# ENV-405 | Water and Wastewater Treatment

**Lecture 1**. Water Quality

**Date**. 09.09.2025

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## **Exercice #1 |** Contribution of micropollutants to dissolved organic carbon (DOC)

Groundwater samples are increasingly monitored not only for classical parameters such as Dissolved Organic Carbon (DOC), but also for the presence of micropollutants such as pesticides, pharmaceuticals, and persistent organic pollutants. In this exercise, you will evaluate the contribution of the selected micropollutants (see table below) to the total DOC concentration.

| **Micropollutant** | **Concentration [ng/L]** |
|---|---|
| Chlorothalonil metabolites R471811 | 250 |
| Atrazine | 800 |
| PFOS | 120 |
| Diclofenac | 500 |

**Q1.** Estimate the carbon contribution (in %) for the overall micropolluants if the DOC concentration of the groundwater is 0.3 mgC/L. Discuss the results.

**Exercice #2 |** Water resources quality

The tables below show the water composition of two raw waters used for drinking water production.

**Water quality #1**

| Parameter | Measured value |
|---|---|
| Temperature | 7-12 ºC |
| pH | 6.4-7.1 |
| DOC | 1-5 mg/L |
| UV (254 nm) | 1.3-19.5 $m^{-1}$ |
| Calcium | 122 mg/L |
| Magnesium | 3.5 mg/L |
| Nitrate as $NO_3^-$ | 25 mg/L |
| Atrazine | 150 ng/L |
| Tetrachlorethylene | 20 µg/L |
| Trichlorethylene | 15 µg/L |
| Bromide | 20 µg/L |
| Turbidity FTU | 0.2 - 150 |

**Q1.** Assess the water quality in terms of the Swiss drinking water regulations (OPBD).

**Q2.** Calculate the hardness in °f

**Q3.** Identify the possible water resources of this water

**Water quality #2**

| Parameter | Measured value |
|---|---|
| Temperature | 11.4 ºC |
| pH | 7.1 |
| DOC | 4 mgC/L |
| Total hardness | 39°f |
| Oxygen | 0 mg/L |
| Magnesium | 3.5 mg/L |
| Nitrate as N | < 0.01 mg/L |
| Nitrite as N | 0.02 mg/L |
| Ammonium as N | 1.2 mg/L |
| Iron | 6.6 mg/L |
| Manganese | 0.22 mg/L |

**Q1.** Assess the water quality in terms of the Swiss drinking water regulations (OPBD).

**Q2.** Identify the possible water resource of this water

**Exercice #3 |** Riverbank filtration – *mixing and transformation processes*

A river water infiltrates in the ground as explained in lecture 1. Thereby, as a function of the infiltration distance, the mixing ratio with groundwater increases. The two waters differ in their chloride concentration: river water 0.1 mM and groundwater 0.3 mM.

The table below shows the measured chloride concentration in sampling wells as a function of the infiltration distance.

| | **Concentration [mM]** | | | | | | |
|---|---|---|---|---|---|---|---|
| **Infiltration distance [m]** | **Cl-** | **$O_2$** | **$NO_3^-$** | **$SO_4^{2-}$** | **$HCO_3^-$** | **$Ca^{2+}$** | **pH** |
| 0 | 0.1 | 0.25 | 0.4 | 0.5 | 2 | 0.9 | 7.7 |
| 20 | 0.104 | 0.05 | 0.25 | 0.49 | 2.4 | 1.15 | 7.4 |
| 80 | 0.11 | 0.02 | 0.054 | 0.485 | 2.6 | 1.3 | 7.5 |
| 90 | 0.12 | | 0.04 | 0.46 | | | |
| 140 | 0.14 | | | 0.44 | | | |
| 250 | 0.3 | 0.15 | 0.2 | 0.2 | 2.6 | 1.3 | 7.5 |

**Q1.** Based on the chloride concentrations, sketch the relative contribution of river water in the groundwater

**Q2.** The information from the chloride profile can now be used to estimate whether a concentration-distance profile for a given redox-sensitive species ($O_3$, $NO_3^-$, $SO_4^{2-}$) is caused by chemical/microbiological processes or by dilution. Sketch the concentrations of the redox-sensitive parameters as a function of the river water content. What can be deduced from such graphs?

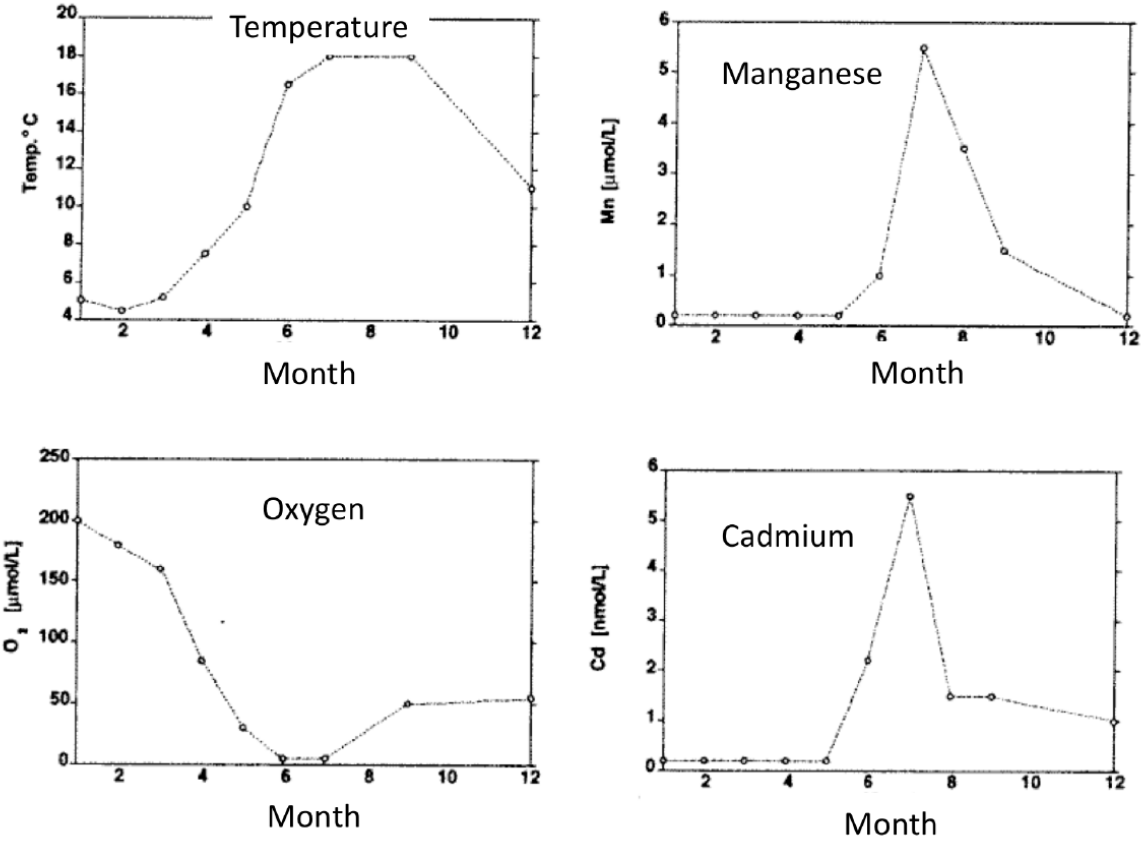
**Q3.** Is the $CaCO_3$ equilibrium fulfilled at each sampling well or do we expect a precipitation of $CaCO_3$ upon contact with the atmosphere (what is $pCO_2$ compared to the atmosphere)?

**Q4.** Riverbank filtration is an important source for drinking water in Switzerland (ca. 25%). If one considers an oxygen concentration of 8 mg/L (0.25 mM), what is the critical concentration of DOC to yield anaerobic conditions? Assumption: DOC is present as $CH_2O$ and is the only source of carbon in the water.

**Q5.** What happens if the DOC concentration is 5 mgC/L and nitrate is 5 mg/L? Assumption: all DOC is biodegradable.

**Exercice #4 |** Riverbank filtration – *biogechemical processes and geochemical consequences*

During infiltration of the Glatt river (Glattfelden) samples were taken at one groundwater sampling well to obtain seasonal information on temperature, oxygen, manganese and cadmium (figure below).




**Q1.** How do you interpret these field observations?

**Q2.** What parameters are problematic from a point of view of drinking water

**Exercice #5 |** Phosphate fertilization in a lake

A stagnant lake has a phosphate concentration of 50 µgP/L in the epilimnion. 90% of this phosphate is transformed into biomass which sinks to the hypolimnion. The volume of the epilimnion is $2.5 \times 10^6$ $m^3$.

**Q1.** What is the minimum volume of the hypolimnion to avoid anoxic conditions. Assumption: the hypolimnion is a completely mixed reactor with an average oxygen concentration of 8 mg/L.

**Q2.** What happens if the column is smaller and what are the consequences for water quality?

**Q3.** An industrial company would like to use lake water for cooling purposes, but this is not authorized in Switzerland. Why?