EOSC - 213
Assignment introduction to the sulfate problem in the TMF

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Outline

The usual

As usual, start by getting the notebooks:

1. Login on your cocalc account
2. Open a terminal (ideally from the eosc213_students folder)
3. `git fetch`
4. `git reset --hard origin/master`

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5. If you have `git` problems, it is likely that you are not in the proper `git` repository (which is the eosc213_students folder)
   - `pwd` shows your current directory
   - `cd folder_name` changes to the folder named `folder_name` (if it exists where you are)
   - `cd` goes back to your root directory (from which you would have to do `cd eosc213_students`)
   - `cd ..` go back the the parent folder
   - `ls` prints the folder and files which are in your current folder

Today's notebooks

You should have 2 notebooks, for the two parts of the class

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1. The first one (to do together solves the TMF problem from the introductory lecture)
2. The second is an assignment due for next wednesday
    - Auto-graded (we'll see how that goes)
    - You will start it today
    - On tuesday, we will see additional concepts which could potentially help you finish
    - Typical problem in groundwater quality

Outline

Recap

In the introduction, we have started studying the mass balance in a TMF.

$$\frac{\Delta V}{\Delta t} = Q_{in} - Q_{out}, \tag{1}$$

which we described in the differential form:

$$\frac{dV}{dt} = Q_{in} - Q_{out}. \tag{2}$$

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which we described in the differential form:

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We will solve this problem using data for Q_{in} and Q_{out}. To do that, we will use

- `pandas` to read the data in an external file
- `matplotlib` to plot our results
- `numpy` to work with arrays

Outline

We will study the evolution of the sulfates ($SO_4^=$) concentration within the TMF. This kind of typical study is motivated by the facts

- Sulfates is one of the major dissolved constituents in most terrestrial waters
- Too high sulfate concentrations can make water undrinkable
- **In some cases**, high sulfate concentration are associated with acidic conditions, which can dissolve other elements and release poisonous heavy metals

The study of the sulfate concentration in groundwater is an environmental concern!

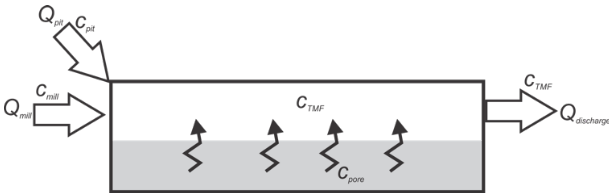
Objectives

The objectives of this assignment are

1. Build a conceptual model
2. Translate the latter into a computational method
3. Solve the model to predict the evolution of the concentration with time
4. Compare the solution to the analytical solution of the associated ODE problem
5. Introduce the concepts of accuracy
6. Use Euler's methods

Conceptual model

The conceptual model considers 4 main interactions which govern the evolution of sulfate concentration in the TMF



1. Flow from the pit containing a certain concentration of sulfates
2. Flow from the mill containing a certain concentration of sulfates
3. Discharge
4. Production of sulfates from the tailings porewater at the bottom of the TMF

Conceptual model - mass transfer

The production of sulfates from the tailings porewater will be described by a "first order mass-transfer"

$$j_{\mathrm{pore}} = k(c_{\mathrm{pore}} - c_{\mathrm{TMF}}) \tag{3}$$

with $c_{\mathrm{pore}} = 2000$ mg/L constant in time

- j_{pore} represents the flux (mg/m^2/s)) at the bottom of the TMF
- This can represent a diffusive source for sulfates
- Or the generation of sulfates through the oxydation of sulfide minerals (pyrite, for example)
- Initially, the concentration c_{TMF} is 93 mg/L. Therefore, this mass transfer tends to increase the concentration in the TMF.

Summary

We have 3 processes contributing positively to the sulfate concentration

- Inflow from the pit
- Inflow from the mill
- Diffusion from the tailings porewater

And one process contributing negatively to the sulfate concentration

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(a) Q
(b) ct
(c) Qc^2
(d) $\frac{c}{Q}$
(e) Qc

Addendum

For the previous question.

- Q represents the inflow of water (in L/s)
- c reprepsents the inflow concentration (in mg/L)

Let us consider $Q = 1$ L/s and $c = 1$ mg/L. That means that, over 1 second.

- 1 liter of water comes in
- There is 1 mg of sulfates in each liter of water
- So 1 mg of sulfates is brought with the inflow at each second
- 1 mg/s of sulfates are being added in the system
- If Q (or c) is doubled, that mass is doubled

Qc represents the mass per unit of time (mg/s) of sulfates which is brought by the flow.

Conceptual model - values

Table: Values

Symbol	Value	Units	Description
c_{pit}	50	mg/L	Concentration in the pit water
c_{mill}	700	mg/L	Concentration in the mill water
Q_{pit}	30	L/s	Flow from the pit
Q_{mill}	14	L/s	Flow from the mill
Q_{dis}	44	L/s	Discharge flow
c_{pore}	2000	mg/L	Concentration in the porewater
k	2.5×10^{-5}	L/s/m^2	Flux coefficient
$Area$	3×10^5	m^2	Area at the TMF bottom
V_0	8.1×10^9	L	Initial water volume
c_0	93	mg/L	Initial sulfate concentration in TMF

Physical intuition 1

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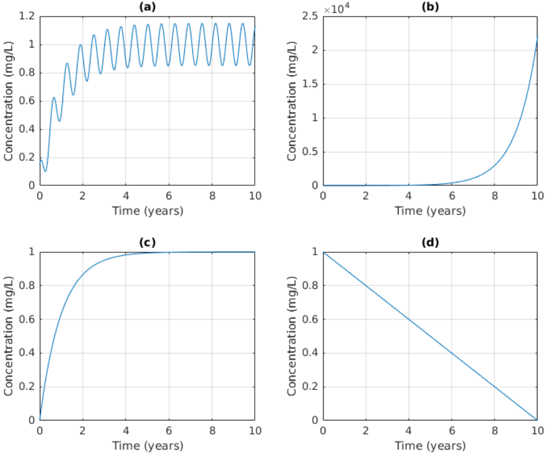
How would you expect the sulfate concentration to evolve over time? It should reach a steady state!



Physical intuition 2

Which of the following values seems the most reasonable one for the asymptotic/final sulfate concentration in the TMF?

(a) 0 mg/L

(b) 1000 mg/L

(c) 2200 mg/L

(d) 2300 mg/L

(e) 10000 mg/L

It should never be 0 because there is a constant influx bringing sulfates. It should never be above 2000 mg/L (which is c_{pore}), because as soon as you reach 2000, the source from the tailings porewater stops acting. The answer has to be between 0 and 2000 mg/L.