# The GATE MARIM database

# Monte Carlo simulations to Assess Radiological Impact on Microorganisms

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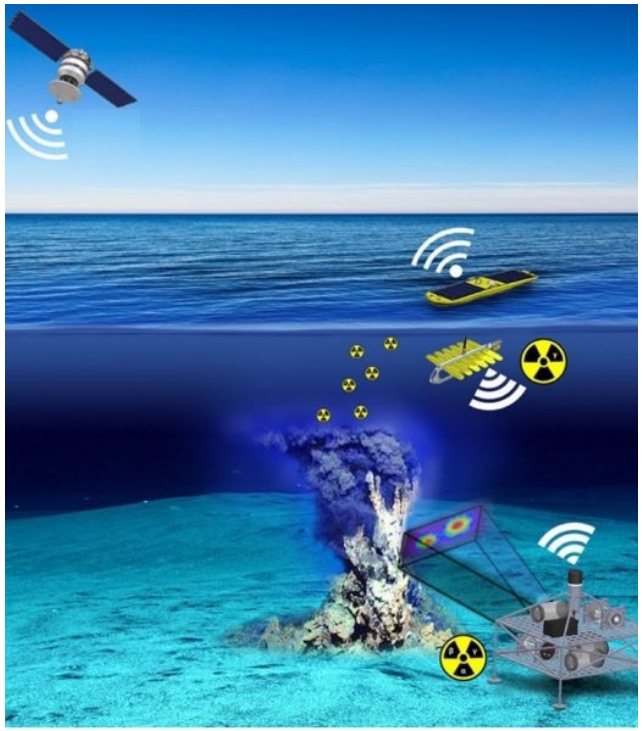
# **RAMONES** EU project

## **RA**dioactivity **M**onitoring in **O**cea**N** **E**co**S**ystems

**Aiming to provide large-scale, continuous monitoring of radioactivity in ocean**



www.ramone-project.eu

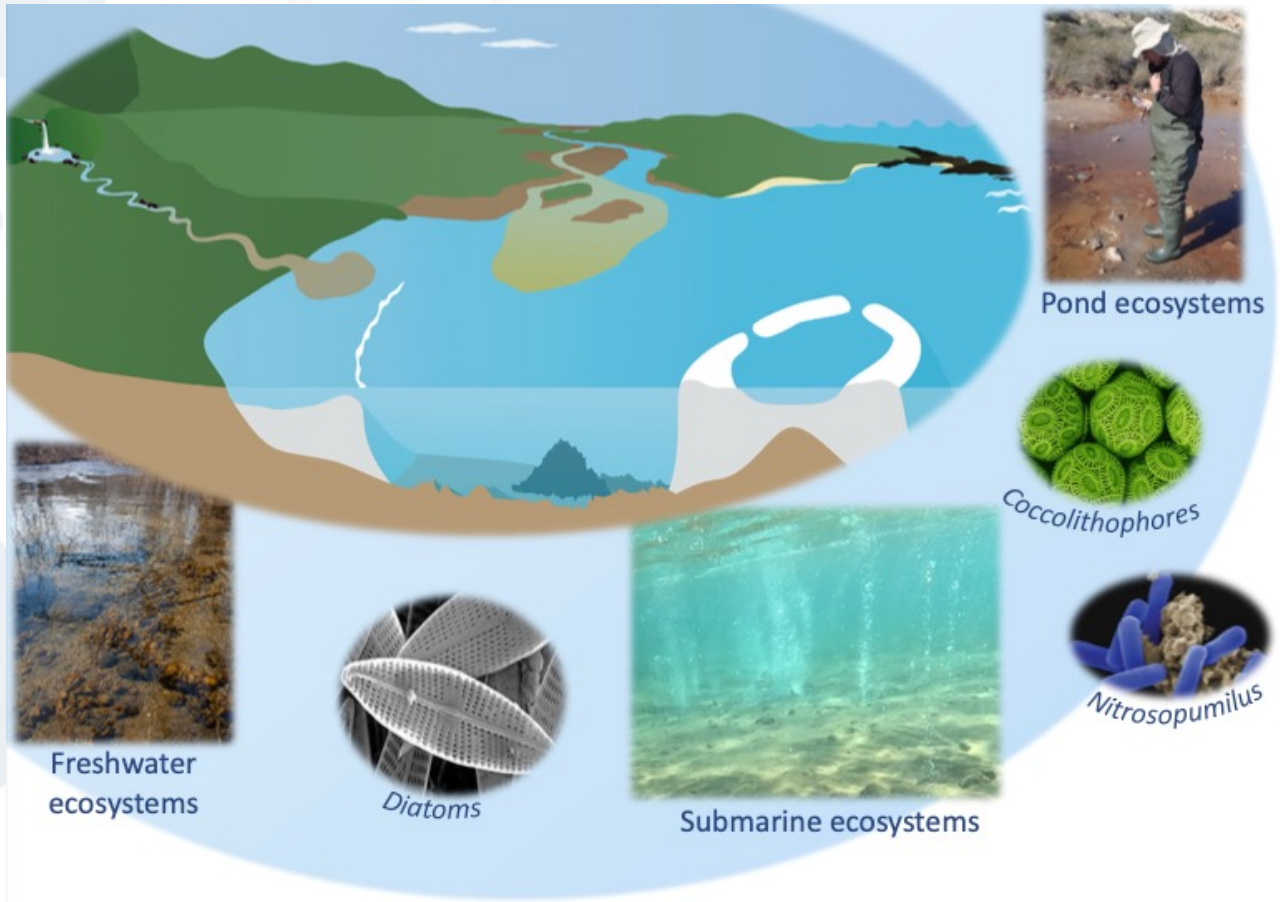
Objectives:

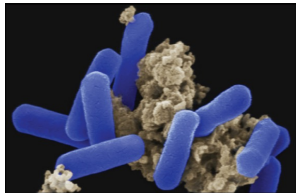
- Novel instruments for measuring radioactivity in seabed and water column
- Marine robotics capabilities for the radiometry instrumentation
- Methodologies for processing marine radioactivity multi-modal data

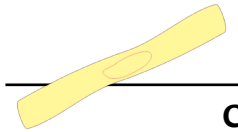
**To evaluate the dose received by microorganisms living in naturally radioactive ecosystems**

Receives funding from European Union under Horizon 2020FET Proactive Program via grant agreement No. 101017808

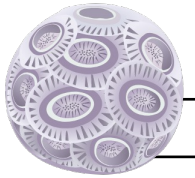
# Coastal and marine environment

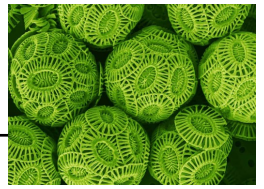




| CHARACTERISTICS | |
|---|---|
| | Prokaryote - Unicellular |
| Cell diameter | 0.17-0.22 µm |
| Cell length | 0.5-0.9 µm |
| Cell shape | Straight rod |

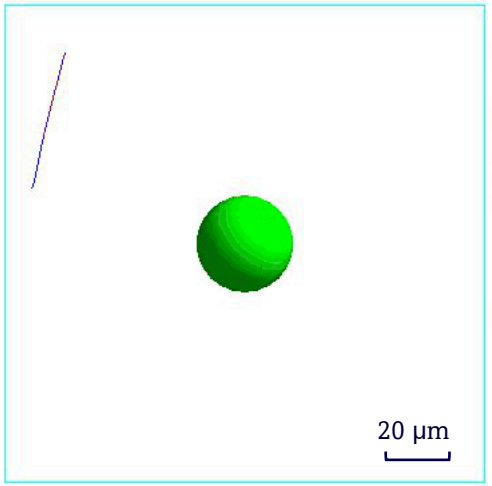




| CHARACTERISTICS | |
|---|---|
| | Eukaryote- Unicellular |
| Cell diameter (include cell coverings) | 2.0 - 75.0 µm |
| Cell shape | Spheric or quite ellipsoidal |
| Chemical Composition | Internal water – External coccoliths layer ($CaCO_3$) |

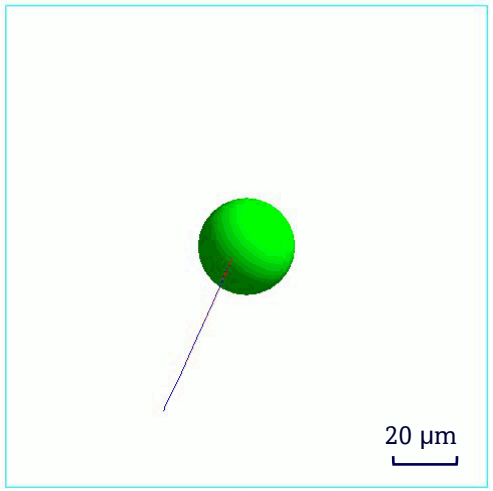
# α-emitter radionuclides from the $^{238}U$ and $^{232}Th$ decay chains

## External exposure



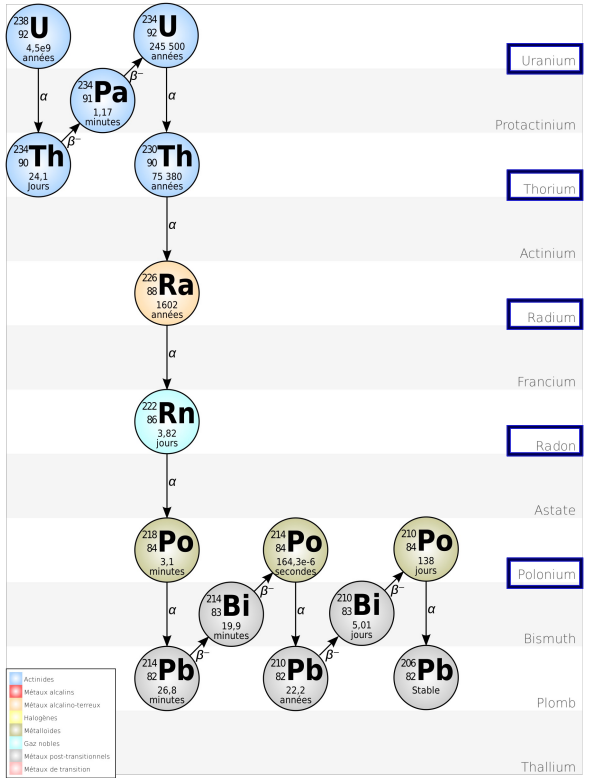

Alpha ($He^{2+}$)
Photons
Electrons

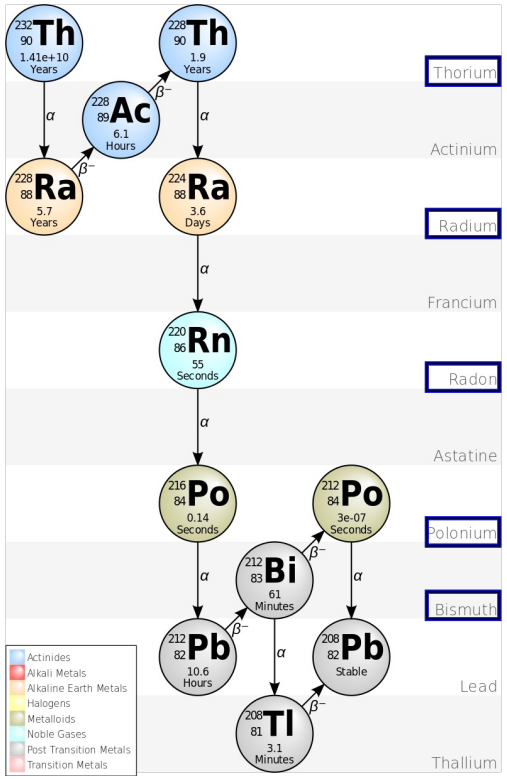
## Internal exposure




Exemple:

$^{226}Ra$ ($E_{max}$= 4.78 MeV)




15 radionuclides (alpha emitters)

# Dose conversion coefficients (DCC)

- specific to the radionuclide and the organism considered
- transformation of radiation exposure to dose rate

$$\mathbf{DCC} = \frac{\mathbf{E_{dep}}}{\mathbf{N}} \times \frac{\mathbf{m_s}}{\mathbf{m_t}} \times \mathbf{C}$$

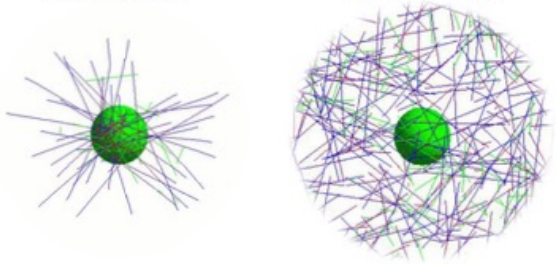
***$E_{dep}$*** *energy deposited in the microorganism (MeV)*
***N*** *number of simulated primary particles (Bq s)*
***$m_s$*** *mass of the source (kg)*
***$m_t$*** *mass of the microorganism (kg)*
***C*** *unit conversion constant* = $5.767 \cdot 10^{-4}$

$$\mathbf{DR} = \mathbf{Cs} \times \mathbf{DCC}$$

***DR****: Dose Rate*
***$C_s$*** *activity concentration of the radionuclide in Bq $kg^{-1}$*
***DCC*** *in µGy $h^{-1}$ per Bq $kg^{-1}$*

**EXPOSURES**

**INTERNAL** **EXTERNAL**



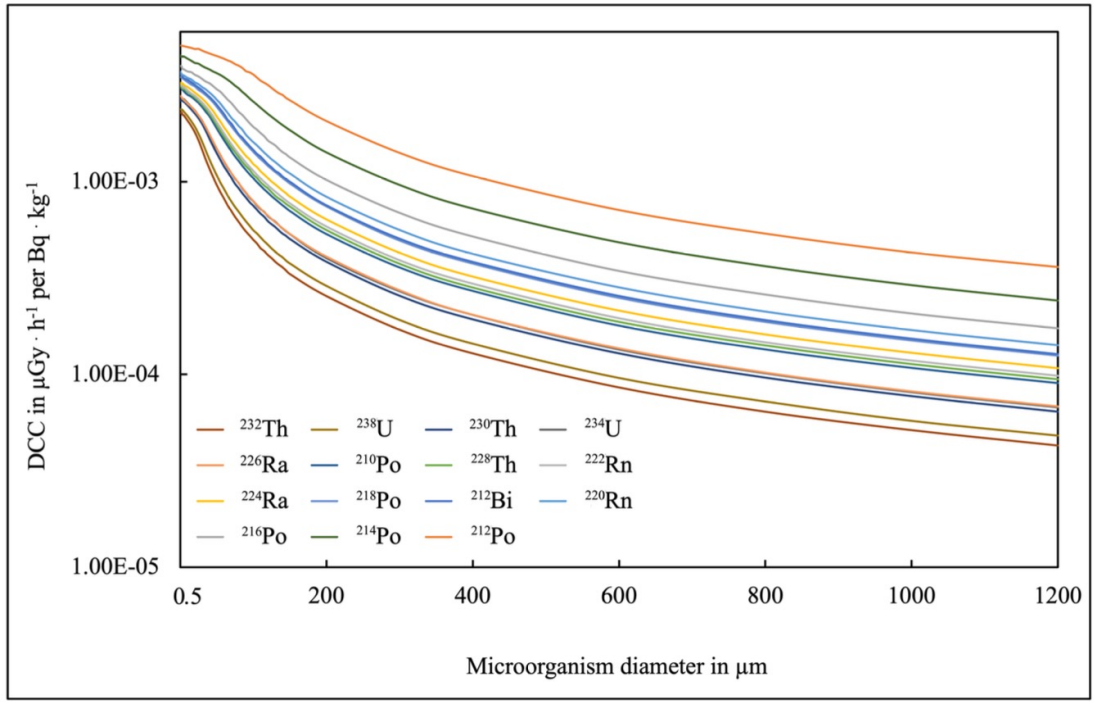
In **external exposure**, environment composition can be defined using a percentage of porosity to evaluate the ratio of water.

$$\mathbf{P(\%)} = \frac{\mathbf{V_w}}{\mathbf{V_{tot}}} \times \mathbf{100}$$

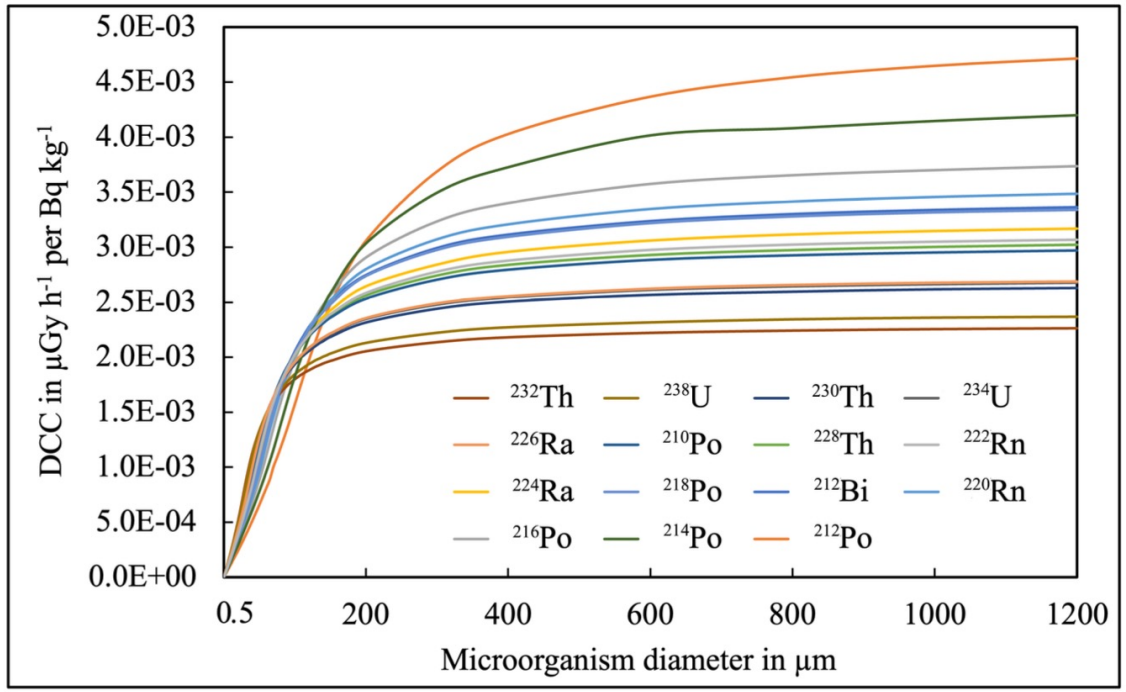
***$V_w$*** *fraction volume of water in the environment*
***$V_{tot}$*** *total environment volume*

# DCC evolution

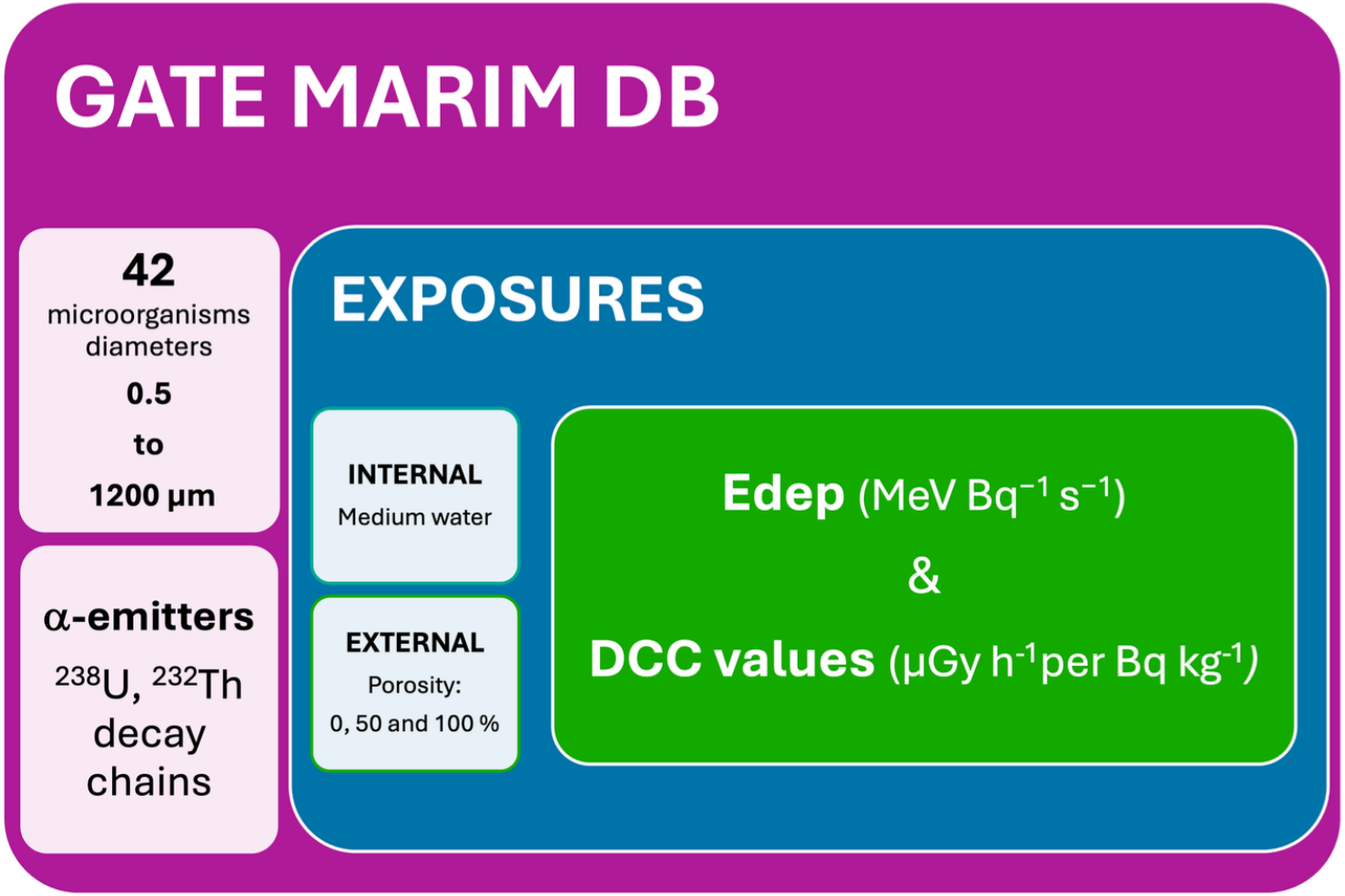
## External exposure - Water




## Internal exposure



# The database




Available on Github

github.com/lpc-umr6533/marim

- SQL file marimdatabase.sql
- Jupyter notebook

# Query to the database through a Jupyter notebook

## Example for $^{222}$Rn external exposure in water on a 20 µm diameter microorganism for activity concentration of 1000 Bq/L

Code

Exposure: External

Select environment density only for external exposure

Environment density (g/cm³): 1.00

Pure water Pure sediment

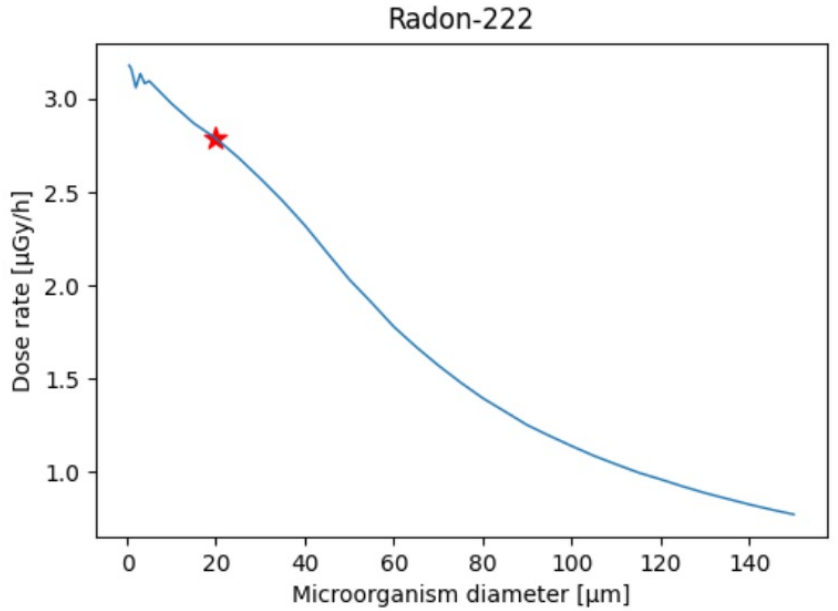
Radionucli... Radon-222

Activity concentration: 1000

Units:

- Bq/kg
- Bq/m³
- Bq/L

Microorganism Diameter (µm): 20



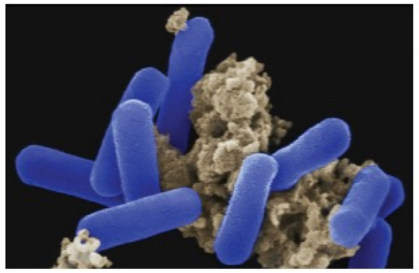

Diameter [µm] 20.0

Dose rate [µGy/h]: 2.788425148836292

Reset

# Dose Rates to some microorganisms

## NITROSOPUMILUS MARITIMUS



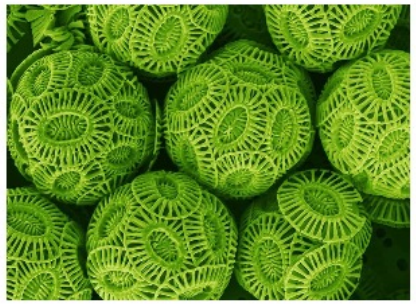
Diameter 0.5 µm
50% water and sediments

$^{226}_{88}Ra$

| External | Internal |
|---|---|
| 2.04 µGy $h^{-1}$ | $9.63 \cdot 10^{-3}$ µGy $h^{-1}$ |

activity
1000 Bq $L^{-1}$

## COCCOLITHOPHORE EMILIANIA HUXLEYI



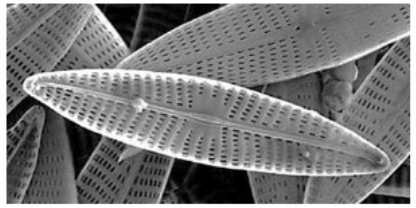
Diameter 10 µm
50% water and sediments

$^{226}_{88}Ra$

| External | Internal |
|---|---|
| 1.77 µGy $h^{-1}$ | $2.05 \cdot 10^{-1}$ µGy $h^{-1}$ |

activity
1000 Bq $L^{-1}$

## DIATOM



Diameter 20 µm
100% water

$^{222}_{86}Rn$

| External | Internal |
|---|---|
| 2.79 µGy $h^{-1}$ | $3.82 \cdot 10^{-1}$ µGy $h^{-1}$ |

activity
1000 Bq $L^{-1}$

# Useful links

## The GATE MARIM database

https://github.com/lpc-umr6533/marim

## Paper in the Journal of Environmental Radioactivity

G R. Fois, S. Kolovi, V. Breton, A. Pereda, P. Chardon, D. Llanes Vega, L. Terray, L. Maigne (2025) GATE MARIM DB, a Monte Carlo database for dose assessment of microorganisms exposed to natural α-radioactivity *Journal of Environmental Radioactivity* 283: 107639 **https://doi.org/10.1016/j.jenvrad.2025.107639**

# THANK YOU

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