Metal dissolution of volcanic ashes in seawater: the effects of organic ligand addition and radiation exposure time

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Abstract

Volcanic ashes contain both dissolvable major and trace metals that would release to the surface water while depositing on the ocean. The input of the minor nutrients may help phytoplankton grow. Some trace metals would require organic ligands to maintain soluble phrase, such as siderophores. In addition, the insolation duration of the Earth surface varies significantly with latitude. The effects of siderophore and sunlight exposure times on the dissolution extent are thus studied. By self-designed experiment setup, we found that siderophore addition significantly increase the dissolution of the metals, Ti, Fe, Co, Cu, Zn and Al in seawater. Light exposure can slightly increase Mo, Pb ,Ti , Fe, Al and decrease Cu, Zn dissolution.

Motivation

Volcanic ashes contain both major and trace metals. While depositing on the ocean, volcanic ashes would release metals that may be essential for cell function and biochemical reactions (Grand et al., 2019). In the ocean, it may increase phytoplankton growth rates (Mahowald et al., 2018). However, what we know about trace metal dissolution in volcanic ashes are limited. More studies are needed.

The ocean makes up 97% of Earth's fluid and covers 71% of the Earth surface. In seawater, organic ligands are essential to maintain high trace metal solubility for some trace metals (Borer et al., 2004; Wang et al., 2017; Kessler et al., 2020; Biswakarma et al., 2021).

Moreover, half of the earth surface is exposed under sunlight and the insolation duration is depended on latitude. In this study, we examined the effects of desferrioxamine mesylate (DFB), a siderophore, addition and sunlight exposure time on the metal dissolution.

Method

In this study, volcanic ashes were added to natural seawater under various light exposure time with or without DFB addition.

- Volcano ash
  - Eyjafjallajökull (Suðurland, Iceland)
  - Sample collect at Sep. 17, 2010
  - Using particle size similar to aerosol (<50um)
- Seawater
  - OR1-1193-9 10m
  - pH: 7.11
- DFB stock solution
  - 1mg desferrioxamine mesylate : 1mL milli-Q
  - Final concentration: 1.522uM
- JNP034 LED light
  - Ra= 97.5
  - E(lux): 35974
  - E(mW/m^2): 131094
  - Wavelength: 410~732nm

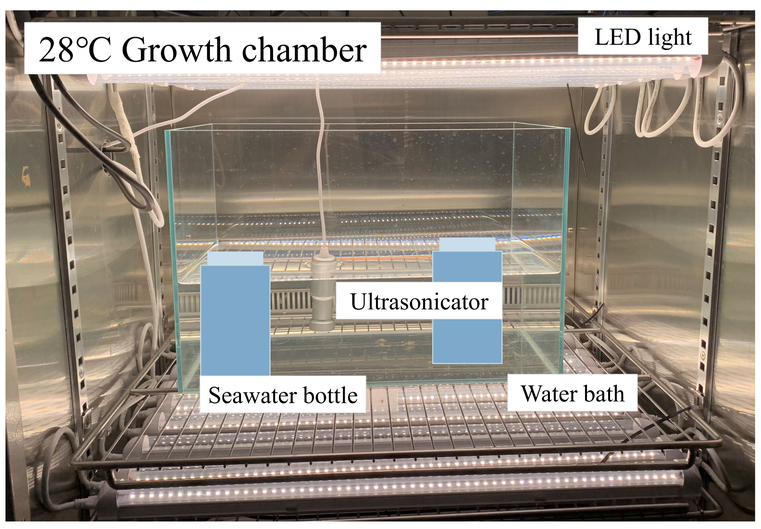

Figure 1. Self-designed experiment setup

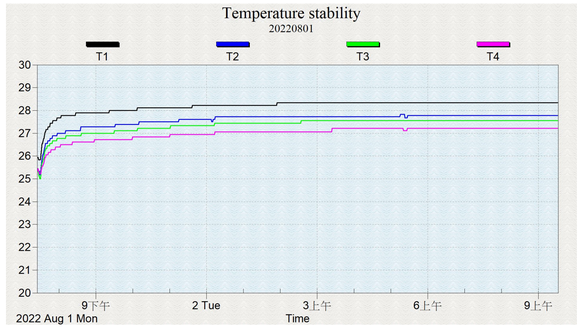

Figure 2. Temperature stability test

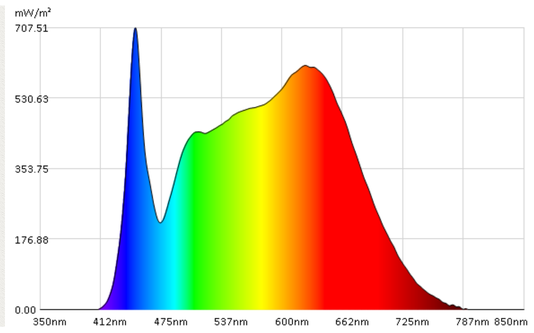

Figure 3. LED light spectrum

Result

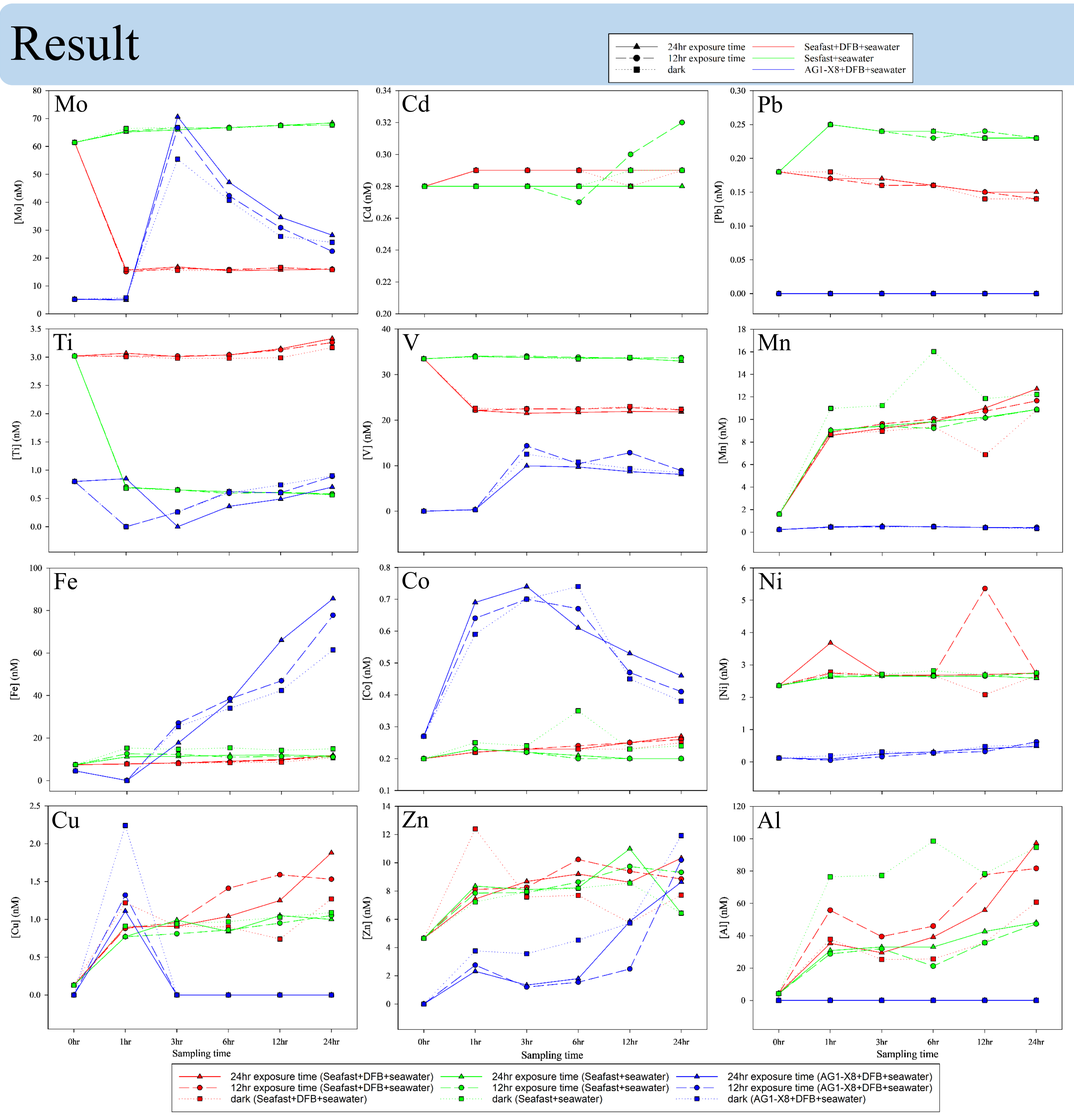

Figure 4. Dissolved metal concentrations under the treatments

Discussion

As a siderophore, DFB addition increases not only Fe, but also Ti, Co, Cu ,Zn and Al dissolution according to my result (fig 4).

In this study, the anion-ion resin exchange column treatment is particularly designed only for iron, yet Mo and Co were also released from DFB complex. It seems to me that different method need to be developed to acquire true dissolved concentrations for different metals in this experiment.

We found that light exposure can slightly increase the dissolution of Mo, Pb ,Ti , Fe, Al and slightly decrease Cu, Zn dissolution. The 24 h radiation period may not be long enough to fully release the soluble fraction. We also observed contamination issues in samples from the data, indicating that the experimental procedures should be adjusted improved.

Acknowledgement

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