WATSON WG3

Using environmental isotopes for waiting time assessment in groundwater protection zones

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LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère du Développement durable
et des Infrastructures

Administration de la gestion de l'eau

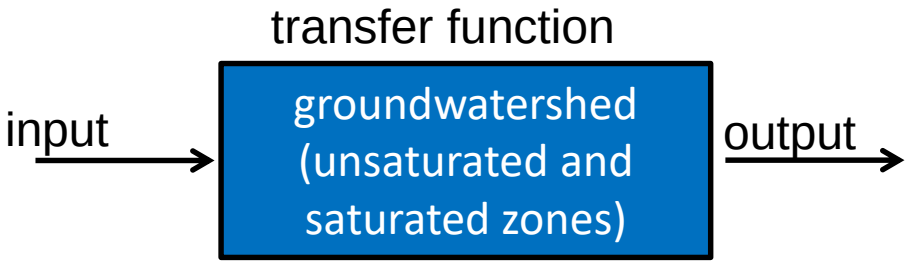
Time horizons in groundwater protection zones

Estimates of waiting times are useful when mitigation measures are taken in a protection zone, and you want to know how long it will take for water quality to improve. For instance:

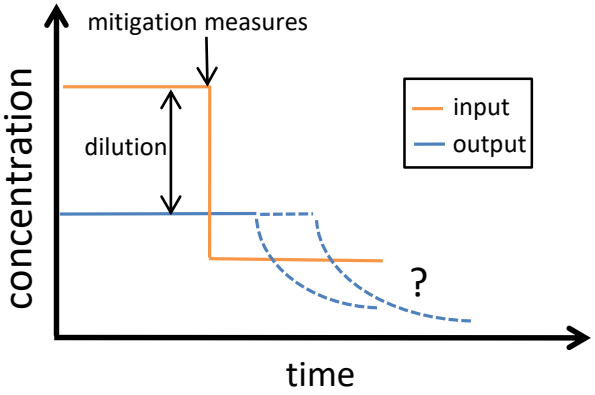
- A upward trend is to be reversed, but nothing happens. Are the measures insufficient, or is the aquifer acting as buffer ?
- An agrochemical has contaminated the groundwater. It is now forbidden, but how long will the water provider have to wait until groundwater can be used again for drinking purposes ?

Where lumped parameter models come in

If we frame the transport of agrochemicals from the fields to the groundwater intake (well or spring) as a classical input-output problem, we have

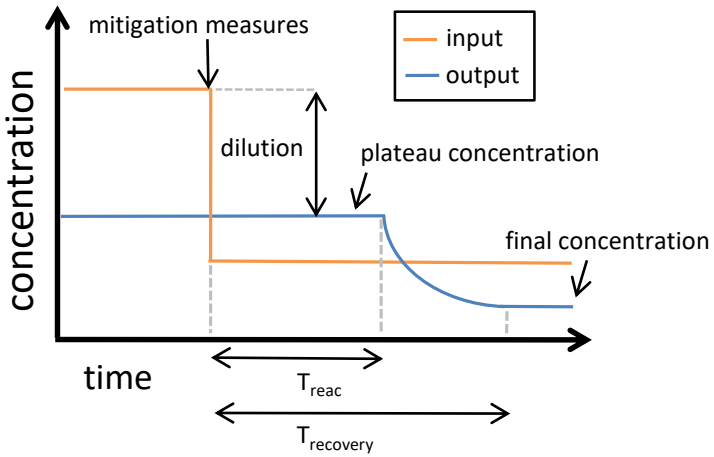


A water manager is interested in predicting the future output for certain mitigation scenarios

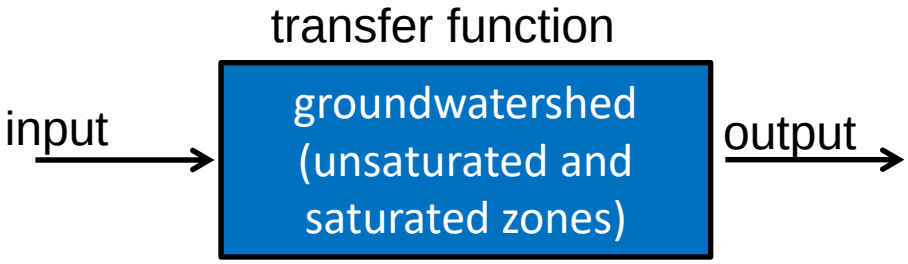


Some useful waiting times

- mean transit time $\bar{T}$: average travel time from injection point to outlet
- reaction time T_{reac}: lag between measure implementation and begin of change at the outlet
- recovery time $T_{recovery}$: lag between measure implementation and reaching a certain concentration goal (e.g. drinking water standard)
- Both T_{reac} and $T_{recovery}$ depend upon $\bar{T}$, but are <u>not</u> equal to it !



Practical implementation



- input➔estimated/reconstructed/simulated
- transfer function➔calibrated with isotopes or historical contaminants
- output➔sought information

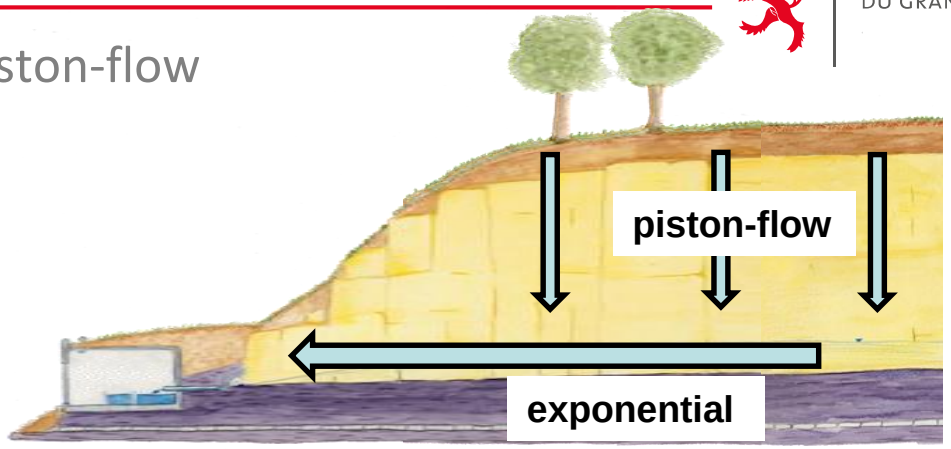
Case study

Several springs providing drinking water to the city of Luxembourg have been abandonned due to increasing concentrations of n,n-dimethylsulfamide (TP of the orchard fungicide tolylfluanide). Tolylfluanide was banned from use in 2008. The water provider wanted to know:

- What the maximum concentrations would be.
- When this maximum would be reached.
- The waiting time until concentrations would be back to the drinking water standard of 100 ng/L.

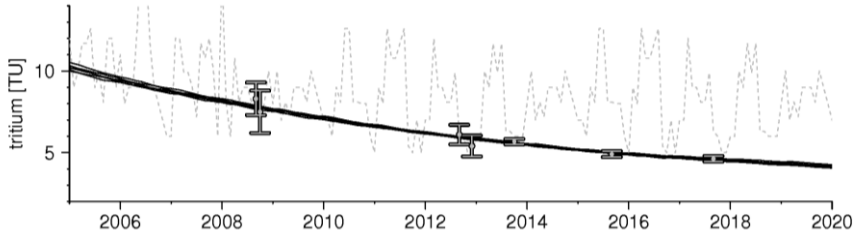
Case study

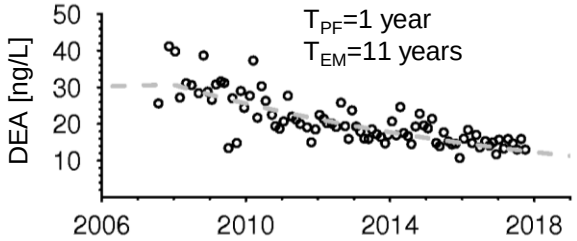
- Model: exponential piston-flow



- Calibration with $^{3}H+^{2}H$ and desethylatrazine

➔$\bar{T}$=T_{EM}≈11-15 years



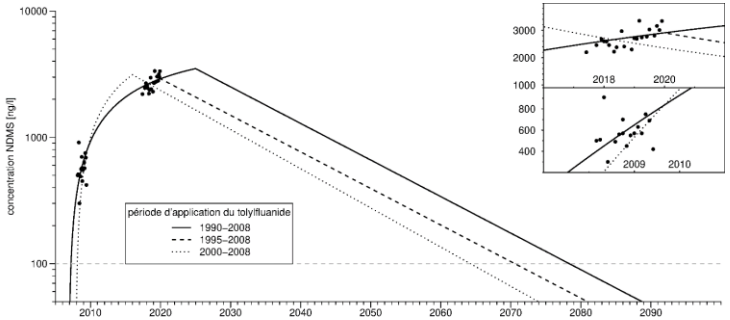


- Prediction

➔T_{reac}≈15 years

➔ $T_{recovery}$≈2070-2080

➔C_{max}≈3000 ng/L



Conclusions

- Classical groundwater dating methods are simple to adapt to (ground)water quality problems.
- The transfer function can be parameterized using environmental isotopes or historical contaminants (combining both is best)
- The different waiting times useful to water managers should not be confused with the tracer mean transit time.
- Useful waiting times can be *derived* from the calibrated transit time distribution.

Question ?