Water chemical evolution in Underground Pumped Storage Hydropower plants and induced consequences

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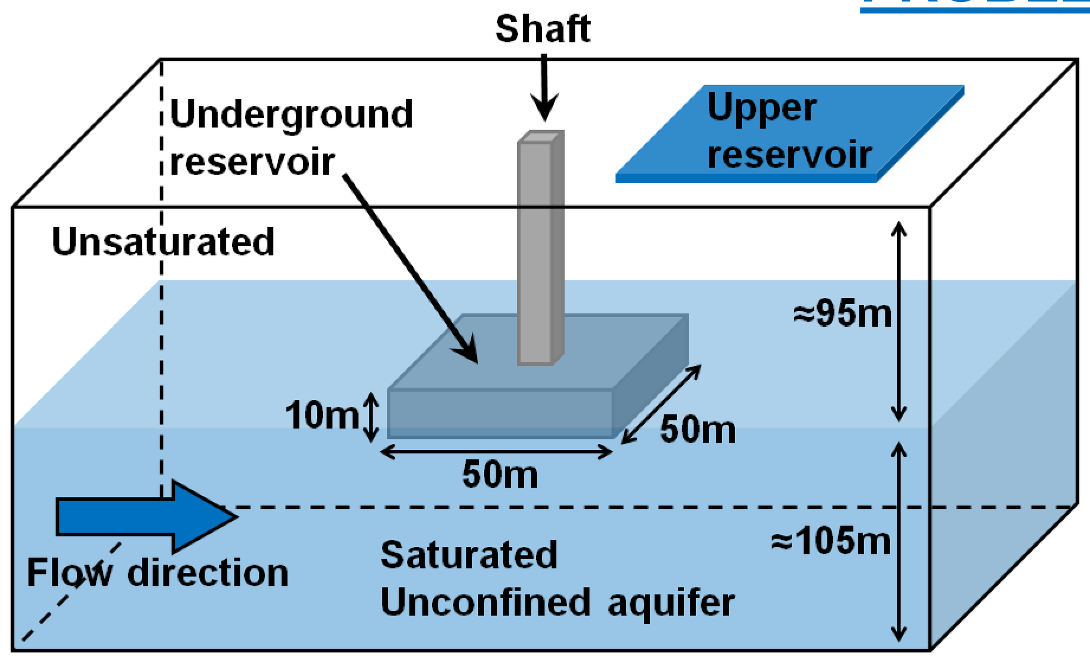
Introduction

UPSH requires pumping groundwater from an underground to an upper reservoir to store electricity in form of potential energy. During this process, water is aerated and equilibrated with the atmosphere (i.e., O_2 and CO_2 vary) and reactions may occur in the upper reservoir. This water is subsequently released into the underground reservoir to generate electricity, and given that its hydrochemistry has varied, reactions may also occur in the underground reservoir. Reactions occur when the released water is mixed with remaining water inside the underground reservoir or interacts with the surrounding environment (groundwater and porous medium). The induced hydrochemical variations can entail negative consequences on the environment and on the efficiency of the UPSH plant, especially in coal mine areas where the presence of sulfide minerals is common. This work assesses the main hydrochemistry trends occurred in three synthetic scenarios and their consequences. The objective is to highlight the importance of considering hydrochemistry aspects during the design stage of future UPSH plants.

Materials and methods

PROBLEM STATEMENT



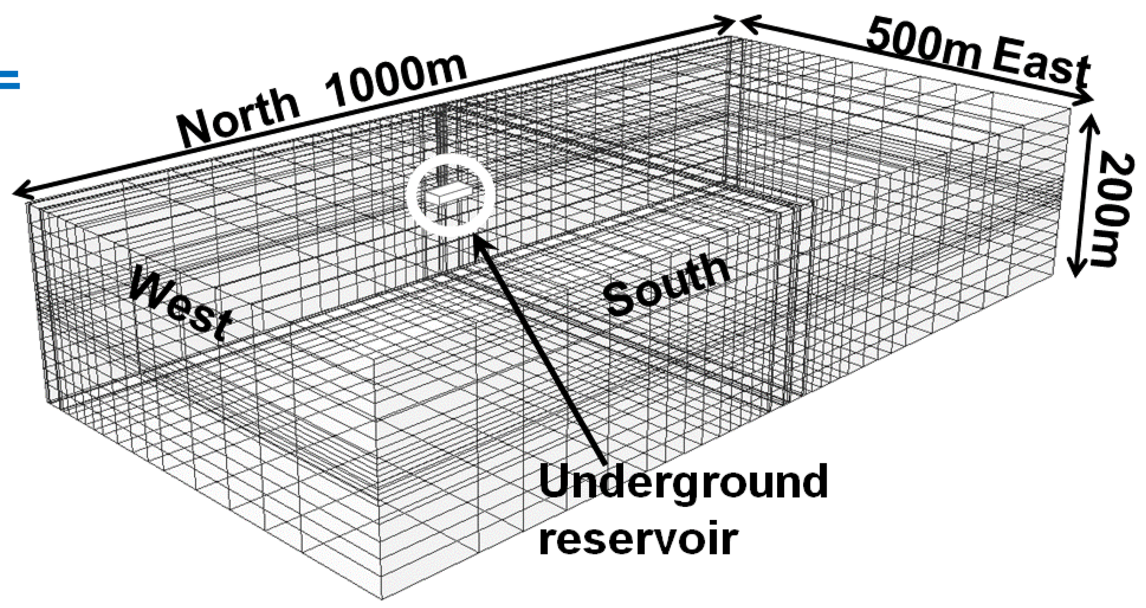
Three scenarios depending on the soil composition:

- **Scenario 1: 1% of Pyrite**
- **Scenario 2: 1% of Pyrite and 30% of Calcite**
- **Scenario 3: 30% of Calcite**

21500m3/d are pumped and injected consecutively in phases of 12 hours

NUMERICAL MODEL

The problem is simulated using the code PHAST (Parkhurst et al., 1995; Parkhurst and Kipp, 2002) that solves multicomponent, reactive solute transport in three-dimensional saturated groundwater flow (Parkhurst et al., 2010).

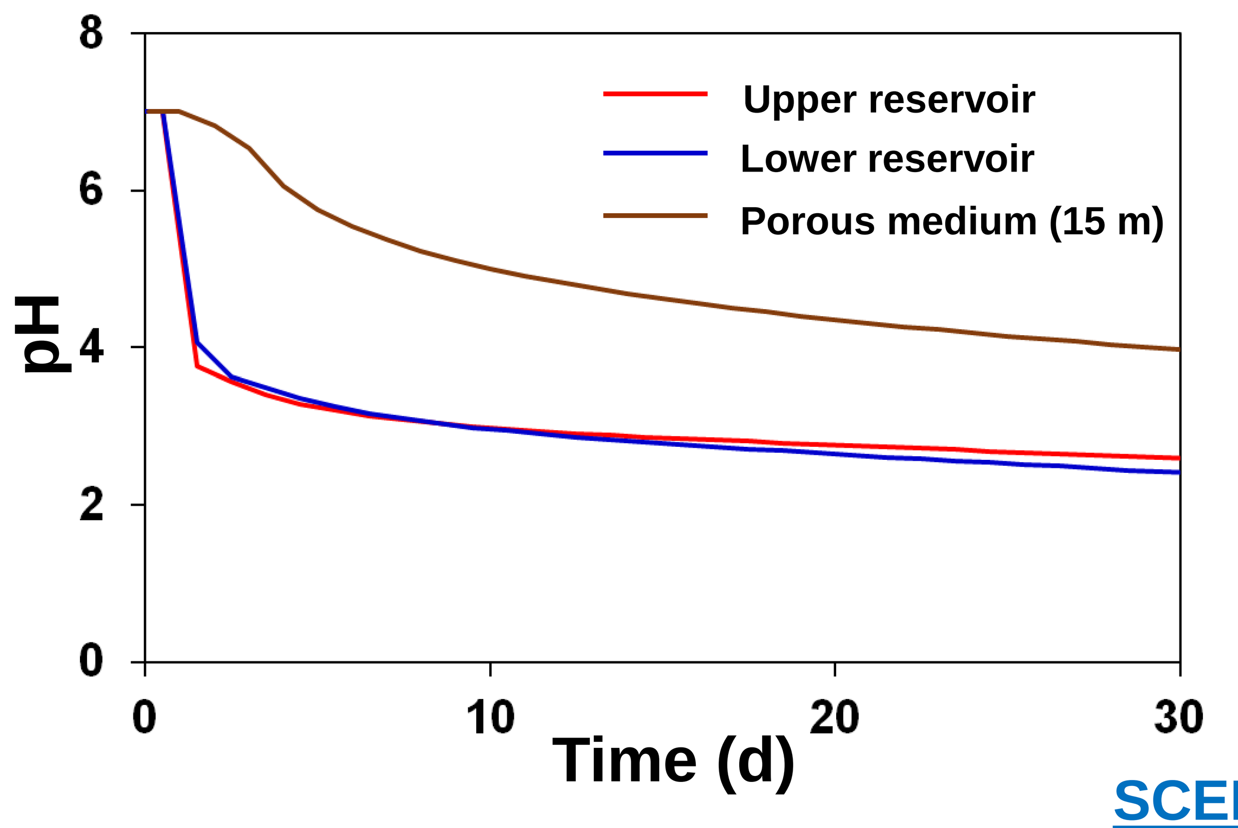


Conclusions

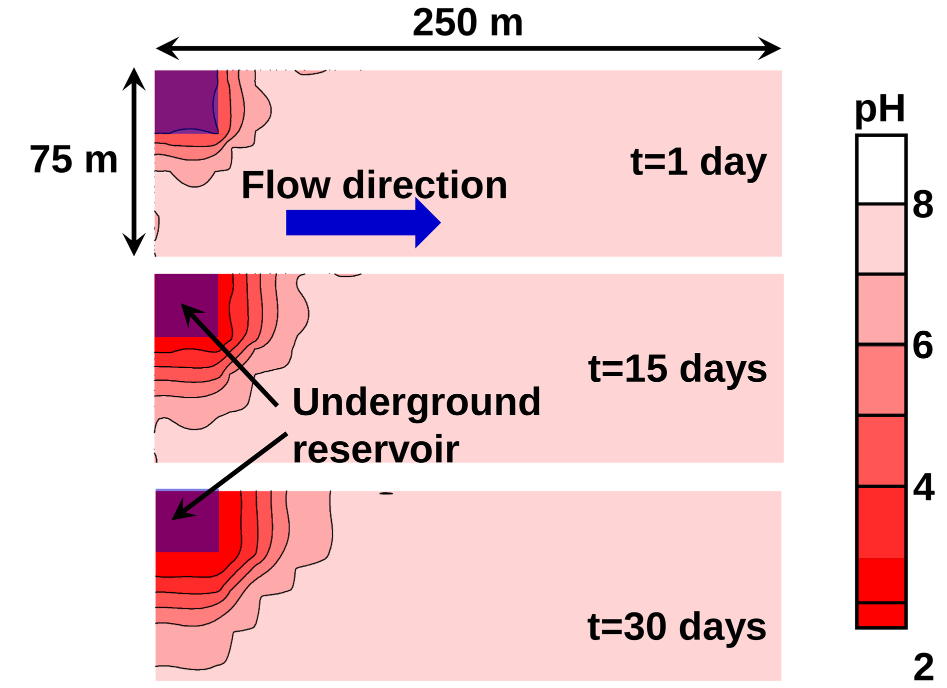
- **The increase of O_2 in the upper reservoir promotes sulfide dissolution when water is released into the underground reservoir. The pH may decreases in the underground reservoir and in the surrounding medium, which may affect the environment and the efficiency of the UPSH plant.**
- **Carbonate minerals avoid pH reduction but promote minerals precipitation (Calcite and Ferrihydrite) in the upper reservoir, which may affect the efficiency of the plant. Calcite precipitates since partial pressure of CO_2 decreases in the upper reservoir.**
- **UPSH induces hydrochemical variations that must be considered in the design of future UPSH plants to avoid environmental impacts and to increase their efficiency.**

Results

SCENARIO 1



pH in the porous medium (104 m depth)



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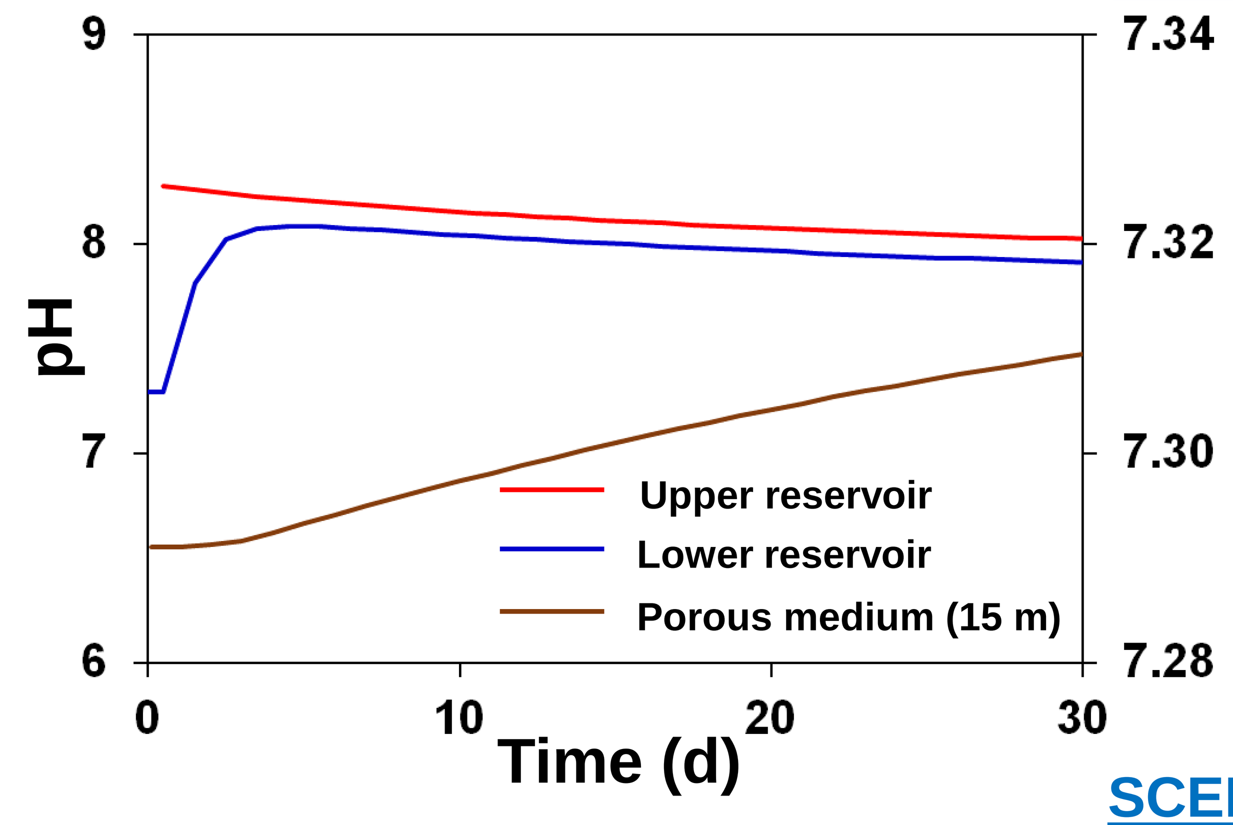
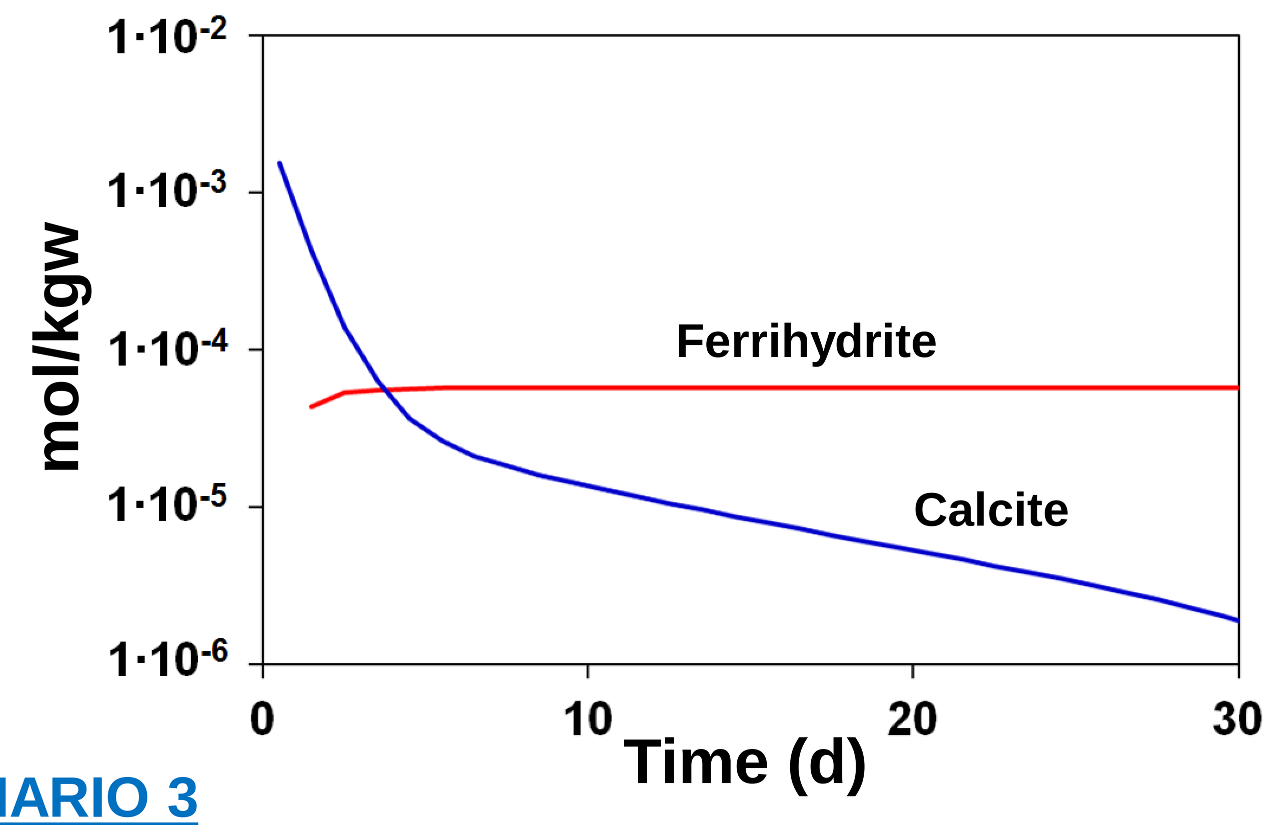
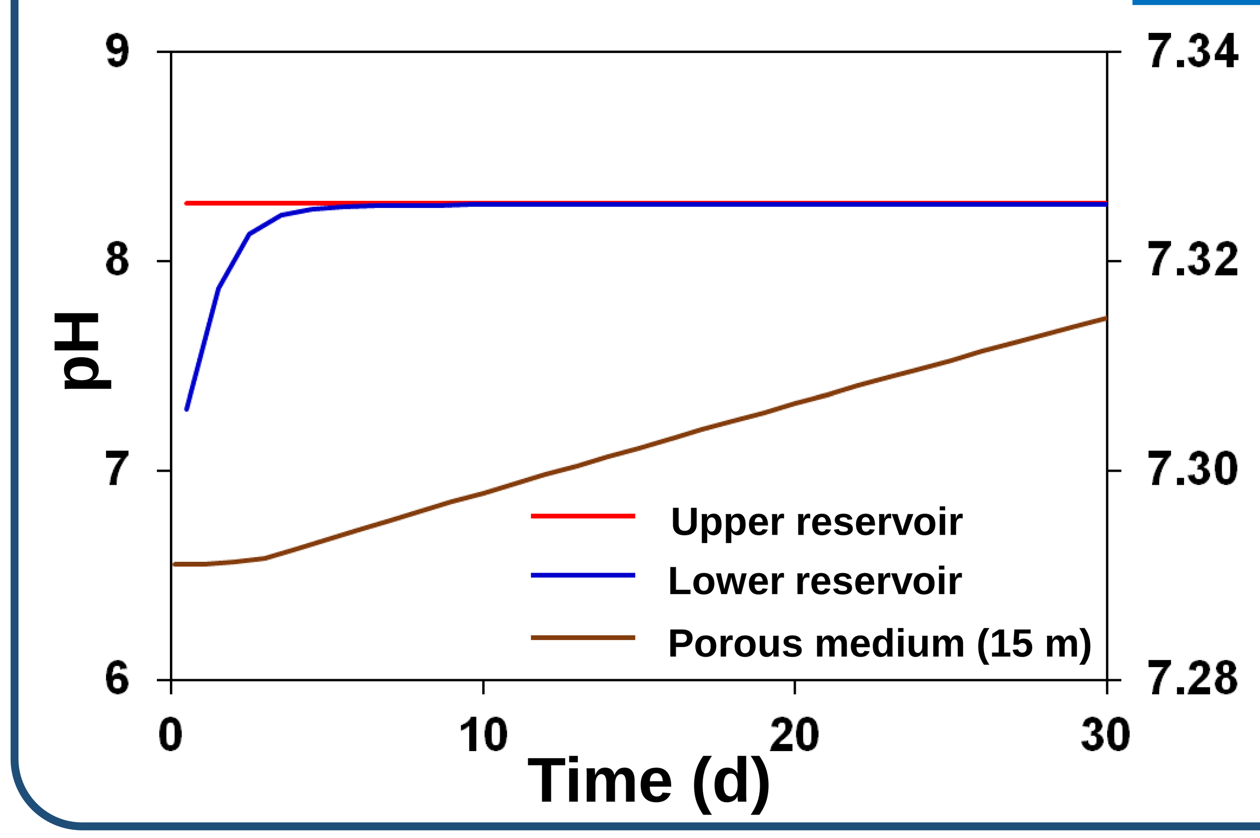
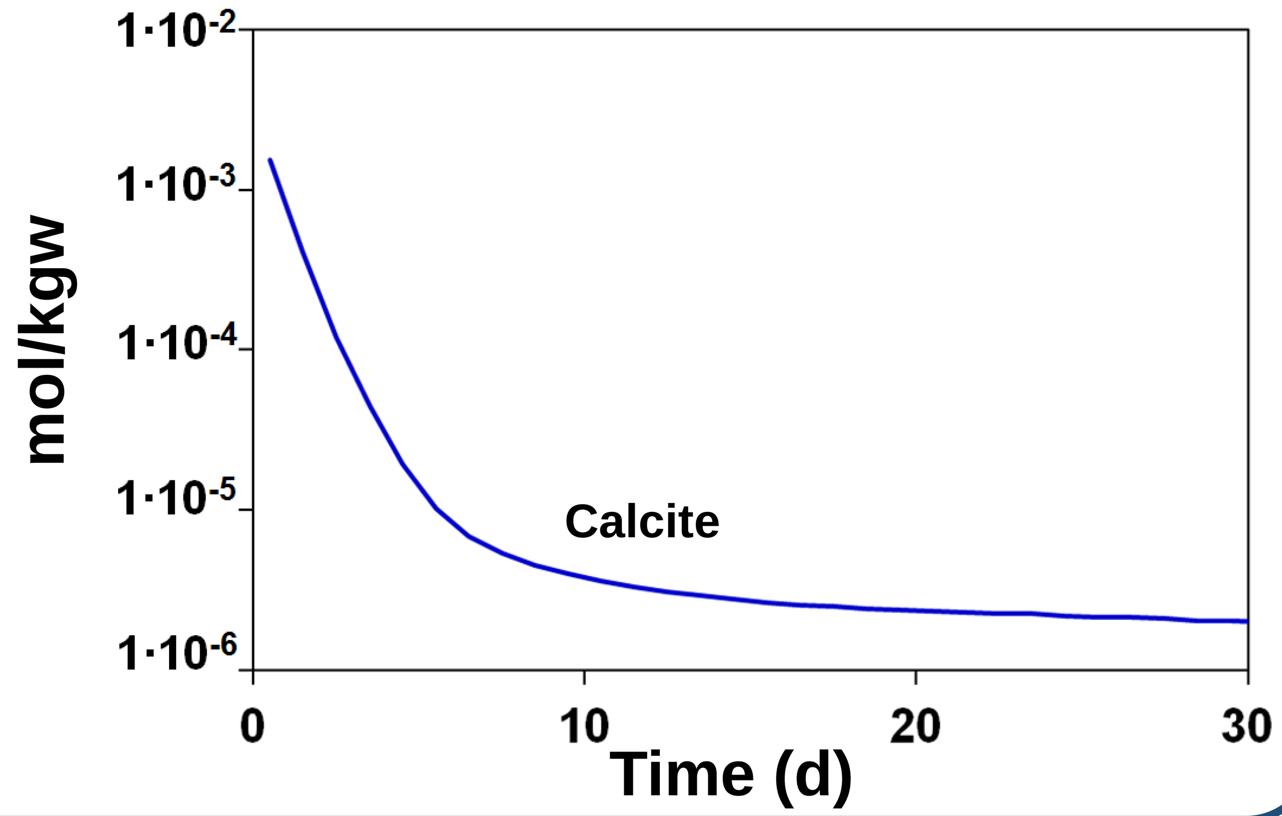




SCENARIO 3





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