Persistent and Mobile Chemicals in the Water Cycle

Workshop on 1,4-Dioxane
Department of Toxic Substances Control
California EPA

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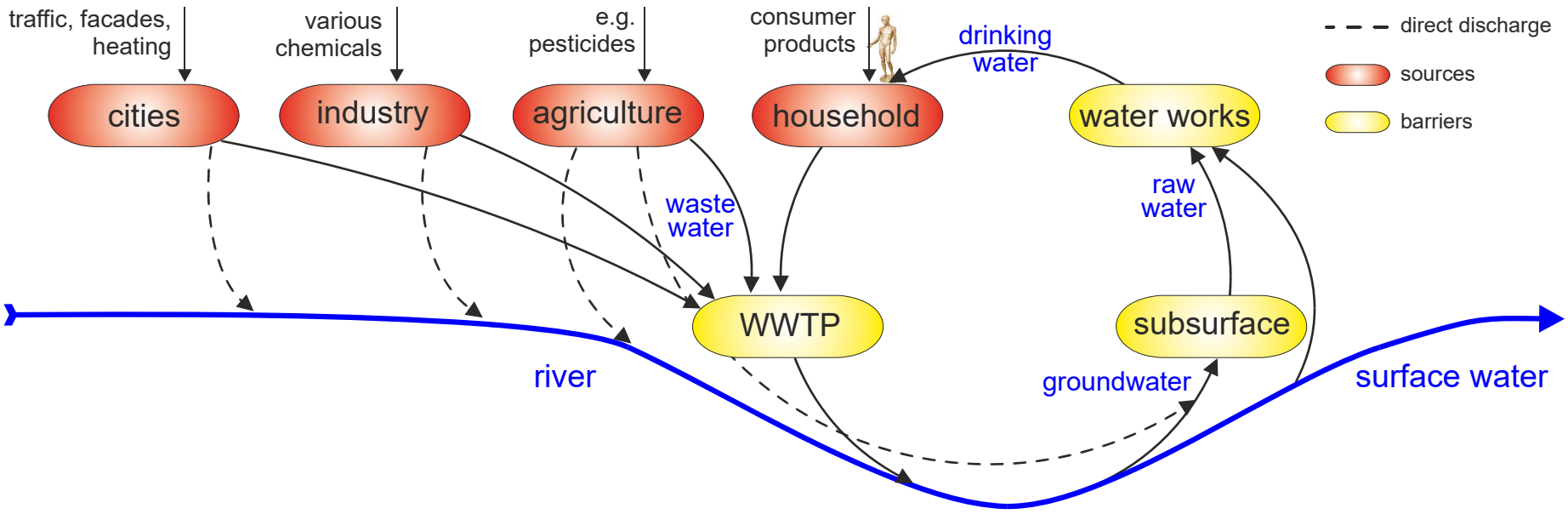
The Partially Closed Water Cycle



- In densely populated areas WWTP discharges to surface water often exceed 20 %
- Barriers in partially closed water cycles rely on microbial degradation and sorption processes

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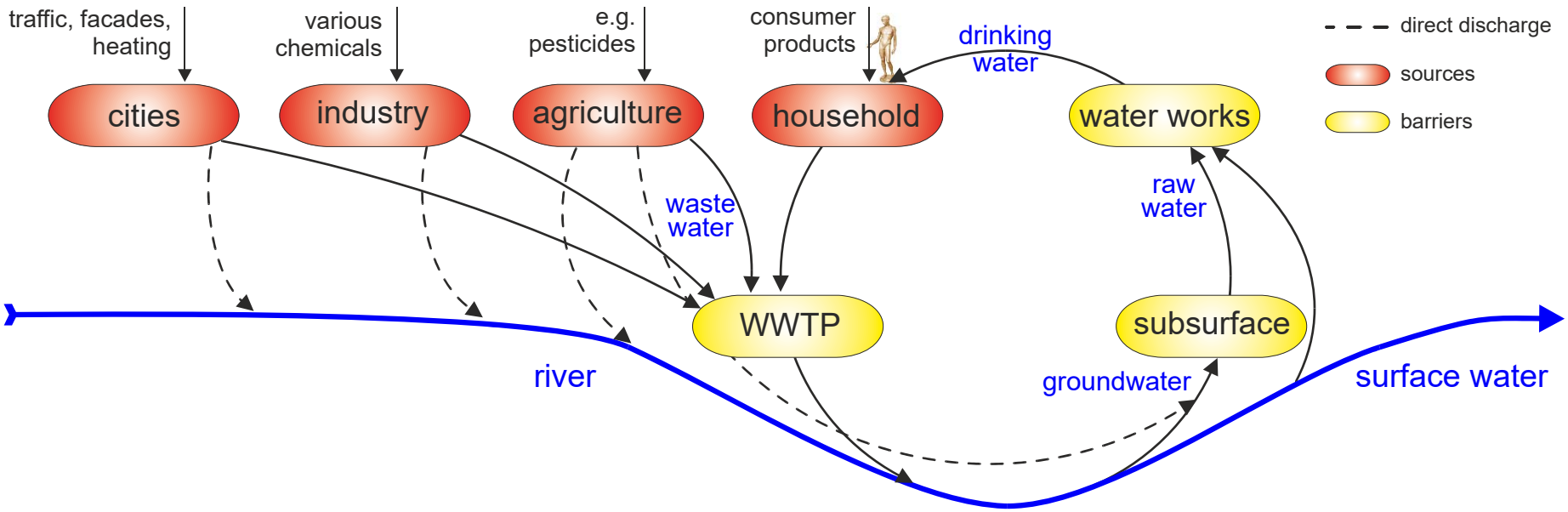
The Protection Gap Against PM Compounds



- For persistent (P) and very polar (mobile, M) organic compounds (PM compounds) these barriers are not effective
  - water cycle may turn into a compound cycle
  - only dilution reduces concentration
- This limits reuse options and endangers water resources

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Search for PM Chemicals in Data Base of REACH* Registration Data

- Search for PM-substances in REACH Database
  - 14.000 registered substances (year 2015)
  - Data provided by the registrants
  - P (ersistence)
    - Half-life in marine water >60 days OR
    - half-life in fresh or estuarine water >40 days
  - M (obility)
    - Water solubility ≥150 µg/L AND
    - log K_{oc} ≤ 4.5

*) Regulation (EC) No 1907/2006 … on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

Arp et al. (2017) Environ. Sci. Process Impacts, 19, 939-955

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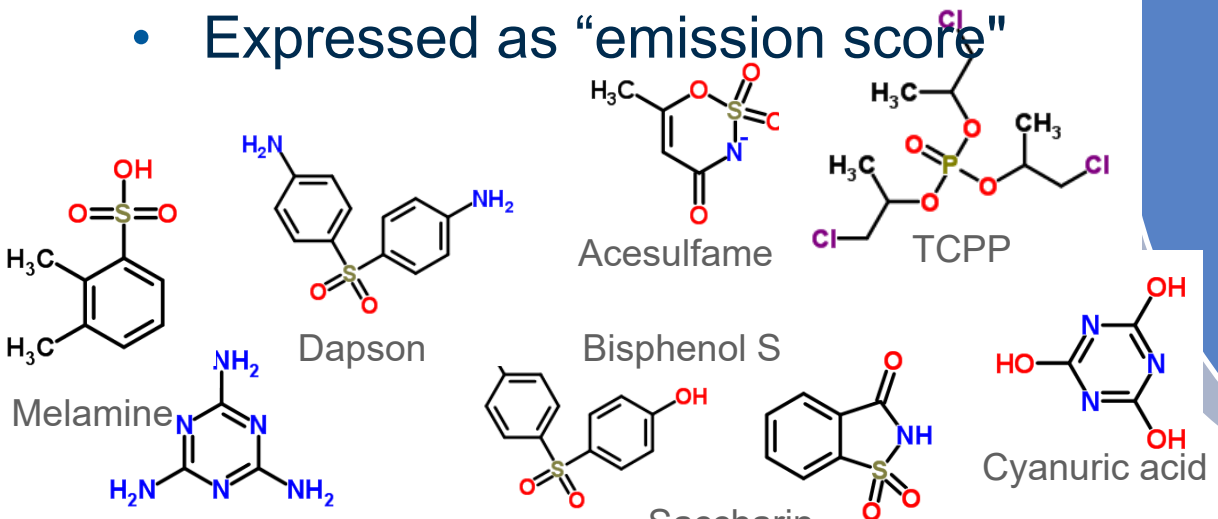
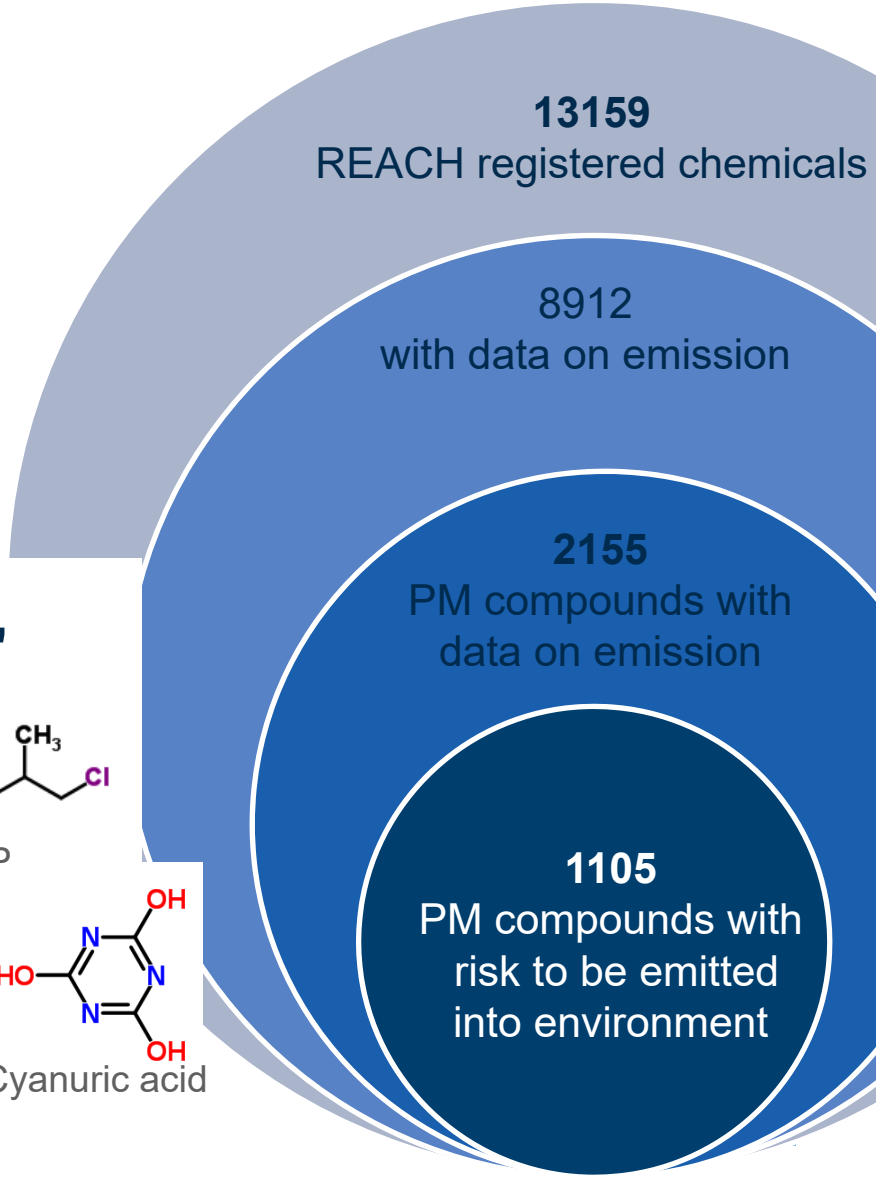
Prioritizing PM Compounds by Risk of Emission

- Likelyhood of emission into the environment depends upon
  - Tonnage
  - use characteristics
    - Open systems
    - Closed systems
    - etc
  - Expressed as “emission score"





Schulze et al. (2018) Sci. Total Environ. 625, 1122

1,4-Dioxan – Detailed Evaluation of PM Criteria

Property	Criteria for PM/PMT	1,4-Dioxane
Persistence	Degradation half-life in marine water at pH 6-8 and 9 ºC > 60 days	OECD 301F: No significant biodegradation (< 10% in 28 d). Therefore assessed to be persistent in water.
	Degradation half-life in fresh or estuarine water at pH 6-8 and 12 ºC > 40 days	
	(Degradation half-life in marine sediment at pH 6-8 and 9 ºC > 180 days)	
	(Degradation half-life in fresh or estuarine water sediment at pH 6-8 and 12 ºC > 120 days)	
	(Degradation half-life in soil at pH 6-8 and 12 ºC > 120 days)	
Mobility	Water solubility at pH 6-8 and 12 ºC) ≥ 150 µg/L	completely miscible
	log K_{oc} ≤ 4,5	log K_{oc} = 0.8

Berger et al. (2018) Assessment of persistence, mobility and toxicity (PMT) of 167 REACH registered substances; German Environment Agency, UBA Texte 09/2018

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1,4-Dioxan – Detailed Evaluation of PMT Criteria

Property	Criteria for PM/PMT	1,4-Dioxane
Persistence	Degradation half-life in marine water at pH 6-8 and 9 ºC > 60 days	OECD 301F: No significant biodegradation (< 10% in 28 d). Therefore assessed to be persistent in water.
	Degradation half-life in fresh or estuarine water at pH 6-8 and 12 ºC > 40 days	
	(Degradation half-life in marine sediment at pH 6-8 and 9 ºC > 180 days)	
	(Degradation half-life in fresh or estuarine water sediment at pH 6-8 and 12 ºC > 120 days)	
	(Degradation half-life in soil at pH 6-8 and 12 ºC > 120 days)	
Mobility	Water solubility at pH 6-8 and 12 ºC) ≥ 150 µg/L	completely miscible
	log K_{oc} ≤ 4,5	log K_{oc} = 0.8
Toxicity	Long-Term no observed effect concentration (NOEC) or EC10 for marine or freshwater organisms is less than 0,01 mg/L	no
	Carcinogenic, germ cell mutagenic or toxic for reproduction (in each case category 1A, 1B or 2), according to CLP Regulation	Carc. cat. 2
	Specific target organ toxicity, after repeated exposure (STOT RE cat. 1 od. 2), according to CLP Regulation	no
	Additional category for effects on or via lactation, according to CLP Regulation	no
	Derived no-adverse effect level (DNEL) is ≤ 9 µg/kg/d (oral, long term, general population)	240 µg/kg/d

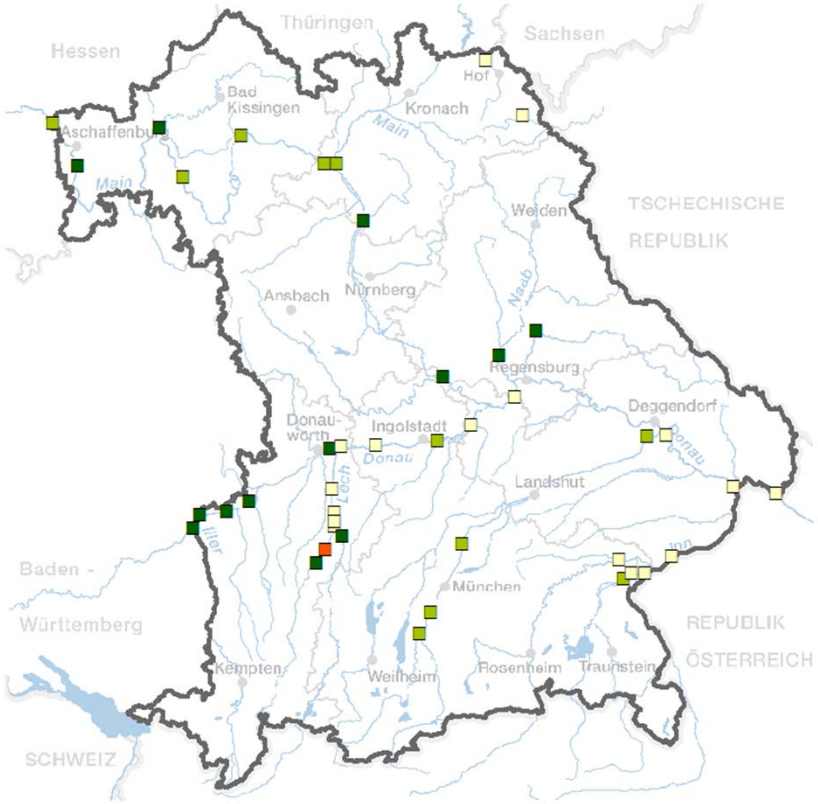
Berger et al. (2018) Assessment of persistence, mobility and toxicity (PMT) of 167 REACH registered substances; German Environment Agency, UBA Texte 09/2018

modified by W. Koerner, Bavarian Environment Agency

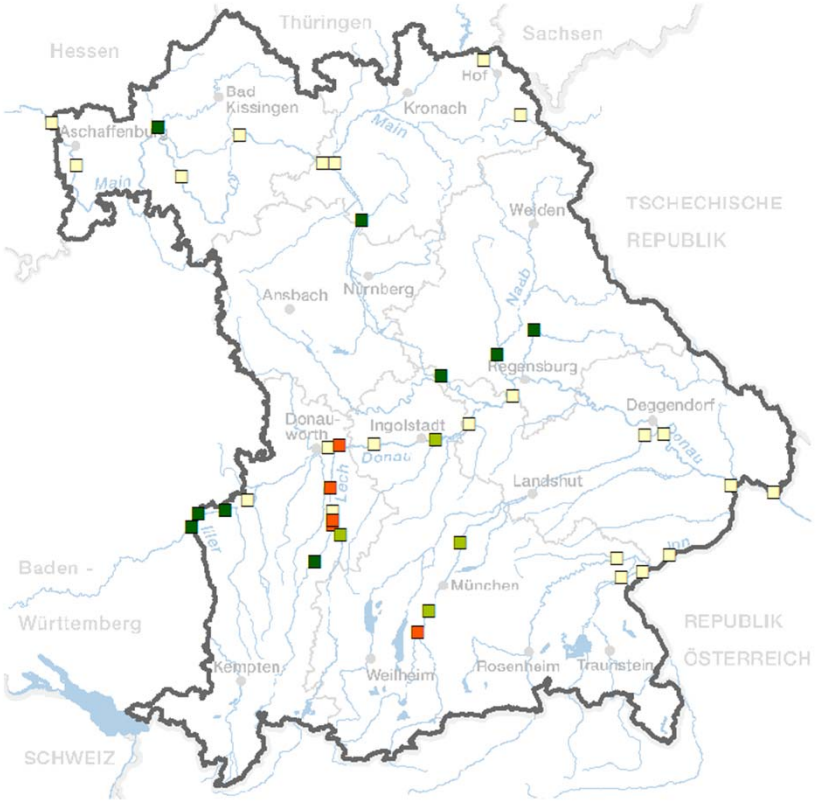
1,4-Dioxane in Surface Waters of Bavaria, Germany

Oct. 2016 – June 2017, 41 sites

Minimum concentration



Maximum concentration



- < 0,2 µg/L
- 0,2 ... 0,35 µg/L
- 0,35 ... 5,0 µg/L
- 5,0 ... 12,0 µg/L

0.2 µg/L method LOQ
0.35 µg/L guidance value US EPA
5.0 µg/L guidance value German EPA

Maps and data: W. Koerner et al. (2018) Bavarian Environment Agency, unpubl.

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Conclusions

- PM compounds are an issue in partially closed water cycles
- Technical measures to remove PM compounds from water are limited
  - No sorption, no biodegradation
- Presence of PM compounds in wastewater endangers drinking water resources and limits wastewater reuse
- PM compounds that are also toxic (PMT) are most critical
- According to UBA 1,4-Dioxane is considered a PMT compound
- Avoiding the release/the use of PMT compounds most sustainable way of protecting water resources

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- References

  - Berger et al. (2018) Assessment of persistence, mobility and toxicity (PMT) of 167 REACH registered substances; German Environment Agency, UBA Texte 09/2018
  - Reemtsma et al. (2016) Mind the Gap: Persistent and Mobile Organic Compounds - Water Contaminants That Slip Through. Environ. Sci. Technol. 50, 10308–10315.
  - Schulze et al. (2018) Using REACH registration data to rank the environmental emission potential of persistent and mobile organic chemicals. Sci. Total Environ. 625, 1122 – 1128.

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