

2020 年臺灣國際科學展覽會 優勝作品專輯

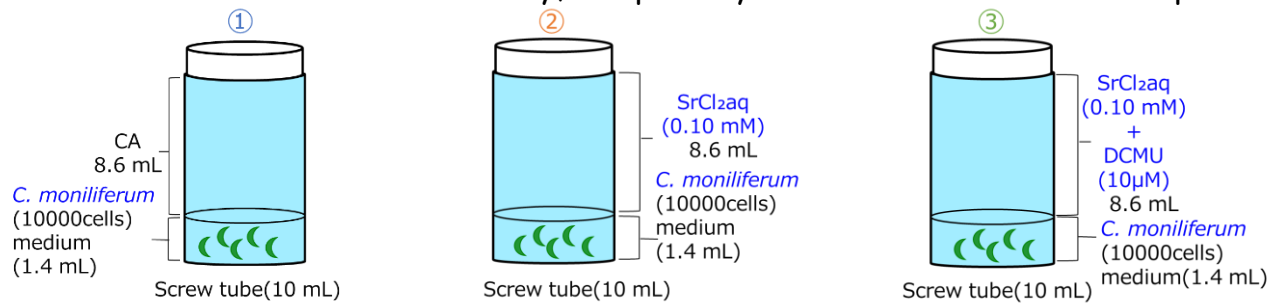
作品編號	200012
參展科別	環境工程
作品名稱	Absorption of Sr²⁺ at low concentrations using C.moniliferum-- With the aim of practical use of contaminated water processing of the Fukushima Daiichi Nuclear Power Station
得獎獎項	大會獎：二等獎
國家	Japan
就讀學校	Fukushima Seikei High School
作者姓名	ENDO MIZUKI KANO SEIYA NEMOTO KEISUKE

作者照片

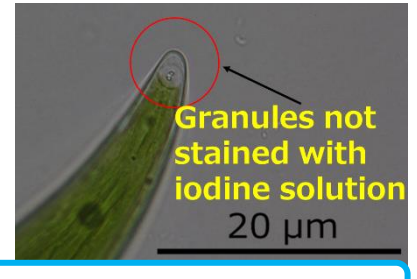
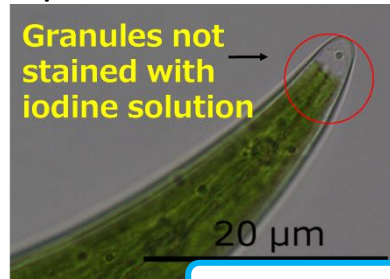
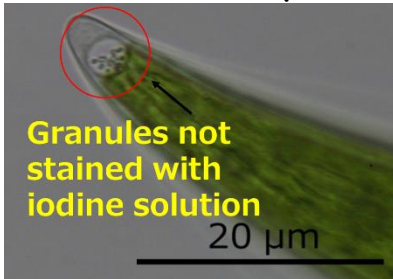


Abstract

We are conducting research for the purpose of treating contaminated water generated by the nuclear accident with *C. moliniferum*. In previous research, the school seniors examined whether there is a difference in absorption by changing the wavelength of the LED to establish efficient Sr^{2+} absorption conditions. As a result, the red wavelength was found to be effective for the efficient Sr^{2+} absorption of *C. moniliferum*. Therefore, in this study, in order to verify how much Sr is actually absorbed into the cell, the amount of Sr absorption using an atomic absorption photometer is quantified, and the previous research has shown that red is effective for the efficient Sr^{2+} absorption. The wavelength was considered to be effective because of photosynthesis, and was observed with a scanning electron microscope (SEM) using the photosynthesis inhibitor (DCMU). As a result, it was clarified that *C. moniliferum* absorbs Sr intracellularly, and photosynthesis was related to absorption.

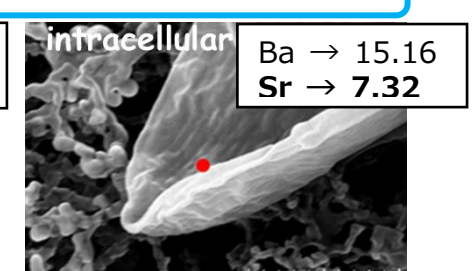
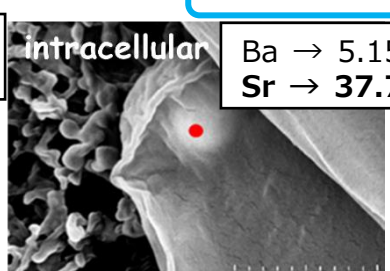
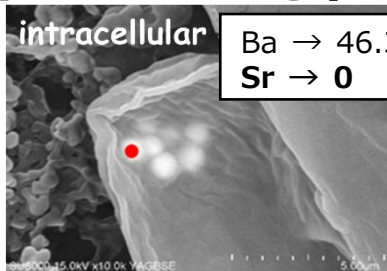


1. [Observation with optical microscope]



2. [Observation with SEM]

Sample ② and Sample ③ may absorb Sr



Numerical value indicates mass concentration (%)

Decreased proportion of Sr were confirmed to inhibit photosynthesis → Sr absorption is related to Photosynthesis

1. Background and Purpose of research

Due to the nuclear accident, radioactive materials including $^{90}\text{Sr}^{2+}$ were diffused. Seniors started a microbiological survey at Chayanuma near the school.

And discovered the *Closterium moniliferum* (Fig. 1).

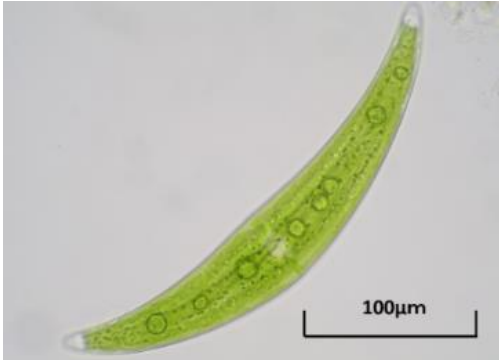


Fig.1. *Closterium moniliferum*

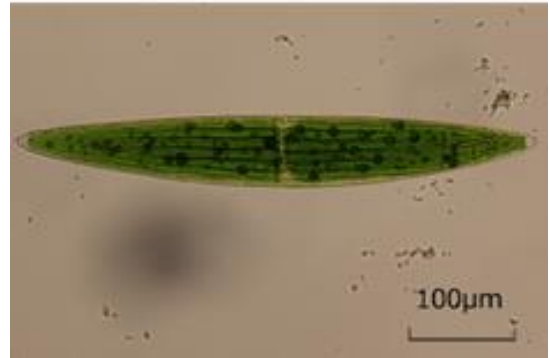


Fig.2 .*Closterium lunula*

Reference 1) describes that Ba^{2+} and Sr^{2+} are absorbed by the terminal vacuole of *Closterium moniliferum*. We are conducting research with the desire to contribute to the recovery of Fukushima by utilizing this *C. moniliferum* and the largest of the Japanese *Closterium*, the *Closterium lunula* (Figure 2), for the treatment of contaminated water.

2. The objective of this study

- (1) The amount of Sr^{2+} absorbed by *C. moniliferum* was measured using an atomic absorption photometer.
- (2) Whether photosynthesis is related to Sr absorption of *C. moniliferum* was examined by observation with a scanning electron microscope (SEM) using the photosynthesis inhibitor (DCMU).

3. This study

(1) Quantitation of Sr absorption using Shimadzu AA-6300 furnace atomic absorption photometer

In order to directly determine how much Sr is actually absorbed into the cells of *C. moniliferum* at a low concentration of SrCl_2 aq (0.10 mM), we asked Prof. Nobuhiko Sakurai of Nagoya City University, to help us and quantified Sr absorption using Shimadzu AA-6300 furnace atomic absorption photometer (graphite tube: planet form tube) (Fig. 3)

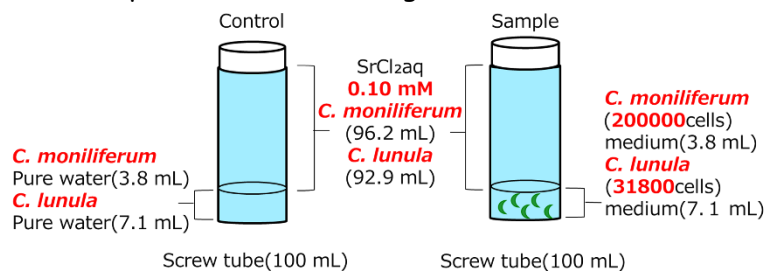


Fig. 3 Controls used in the experiment and conditions for loading the sample

[Experimental conditions]

** The possibility that red wavelength is effective for efficient Sr^{2+} absorption of *C.moniliferum* increased. Based on this, *C. moniliferum* and *C. lunula* were used under the conditions where the most Sr^{2+} absorption was observed (Fig. 4).

< using *C.moniliferum* >

** Red LED (640 nm, irradiation distance 37 cm, photon quantity $7.5 \mu \cdot \text{molm}^{-2} \text{s}^{-1}$)

Irradiate and put into SrCl_2aq for 48 hours

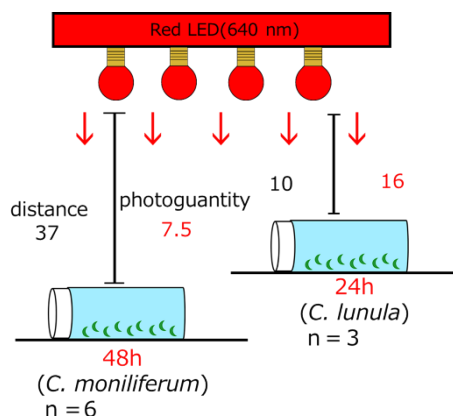


Fig. 4 Color of irradiated LED and irradiation distance (cm)
Photon quantity ($\mu \cdot \text{molm}^{-2} \text{s}^{-1}$)

< using *C.lunula* >

** Irradiate with red LED (640 nm, irradiation distance 10 cm, photon quantity $16 \mu \cdot \text{molm}^{-2} \text{s}^{-1}$) and put into SrCl_2aq for 24 hours

[Sample liquid preparation method and procedure]

- ① *C. moniliferum* and *C. lunula* after being put into SrCl_2aq were filtered with a membrane filter.
- ② Filtered *C. moniliferum* and *C. lunula* were ashed in an electric furnace.
- ③ A sample solution for measurement was prepared with reference to the analysis center method in Document 3).
- ④ The amount of Sr absorption was quantified using Shimadzu AA-6300 furnace atomic absorption spectrophotometer (graphite tube: planet foam type tube). Prof. Sakurai of Nagoya City University supports it

[Experimental results and discussion]

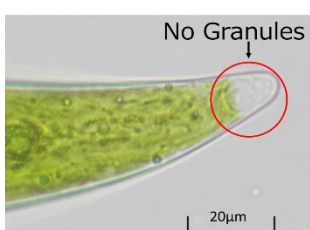


Fig. 5 *C.moniliferum*
Before putting into
 SrCl_2aq

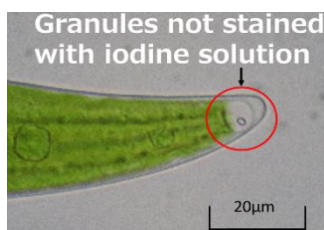


Fig. 6 *C.moniliferum*
Poured into SrCl_2aq

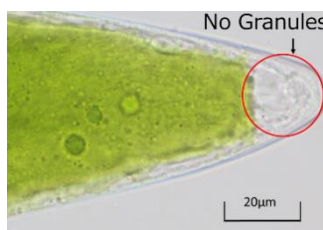


Fig. 7 *C.lunula*
Before putting into
 SrCl_2aq

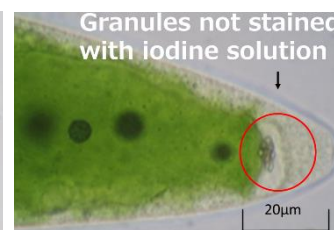


Fig. 8 *C.lunula*
Poured into SrCl_2aq

Actually, Sr was detected from the inside of *C. moniliferum*, and the absorbed amount of *C. moniliferum* was 0.092 ng / cell and the absorbed amount of *C. lunula* was 1.9 ng / cell. In addition, as a result of seeking Sr recovery in solution, *C. moniliferum* 2.1% at 48 hours, *C. lunula* is 2.5% at 24 hours, using an optical microscope observed the cell state that before putting into SrCl₂aq (0.10 mM) and Poured into SrCl₂aq (Figs. 5 and 7)

As a result, granules were not stained with the iodine solution and confirmed in the terminal vacuoles of the cells that had been poured into SrCl₂aq (0.10 mM) with each *C. moniliferum* (Figs. 6 and 8).

As a consideration, even though the concentration of SrCl₂aq was as low as SrCl₂aq (0.10 mM), Sr²⁺ in the solution was absorbed so possibility of selectively absorbing Sr²⁺ in solution increased. In addition, comparing the absorption of *C. moniliferum* and *C. lunula*, The *C. lunula* has a smaller number of cells than *C. moniliferum*, and has a higher Sr recovery rate in solution in a shorter time than *C. moniliferum*. Therefore, it thought that Sr can be collected efficiently by *C. lunula*.

(2) Observation of *C. moniliferum* using photosynthesis inhibitor (DCMU) with high resolution scanning electron microscope (SEM)

In order to verify whether photosynthesis is involved in efficient Sr²⁺ absorption of *C. moniliferum*, we prepared samples which with photosynthesis inhibitor (DCMU) and asked Fukushima University to observe *C. moniliferum* with a high-resolution scanning electron microscope (SEM) (Fig. 9),

- sample① → put into CA medium
- sample② → SrCl₂aq only (DCMU-free)
- sample③ → SrCl₂aq with DCMU

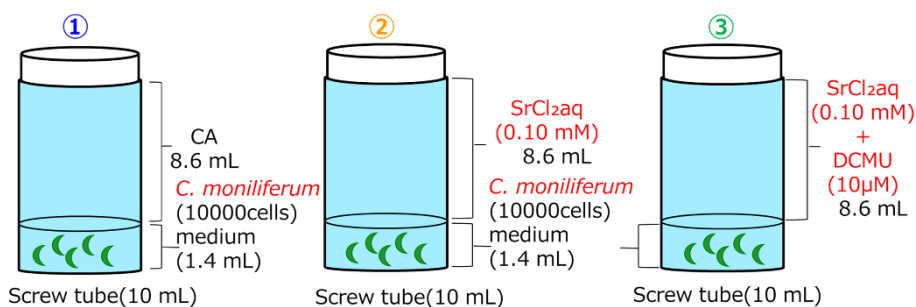


Fig. 9 Controls used in the experiment and conditions for loading the sample

<Experimental conditions>

The possibility that red wavelength is effective for efficient Sr²⁺ absorption of *C. moniliferum* increased. Based on this, the conditions under *C. moniliferum* showed the most Sr²⁺ absorption were used. [Red LED (640 nm, irradiation distance 37 cm, photon amount 7.5 μ · molm⁻² s⁻¹) is irradiated into SrCl₂aq for 48 hours]

【 Observation results 】

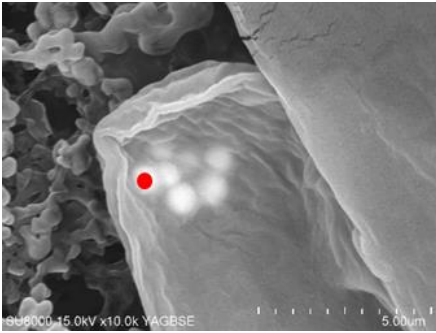


Fig. 10 Electron micrograph of sample ①
(The red dot indicates the observed part)

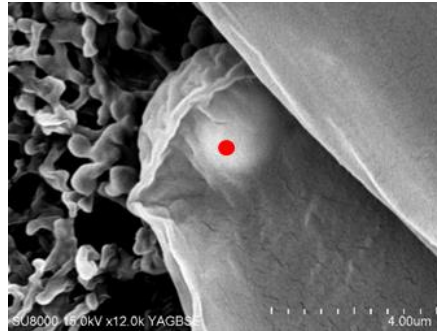


Fig. 11 Electron micrograph of sample ②

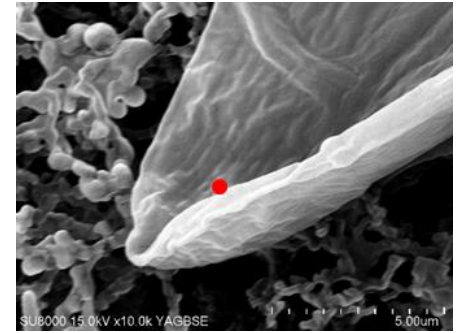
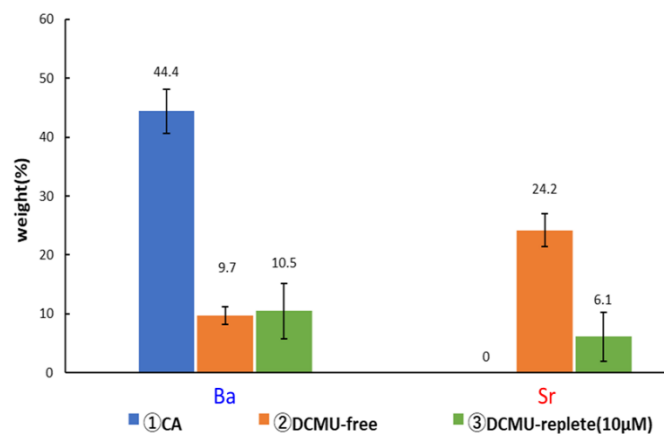


Fig. 12 Electron micrograph of sample ③

Table 【 EDX data of sample ①, ②, ③ 】

Element	Weight [%]		
	①	②	③
C	20.47	26.92	31.94
O	16.12	9.02	34.78
S	11.85	15.05	6.85
K	4.15	6.12	3.34
Cl	1.02	0	0.61
Sr	0	37.75	7.32
Ba	46.38	5.15	15.16
total	100.00	100.00	100.00

Comparison of mass concentration [%] of Ba and Sr in each sample



【 Conclusion 】

Ba was confirmed in the terminal vacuole from *C.moniliferum* of sample ① (Fig. 10, Table).

Sr was confirmed in the terminal vacuole part from *C.moniliferum* of sample ② (Fig. 11) and

C.moniliferum of sample ③ (Fig. 12). However, the percentage of Sr confirmed in sample ③ was lower than sample ② (Fig. 11). and a large proportion of Ba was confirmed (Table).

It is thought that the effect of the inhibitor appears. Furthermore, the ratio of Sr confirmed from *C.moniliferum* of the sample was small which DCMU was added, it is considered that photosynthesis is related to the absorption of Sr^{2+} .

4. Future view

There was an article in the Asahi Shimbun (August 9, 2019) article 4) that the upper limit of the contaminated water tank was reached within 3 years.

In addition, when elemental analysis was performed with *C.moniliferum* , K was confirmed, so Cs may also be absorbed.

In the contaminated water tank, not only $^{90}\text{Sr}^{2+}$ but also $^{137}\text{Cs}^+$ is still untreated and there is a large amount, so we would like to verify that *C.moniliferum* can absorb not only Sr but also Cs and use it for contaminated water treatment.

5. [Acknowledgments]

Part of this research was conducted with the support of the River Foundation grant project of the River Foundation and JSPS KAKENHI JP18H00347. In addition, Dr. Kenji Namba and Dr. Tsugiko Takase from Fukushima University who gave observation guidance using a scanning electron microscope (SEM), Prof. Shuji Otani of Shimane University who taught us how to collect, culture, and observe with an optical microscope, advice on quantification using calibration curves and absorptimeters, Dr. Daisuke Sugimori and Prof. Hironori Ohashi of Fukushima University who provided the experimental instruments, taught us how to prepare and measure samples using atomic absorption photometers. Prof. Nobuhiko Sakurai from Nagoya City University who gave guidance, Dr. Mikio Tsuzuki from Tokyo Pharmaceutical University with advice on experiments using photosynthesis inhibitors (DCMU), National Institute for Environmental Studies who provided algae ,and we received guidance , advice from Mr. Yamamoto . In addition, this research was carried out with the approval of the research supported by the Live Next Institute for Educational Research. In addition, we would like to thank to Grand Contest on Chemistry for High School Students in 2019. Thank you for all of the support and guidance.

6. References

- 1) Krejci et al. J. Struc. Biol. 176, 192 (2011)
- 2) Access to your success SHIMADZU "AA-6300 Shimadzu Double Atomic Absorption Spectrophotometer URL : <http://www.shimadzu.com>
- 3) Niigata Radiation Monitoring Center Annual Report Vol. 5 2007 "Comparison of stable strontium measurement methods"
- 4) August 9, 2019, morning edition of Asahi Shimbun

【評語】 200012

C. moniliferum and *C. lunula* were used for Sr^{2+} absorption under different wavelength of LED light illumination. *C. moniliferum* can effectively absorb Sr intracellularly, and photosynthesis plays an important role in the absorption process. This is an interesting and practical study for contaminated water of nuclear power station.