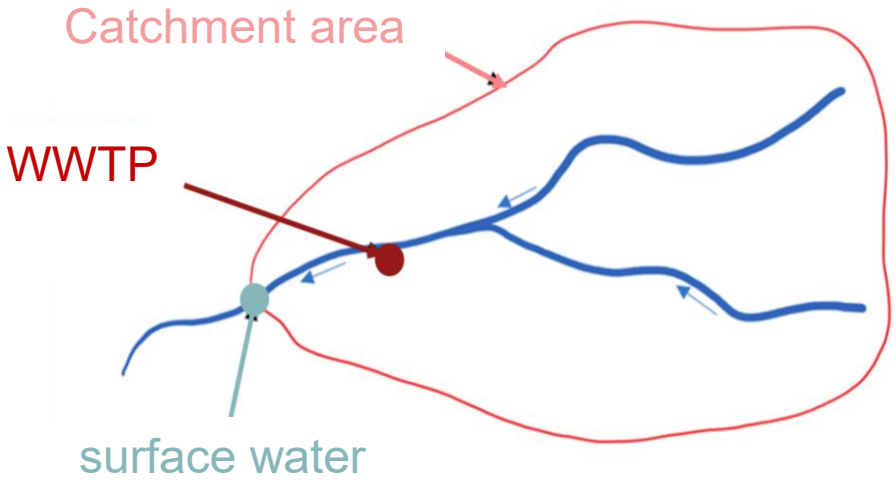
- Multi-target screening to capture all relevant pesticides and their transformation products
- Ultra-sensitive analytics to detect very toxic pesticides below EQS value (e.g. pyrethroids)
- High-throughput sampling to capture pollution dynamics in surface water
- Suspect screening of pesticide transformation products in groundwater & drinking water treatment

NAWA Campaign 2023 – broad sensitive screening and input pathways







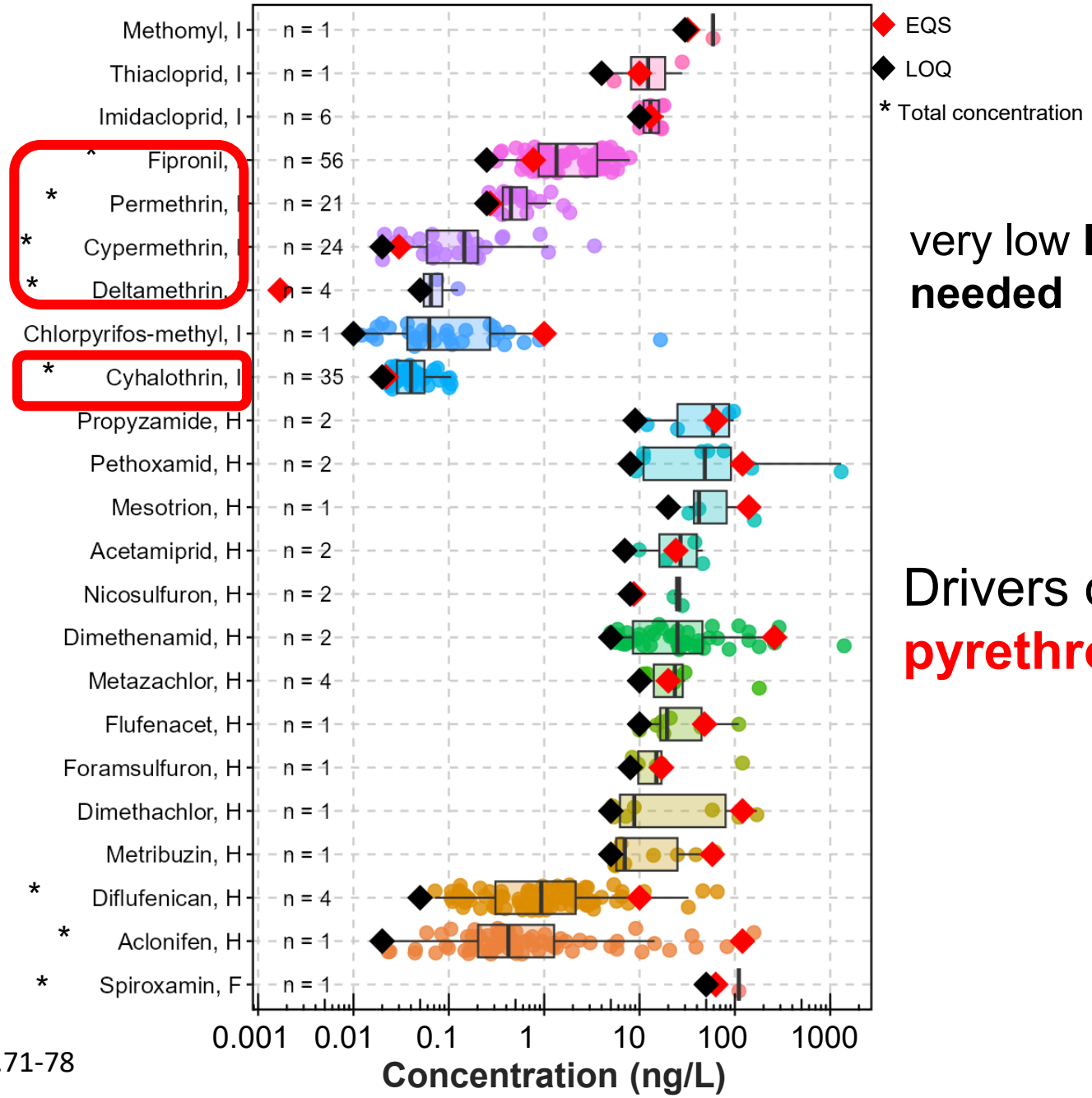


- 5 watercourses with **different land uses** in the catchment area
- **Time-proportional 2-week composite** samples (February – November 2023)
  - Surface water samples
  - Wastewater samples
- **A variety of analytical methods**

Results - Concentrations

- **138 of 265** substances detected*
- **23 substances** with **EQS exceedances**

Insecticides with EQS exceedances



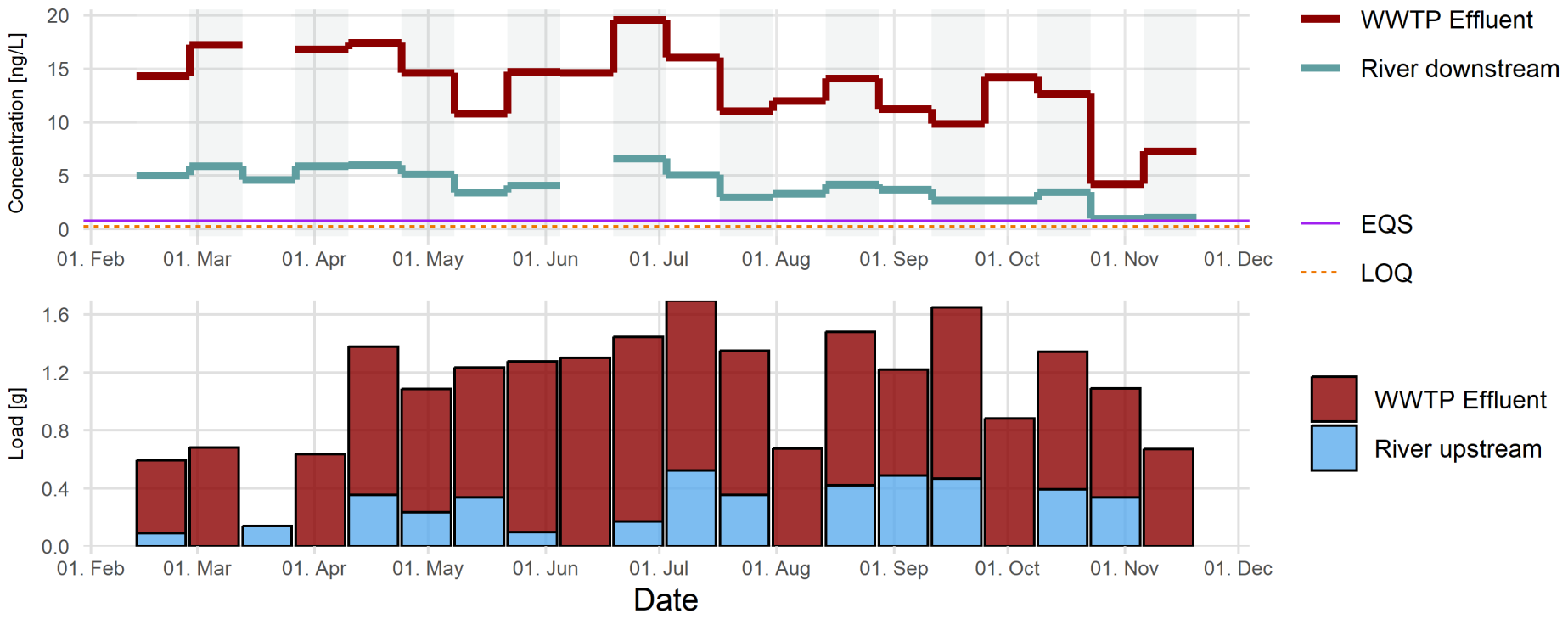
very low **LOQs < EQS (pg/L) needed**

Drivers of **toxicity** are **pyrethroids** and **fipronil**

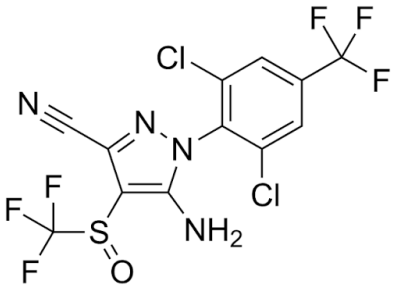
Schorr et al., Aqua & Gas No10, 2025, S.71-78

Results – Input pathways

Fipronil



LOQ: 250 **pg/L**
EQS: 770 **pg/L**



- **Suspected source:** Continuous use as **veterinary medical** product in urban areas and biocides (until 2026)

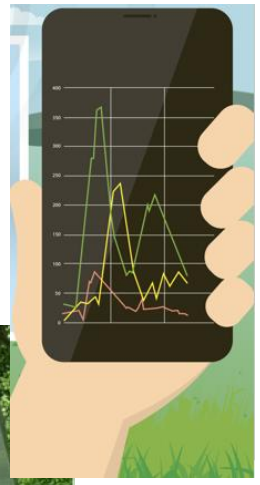


Barth et al., Aqua & Gas No10, 2025, S.90-95

In-situ measurement to capture dynamics

Automated sampling and analysis every 20 mins



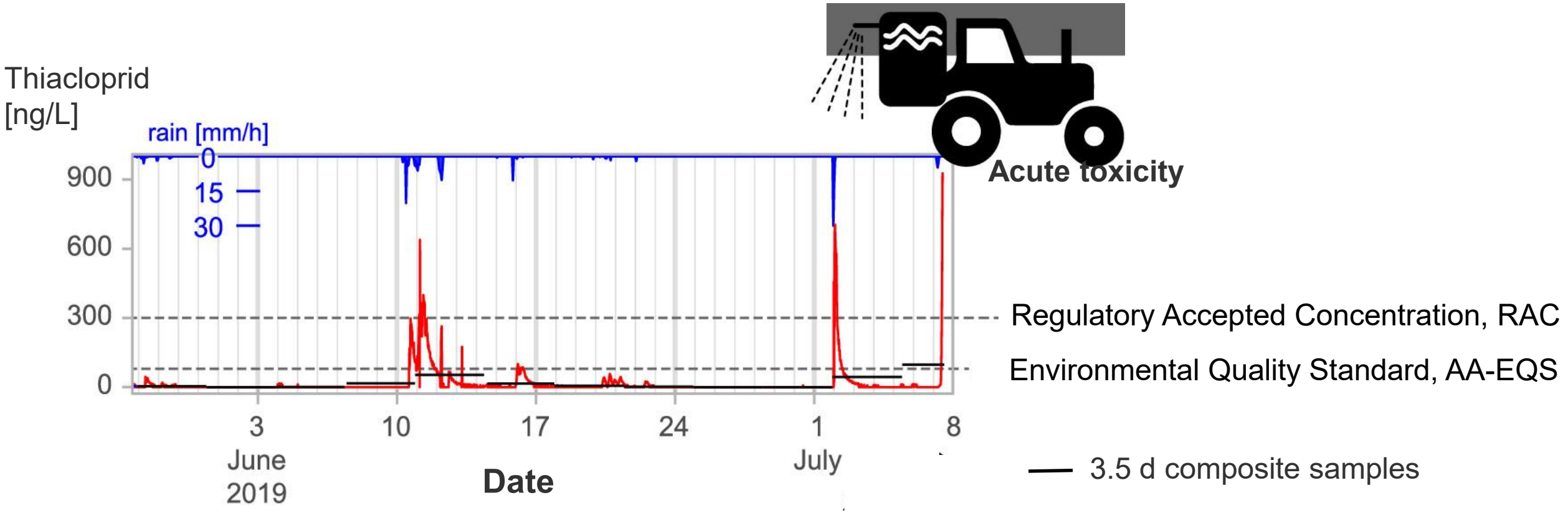




Stravs (2021) EST letters, 8, 373−380

Pesticide dynamics

- **Exceedance during short time intervals**



- **Fast uptake in organisms shown**

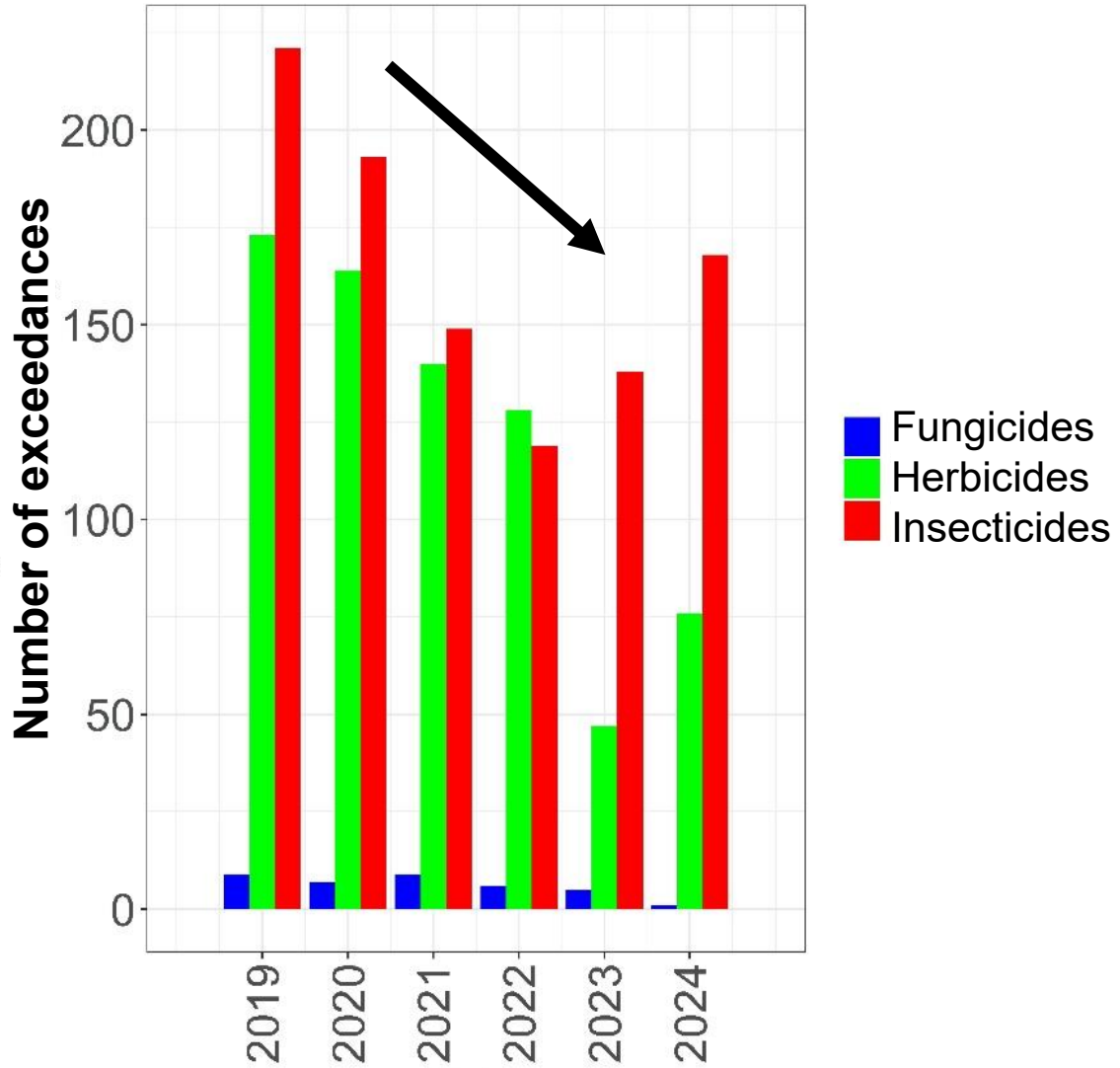


Stravs et al., ES&T letters 2021, doi.org/10.1021/acs.estlett.1c00066; Lauper et al., ACS AU 2022 doi.org/10.1021/acsenvironau.1c00023; Raths et al., Env Int 2026 doi.org/10.1016/j.envint.2026.110424

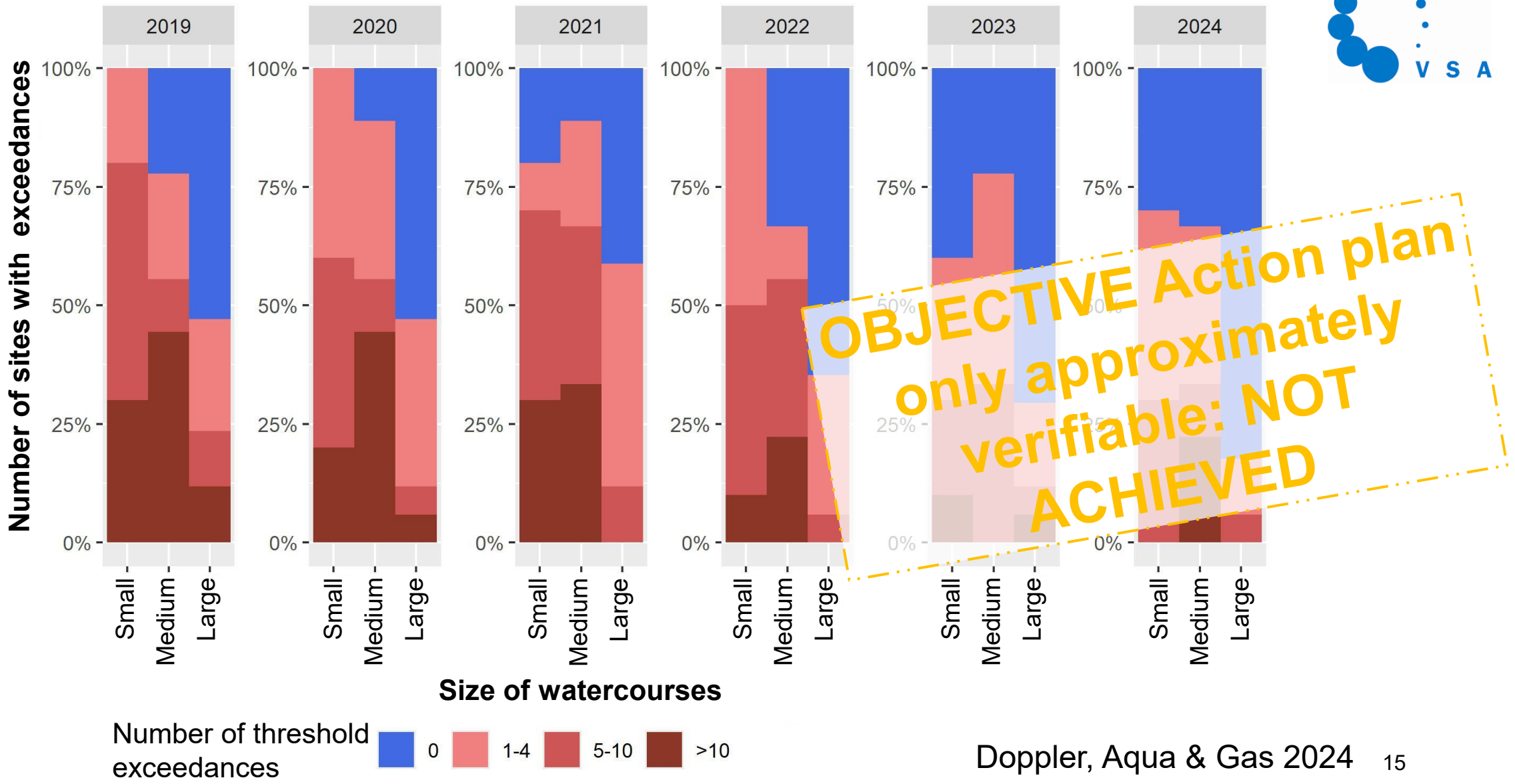
Risk development over time in whole CH - Number of exceeding pesticides in NAWA program

(only plant protection products)

- Significant **decrease** in the number of exceedances due to withdrawl & ban of some insecticides
- **40 substances** (mainly insecticides and herbicides) exceed chronic quality criteria at least once in 2019-2024

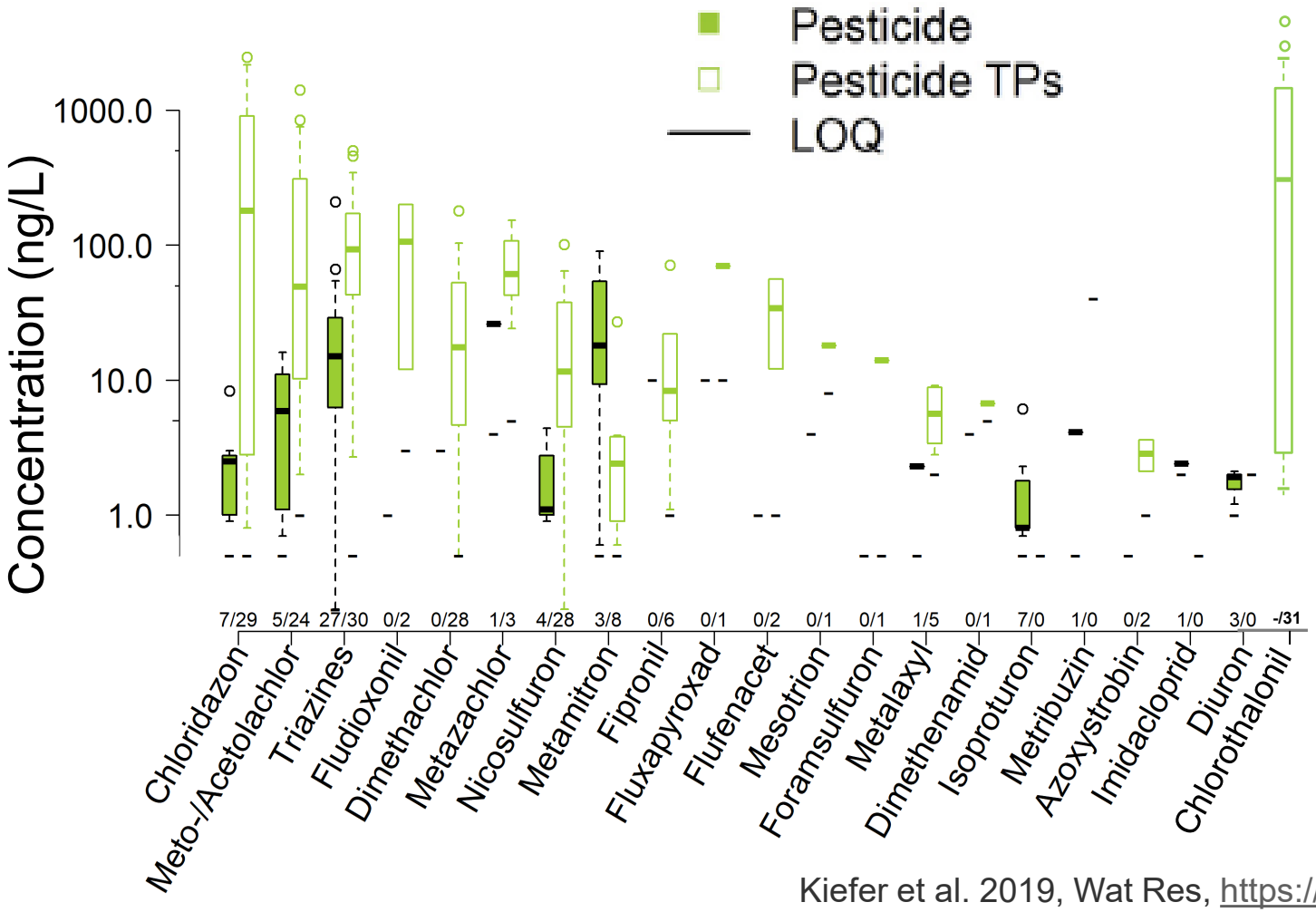


Improvements over time in CH – watercourses with threshold exceedances (only plant protection products)



Multi-target screening of pesticides and their transformation products (NAQUA)

31 sites in catchments with agriculture





Transformation products are often

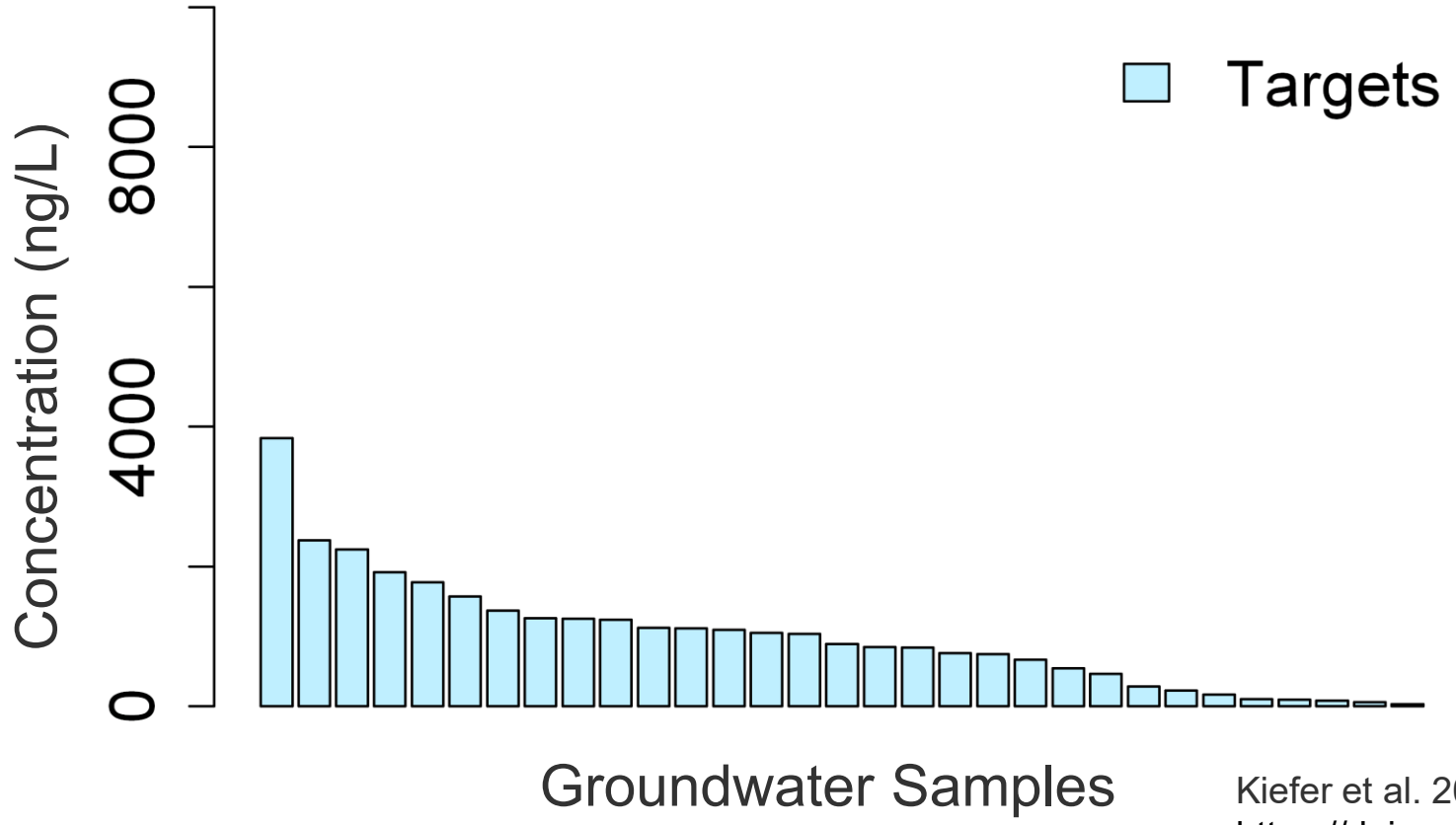
- **more mobile**
- **more persistent**
- **higher concentrated**

than parents

Kiefer et al. 2019, Wat Res, https://doi.org/10.1016/j.watres.2019.114972 apdated

Target screening results

- **Target screening: 105 of 519 micropollutants detected:** 33 pesticides, 30 pesticide TPs
- **14 targets: > 100 ng/L** (3 pesticides, 6 pesticide TPs)
- Total concentration: 30 – 3800 ngL^{-1}



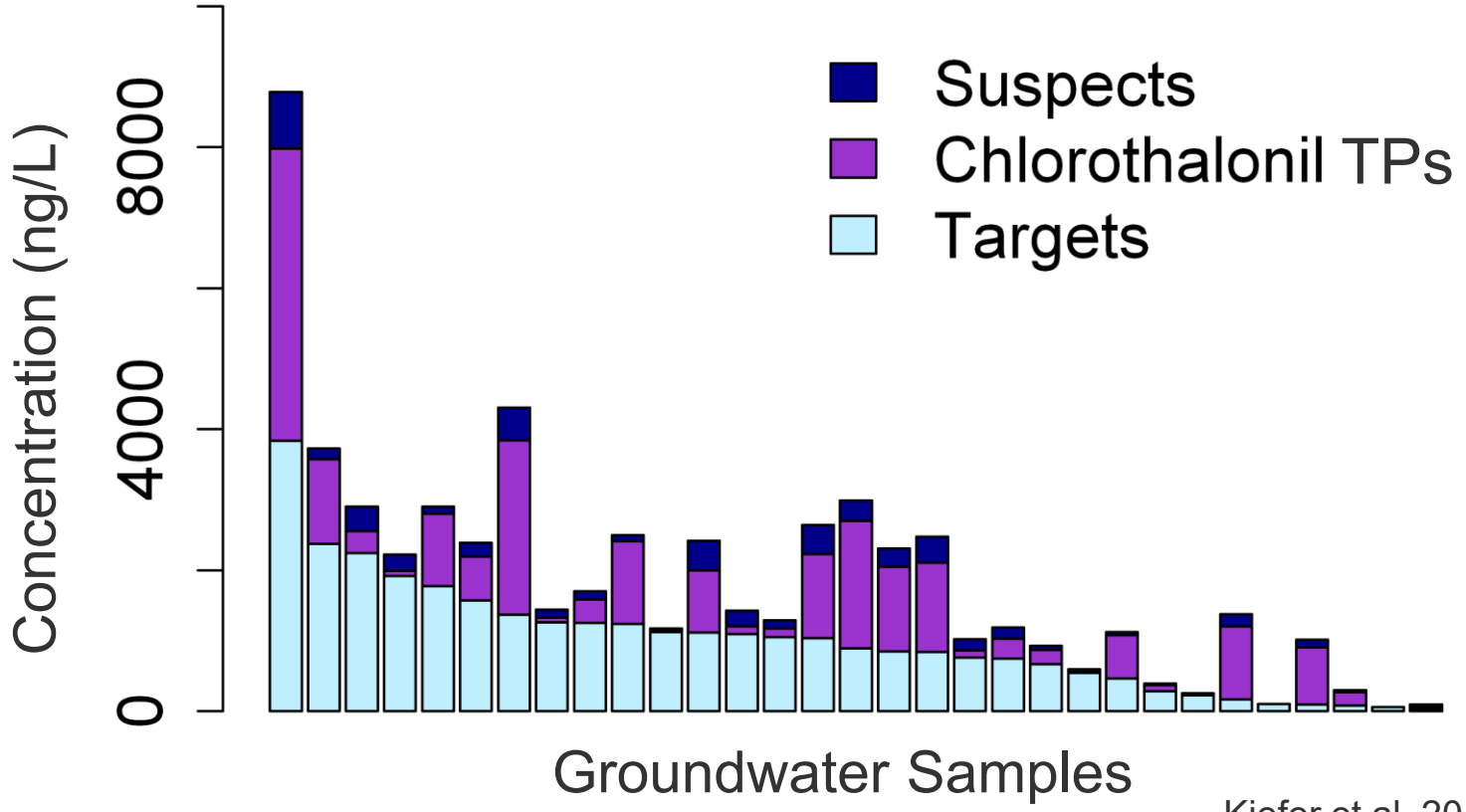
Kiefer et al. 2019, Wat Res,
https://doi.org/10.1016/j.watres.2019.114972

Transformation products (TPs) suspect screening

Suspect screening with LC-HRMS **: ~1000 TPs from EU registration dossiers & literature (NORMAN list S60)**

⇨ **13 novel pesticide TPs** + 12 not yet monitored TPs in CH

Total concentration: 60 – 9000 ngL^{-1}



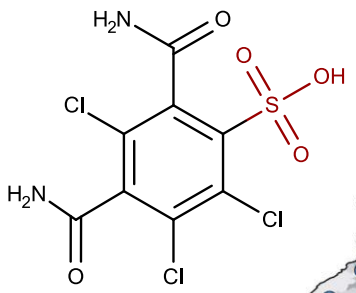
➡ **Inclusion in national monitoring**

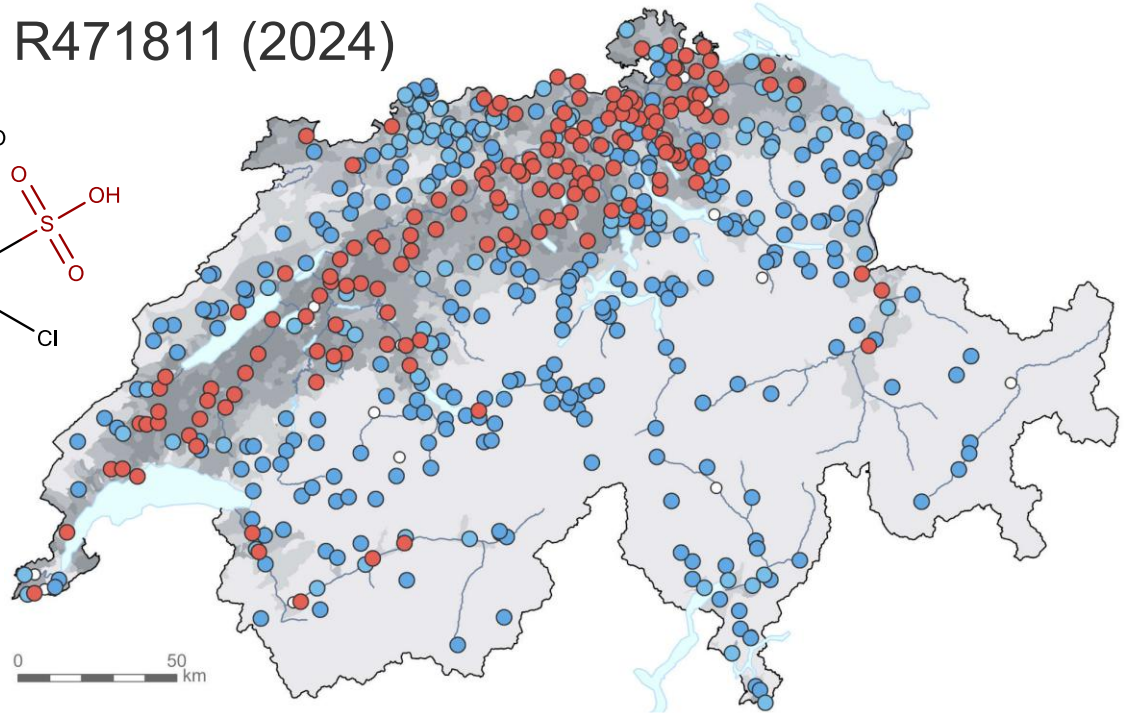
Kiefer et al. 2019, Wat Res, https://doi.org/10.1016/j.watres.2019.114972

Chlorothalonil TPs monitoring by cantonal authorities

- **> 30%** of the groundwater monitoring sites exceed 0.1 µg/L threshold value
- Drinking water for 1 Mio Swiss people

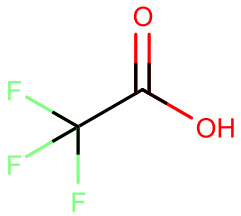
Chlorothalonil R471811 (2024)





Picture: FOEN

Trifluoroacetic acid in Swiss groundwater (2022/23)

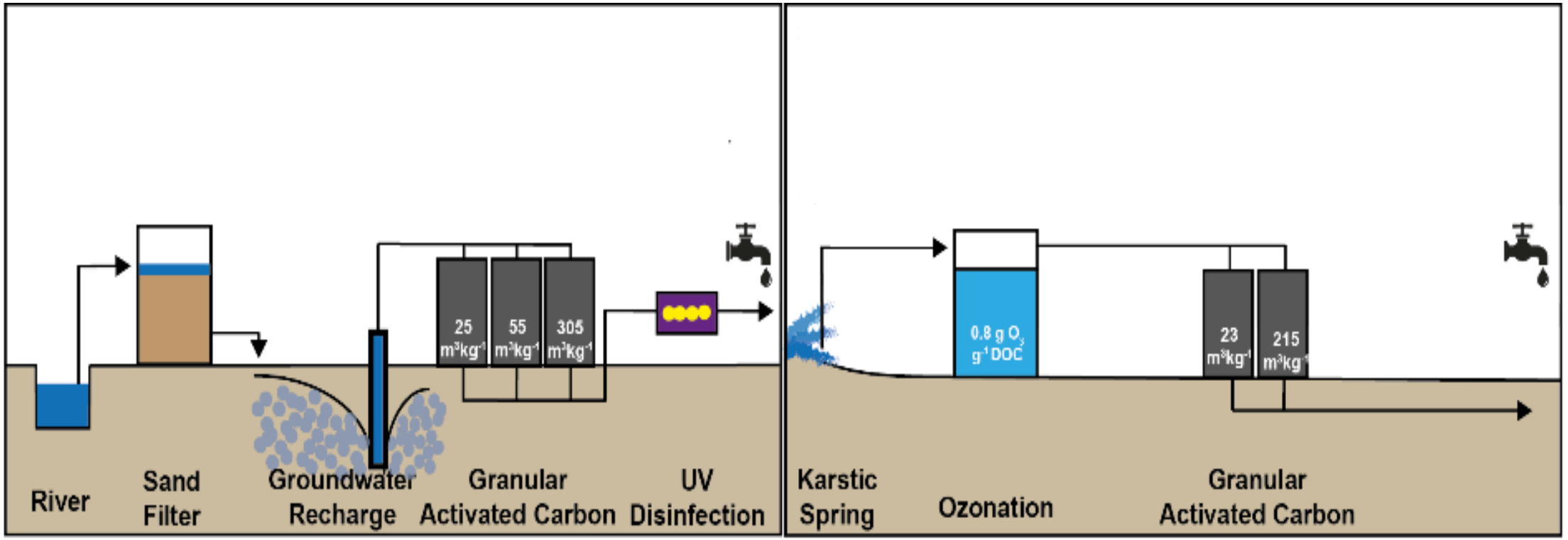


Picture: FOEN

- Increasing background concentration due to **degradation of refrigerants**
- Hot spots due to **industrial input**
- Higher concentration in areas with more **agricultural activities**
- **14 pesticides** with CF3 group are still in use in Switzerland

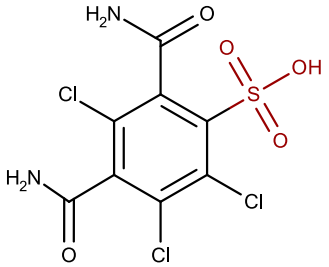
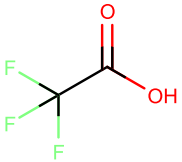
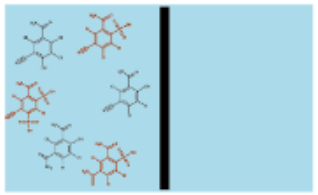
Removal of persistent and mobile compounds in drinking water resources

- **80%** of drinking water is produced from **groundwater**
- **Renewal of** groundwater takes **years to decades**
- **Dilution** with less contaminated water is often not possible



Kiefer et al. Wat Res 2020, https://doi.org/10.1016/j.watres.2020.116066
Faktenblatt Eawag Feb 2020

Drinking water treatment – Technical solutions

Technical solutions	Chlorothalonil sulfonic acids	TFA	
			
UVC disinfection 	X	X	
Ozonation 	X	X	
Advanced oxidation processes 	X	X	
Activated carbon 	(✓)	X	Frequent exchange
Reverse osmosis 	✓	✓	high energy demand ~25% reject water

Kiefer et al. Wat Res 2020, Faktenblatt Eawag Feb 2020

Conclusions

- **Spatial & temporal highly resolved sampling** combined with **ultra-sensitive multi-compound analytics** needed to monitor the risk of pesticides and their transformation products comprehensively
- Concentration profiles and loads allow to evaluate potential pathways and **possible sources**
- **Some improvements but still exceedance of environmental quality standards**
- Drivers of toxicity: **Pyrethroids and fipronil**
- **Effective** mitigation measures depend on **more information regarding sales records & application data**
- **End-of-pipe solutions** can be difficult, **zero-emission** would be best

Thank you

- Swiss Federal Office for the Environment (FOEN)
- Eawag: Vera Ganz, Johannes Schorr, Elia Ceppi, Birgit Beck, Philipp Longrée, Heinz Singer, Karin Kiefer, Urs von Gunten
- Participating cantons and WWTPs
- VSA, Platform for Water Quality: Tobias Doppler, Sofia Barth
- Ecotox Center: Marion Junghans, Breanne Holmes

