What is persistence?

Seeking for a practical interpretation for regulatory practice

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1. Plant protection products → Regulation 1107/2009 applies

- "An active substance, safener or synergist shall only be approved if it is not considered to be a persistent, bioaccumulative and toxic (PBT) substance. A substance that fulfils all three of the criteria of the points (persistence, bioaccumulation, toxicity) is a PBT substance." [1]

→ **Hazard-based cut-off: no possibility for subsequent risk assessment**

Persistence trigger	Soil DT50	Sediments DT50	Water DT 50
PBT	> 120 d	> 180 d (marine) > 120 d (freshwater)	> 60 d (marine) > 40 d (freshwater)
vPvB	>180 d	> 180 d (marine) > 180 d (freshwater)	> 60 d (marine) > 60 d (freshwater)
POP	> 6 months	> 2 months	> 2 months

Table 1: Persistence criteria for POP, PBT and vPvB classification under the EU regulation 1107/2009. B and T criteria are not subjects of the current work

- Half-lives are compared to persistence triggers in each compartment individually
- Simple definition, but a substantial amount of existing data are not considered

→ **Hazard-based cut-off might lead to unjustified P classifications**

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2. Critical point: persistence is not a substance property, only

- In an environmental context, persistence is commonly understood as "residence time of a substance in a defined environmental compartment" (i.e. soil, sediment or water).

Persistence can not be directly measured

Persistence is not an intrinsic substance property

- Residence times of substances in environmental compartments are determined by
  - inherent substance properties and by
  - compartment properties (such soil microbial activity) and by
  - environmental factors (such as temperature) and by
  - transport processes.

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3. Persistence triggers in the context of agricultural practice

- Accumulation factor: ratio of concentration after long-term use and concentration after single application → **a practical indicator of persistence**

$$\frac{C_{plateau}}{C_0} = \frac{1}{1-e^{-kt}}$$

Soil DT$_{50}$	Accumulation factor
120 d (P in PBT)	1.14
180 d (P in vPvB)	1.32

Reality of pesticide residues in the field:
- Application rates can vary by a **factor of 2-5**
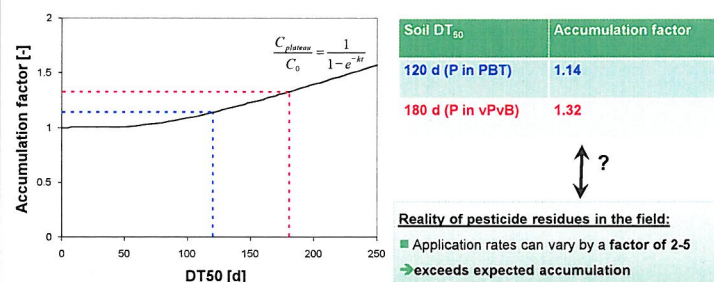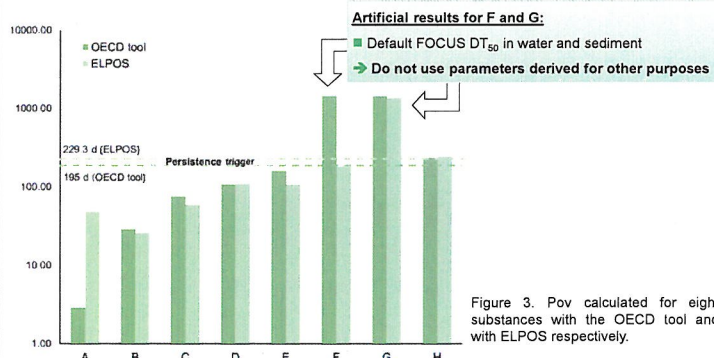→ **exceeds expected accumulation**

Figure 1: Accumulation factor calculated for different half-lives (C_0: intial concentration, $C_{plateau}$: concentration after long-term use). Colours indicate persistence triggers within the PBT an vPvB classifications, respectively.

→ **Above defined persistence triggers have limited practical relevance**

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4. Overall persistence as a possible indicator of persistence

- Overall persistence (P_{OV}) is "a measure of the time scale of degradation of the chemical in the whole environment" [2]. Multimedia partitioning is consired for the calculation of P_{ov}.

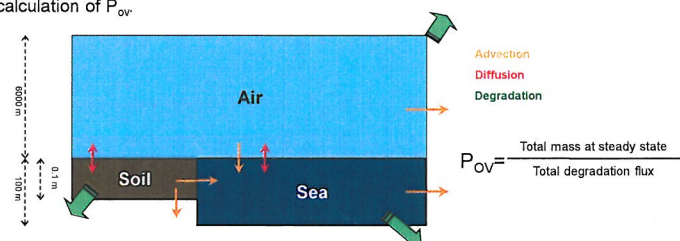$$P_{OV} = \frac{\text{Total mass at steady state}}{\text{Total degradation flux}}$$

Figure 2: Environmental compartments and processess considered for the calculation of P_{ov} (Modified after [2])

- Different software tools (e.g. ELPOS, OECD tool, etc) are available to calculate P_{OV}
- Persistence trigger is defined using a set reference substances (P and not P)
- Similar models were implemented with differences in individual assumptions
→ Results and their sensitivity to changes in input parameters can differ for each tool

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5. Overall persistence (P_{OV}) for a set of substances

- P_{OV} was calculated for a set of registered plant protection products with the EXCEL-based tools ELPOS and the OECD tool. Calculated values were compared to indicator values based on reference substances.
- Most cases: respective P_{OV} calculated with the two different tools were comparable

Artificial results for F and G:
- Default FOCUS DT$_{50}$ in water and sediment
→ **Do not use parameters derived for other purposes**

Figure 3. Pov calculated for eight substances with the OECD tool and with ELPOS respectively.

- In contrary to the OECD tool, ELPOS considers water and sediment separately. This leads to significantly different P_{OV} predicted by the two tools

→ **Relevant parameters for P_{OV} assessment must be identified**

Trigger for P: An extensive set of persistent reference substances is required

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6. Summary

- A reductionistic and rigid interpretation of persistence neglects a huge amount of data which is available on the partitioning and fate of substances in the environment.

Persistence has regulatory consequences → "Persistent" is not an adjective

Persistence triggers must reflect all relevant information on a substance

- Overall persistence (P_{OV}) appears to be an appropriate measure of persistence
- However...
  - triggers, assessment methods and parameters must be consistent
  - P_{ov} trigger must be derived using a set of persistent substances as reference
  - input parameters must be derived for this specific purpose
  - typical emission pattern of plant protection products needs to be considered.

References & Acknowledgement

[1] Regulation (EC) No.1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC
[2] Wegmann et al. (2009) Env. Mod. & Software 24. 228-237:
[3] Scheringer et al. (2009) IAEAM 5/4. 557-576
[4] Matthies et al.(2009) Environ. Sci. Technol. 43. 9223–9229
[5] Klaismeier et al. (2006) ES&T 40, 53-60
[6] Boethling et al. (2009) IAEAM 5/4. 539-556

Supporting data:
Main parameters of the selected plant protection products

Substance	A	B	C	D	E	F	G	H
DT$_{50,soil}$ [d]	2	20	20	75	75	130	150	170
DT$_{50,air}$ [d]	0.3	0.1	0.1	0.5	1	1	0.3	0.4
DT$_{50,wat}$ [d]	35	10.3	6.8	1000*	59.8	32	1000*	13
DT$_{50,sed}$ [d]	1.36	4	80.5	15.1	61.4	1000*	1000*	17
DT$_{50,wat/sed}$ [d]	2	11	55	25	110	1000*	1000*	6
log K$_{OW}$	3.4	4	4.5	5.2	3.3	3	3.1	5.3
log K$_{AW}$	-6.8	-8.7	-4	-2.9	-8.2	-7.7	-9.9	-2.4

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