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# Cyanobacteria Arthospira platensis as an effective tool for gadolinium removal from wastewater

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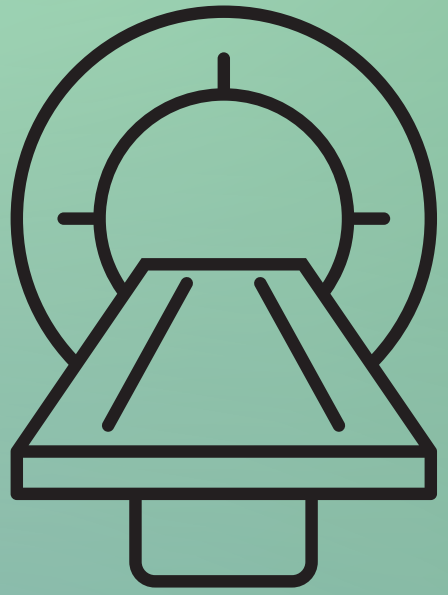
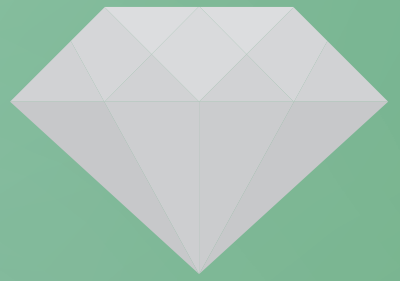
# Applications of gadolinium



Gadolinium-based MRI contrast agent



Gadolinium garnet

Magnetic refrigeration

Luminophores

Metal alloys

Gadolinium oxide control rods

# Relevance of the work

**Traditional idustrial wastewater treatment methods**

- Mechanical
- Settling, filtration
- Chemical methods
- Complexation, precipitation
- Physical and chemical methods
- Coagulation, extraction, sorption, distillation
- Aeration tanks, filtration fields, biofilters, biological ponds

**Limitations**

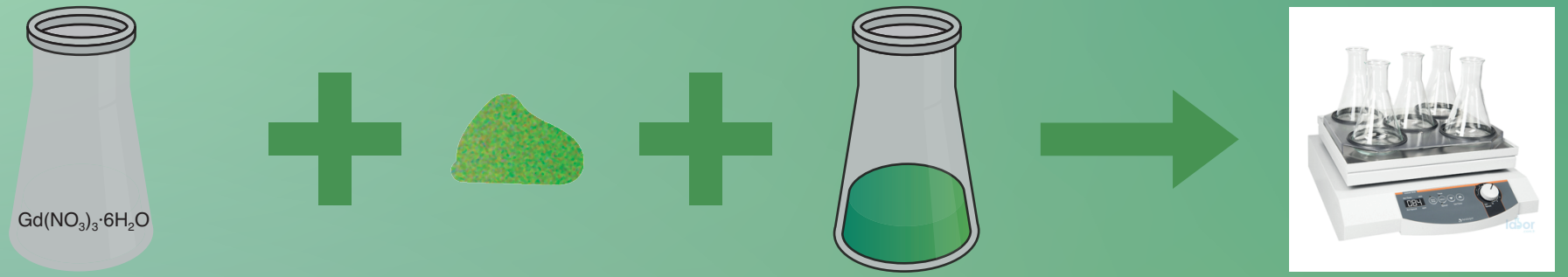
- High cost
- Difficulty in operation
- Exposure to toxic substances

**Advantages of biological methods**

- Low cost
- High efficiency
- Environmental friendliness

# The scheme of the experiment

## Biosorption




V=20ml

C = 10 mg/L

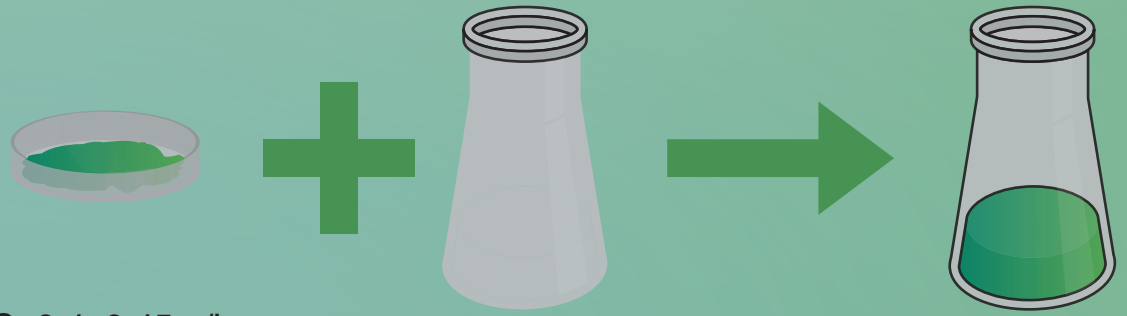
CNMN-CB-02

m=100 g

t= 60 min

v=200 rpm

## Bioaccumulation



C=0.4–0.45 g/L

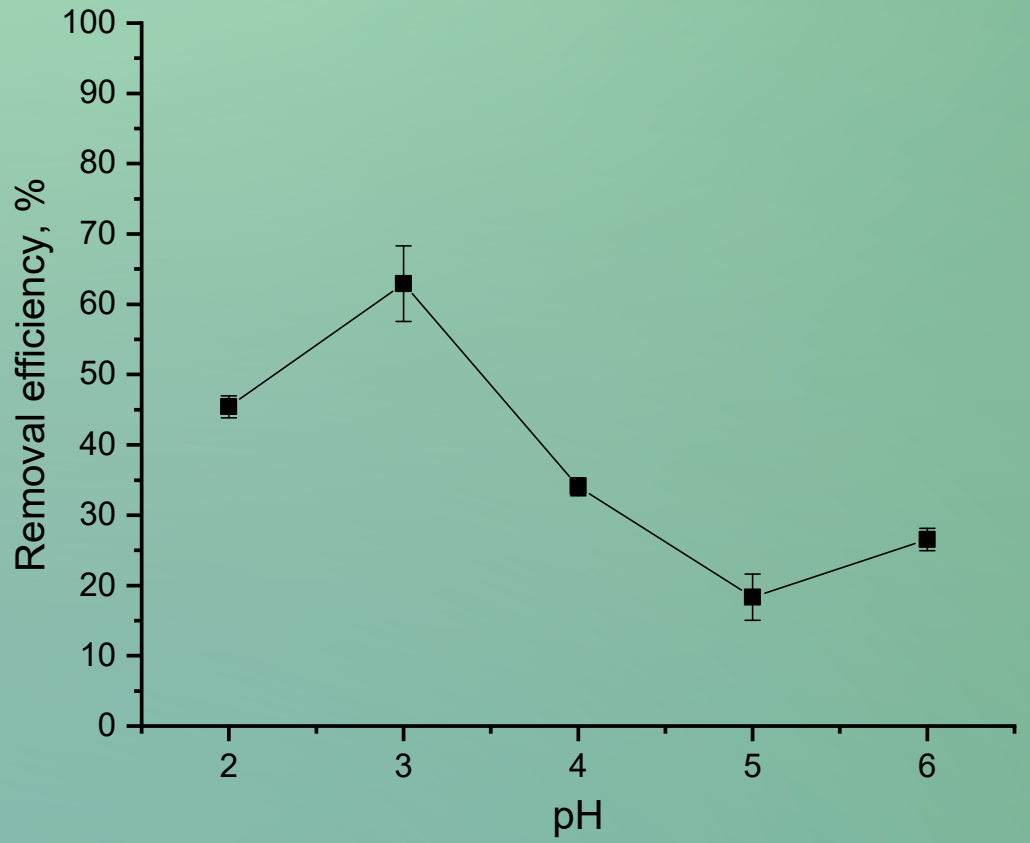
V = 100 ml

C = 10, 20, 30 mg/L

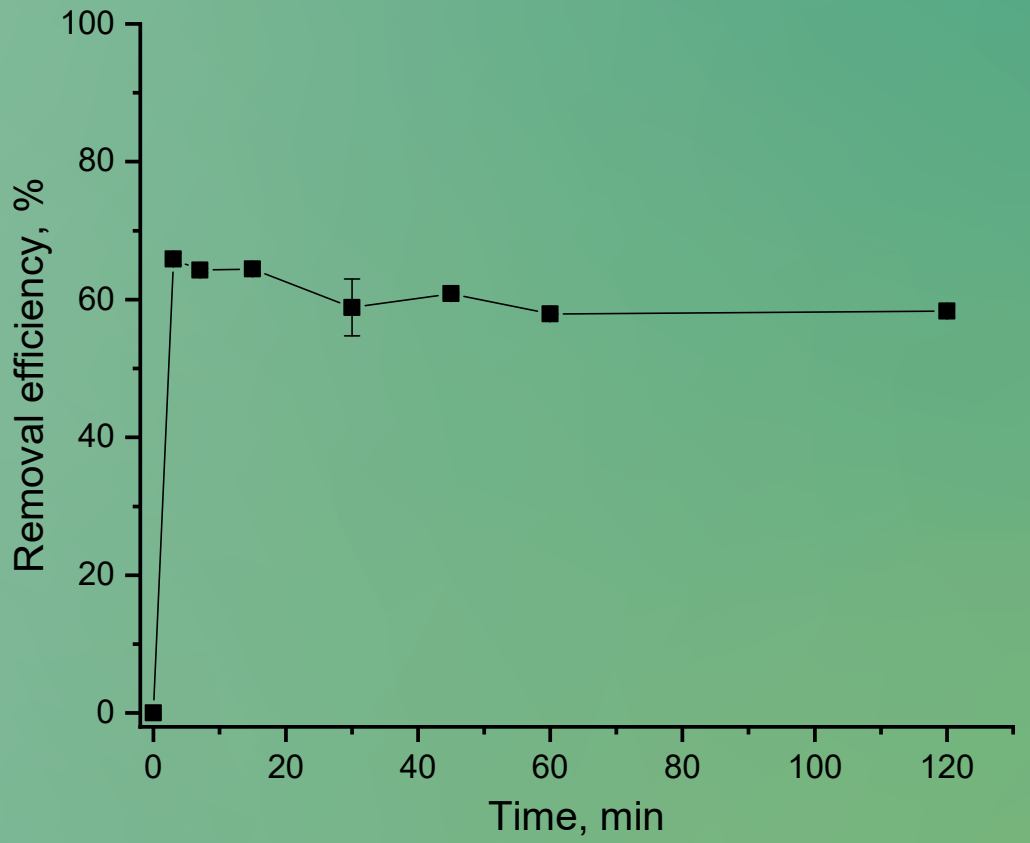
t=3 days

| Parameters | 1-2 days | 3-6 days |
|---|---|---|
| Temperature, °C | 25-28 | 30-32 |
| Illumination, $\mu$M photons × $m^{-2}$ × $s^{-1}$ | ~37 | ~55 |
| pH | 8-9 | 9-10 |

# Biosorption

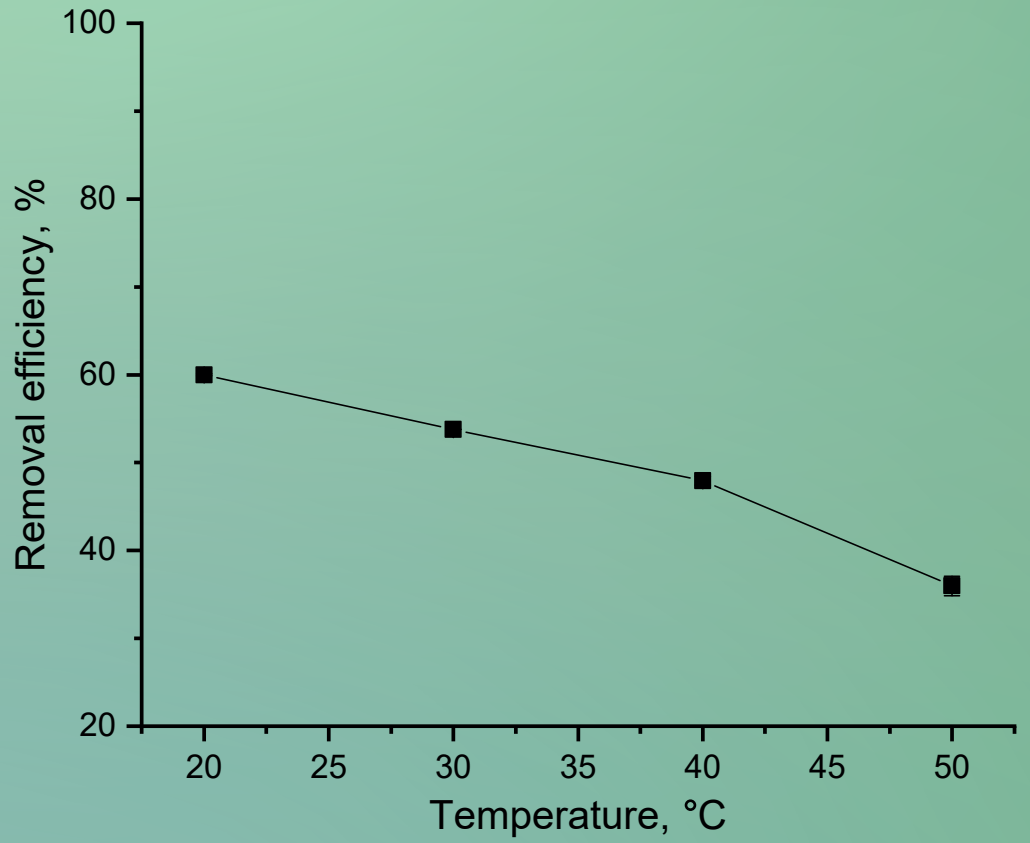



Effect of temperature on gadolinium biosorption




Effect of time on *A. platensis* biosorption capacity

# Biosorption

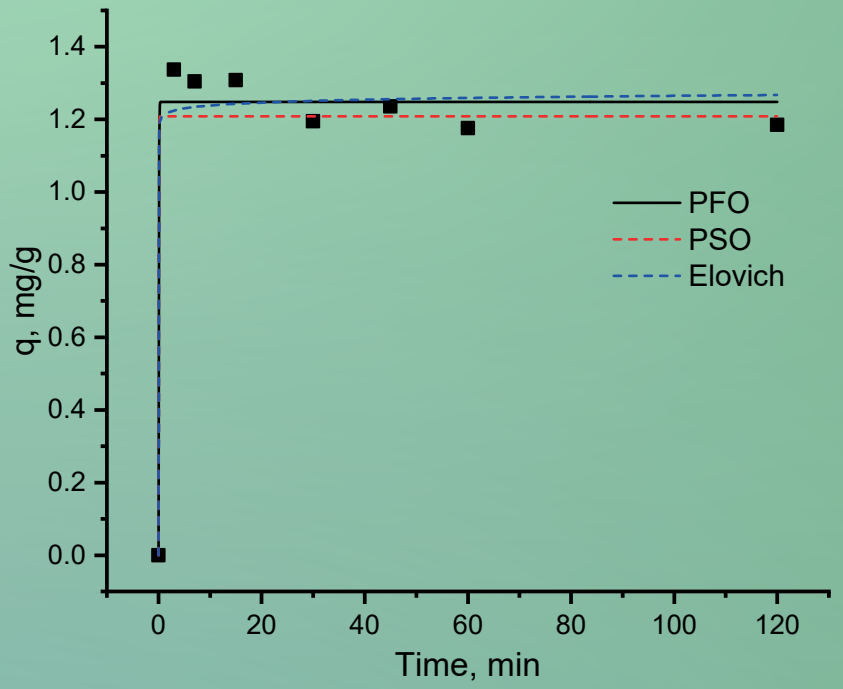



Effect of temperature on gadolinium biosorption

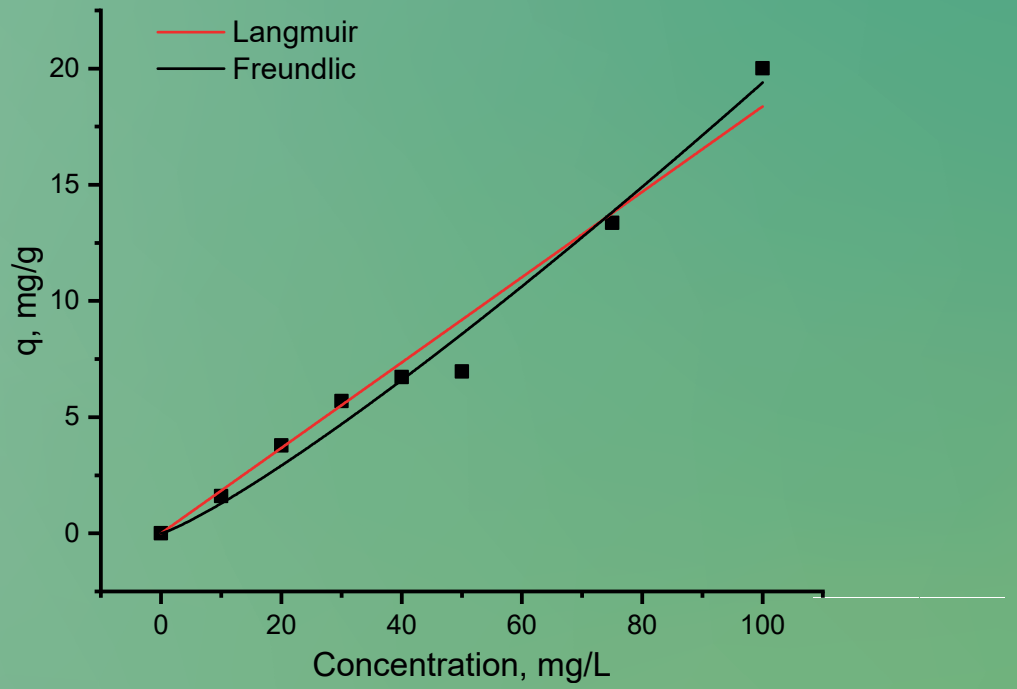
**Thermodynamics parameters for gadolinium biosorption**

| Temperature, K | ΔG°, kJ/mol | ΔH°, kJ/mol | ΔS°, J/mol·K |
|---|---|---|---|
| 293 | -14.0 | -24.9 | -37.1 |
| 303 | -13.7 | | |
| 313 | -13.3 | | |
| 323 | -12.9 | | |

# Biosorption




Kinetics of gadolinium biosorption

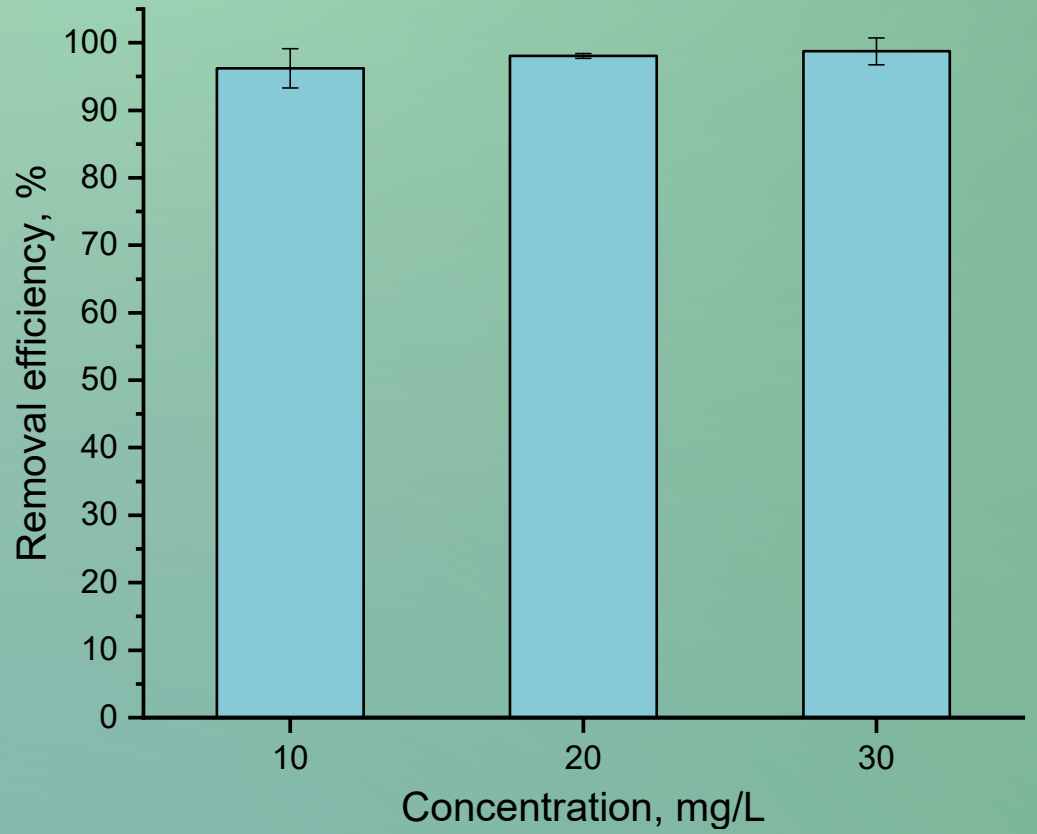



Isotherms of gadolinium biosorption

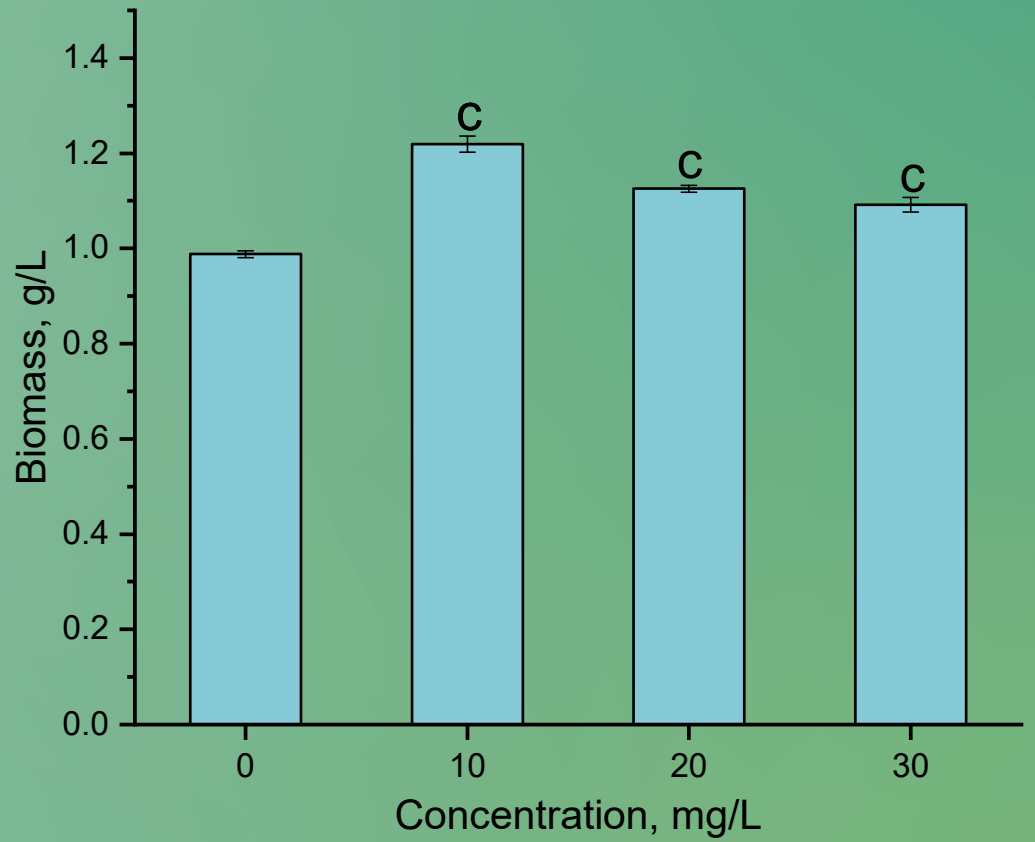
| Model | Pseudo-first-order | | | Pseudo-second-order | | |
|---|---|---|---|---|---|---|
| Parameters | $q_e$ | $k_1$ | $R^2$ | $q_e$ | $k_2$ | $R^2$ |
| Gd | 1,24 | 19,8 | 0,98 | 1,24 | -0,6 | 0,97 |

| Model | Langmuir | | | Freundlich | | |
|---|---|---|---|---|---|---|
| Parameters | $q_m$ | b | $R^2$ | $K^F$ | n | $R^2$ |
| Gd | 101 | 0,0081 | 0,08 | 0,09 | 0,84 | 0,98 |

# Bioaccumulation

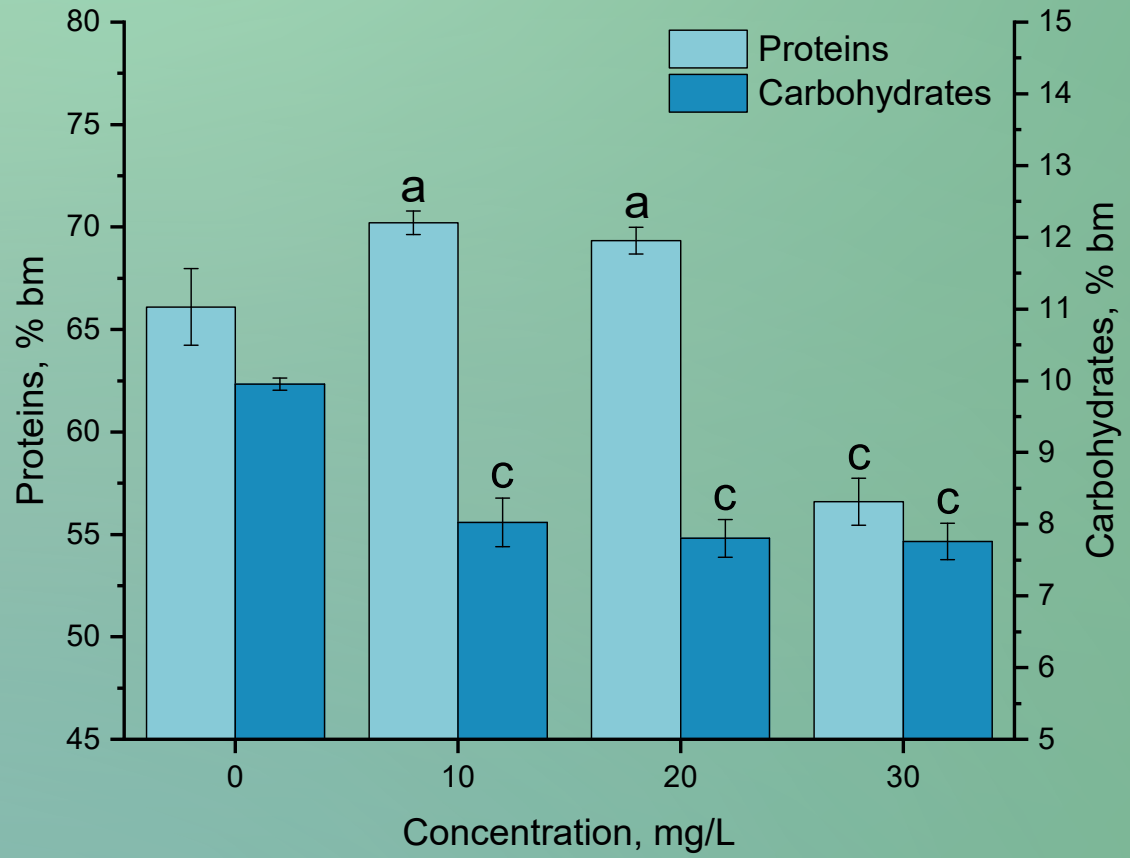



Efficiency of gadolinium removal by bioaccumulation

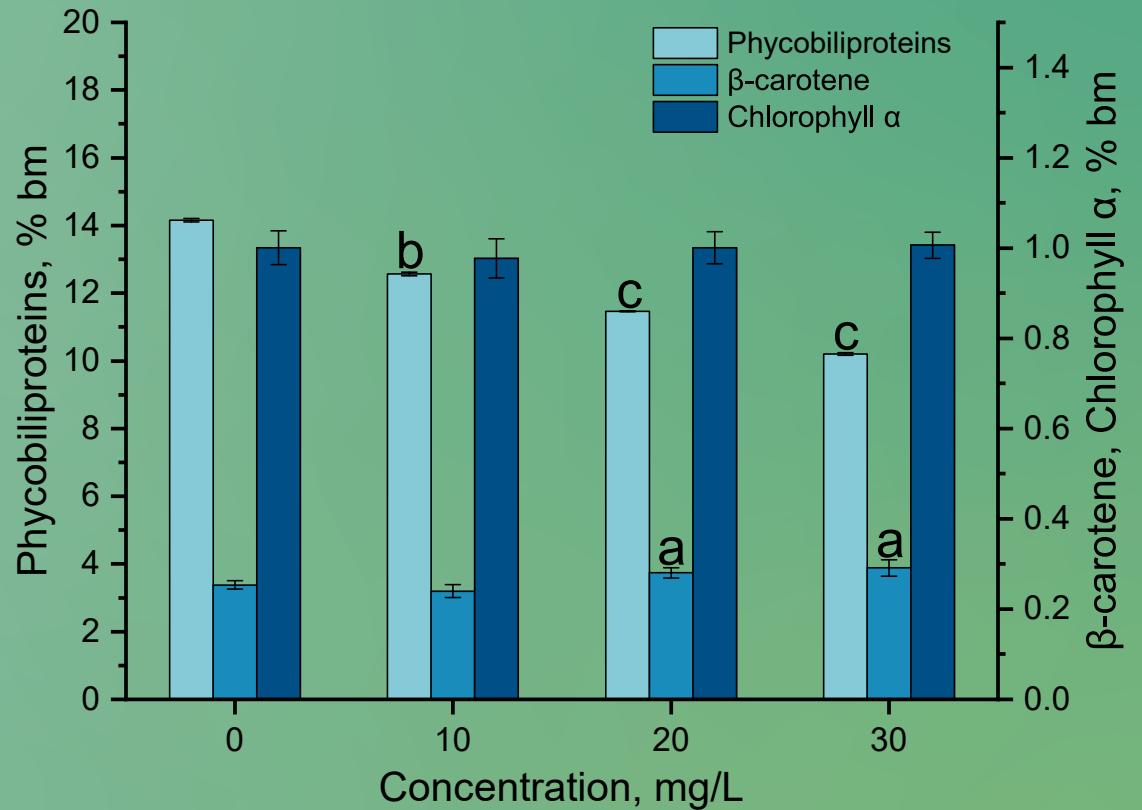



The effect of gadolinium on the *A. platensis* biomass
(a — p <0,0005, b — p <0,005, c — p <0,05)

# Bioaccumulation

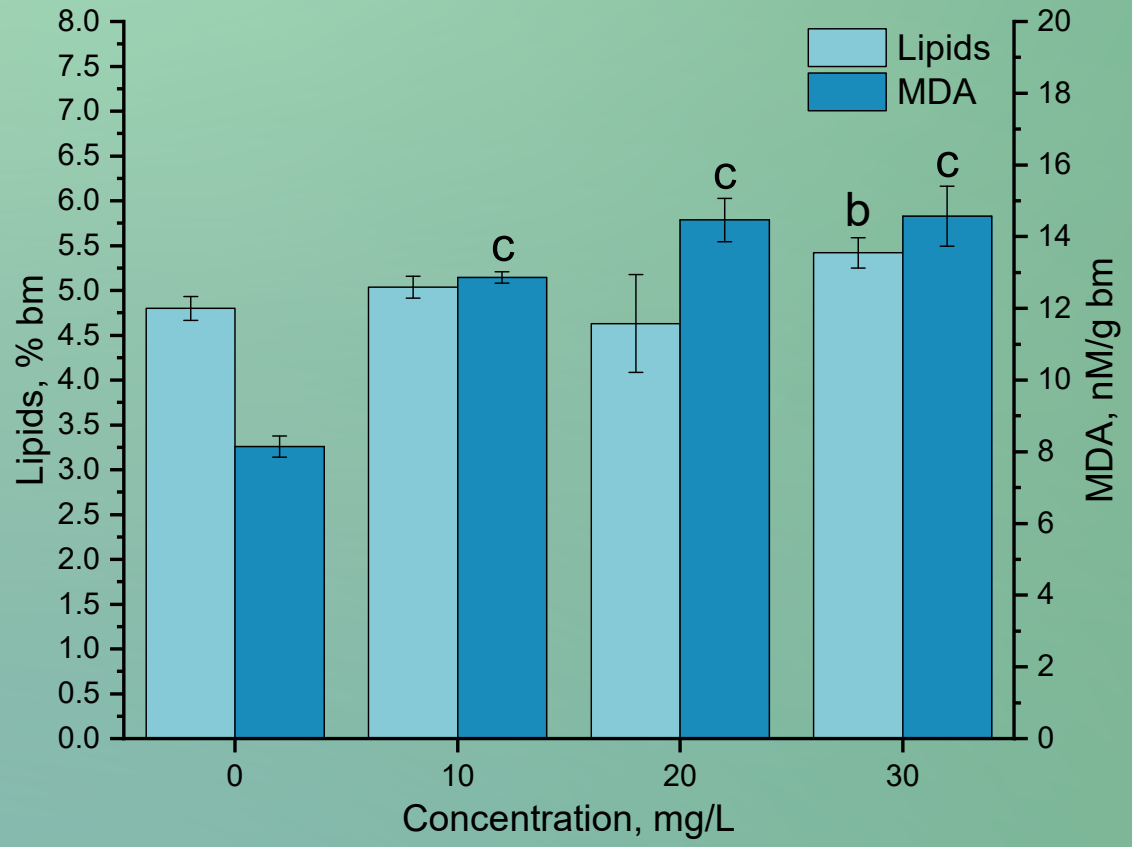



The effect of gadolinium on the amount of proteins and carbohydrates in biomass (a — p <0,0005, c — p <0,05)

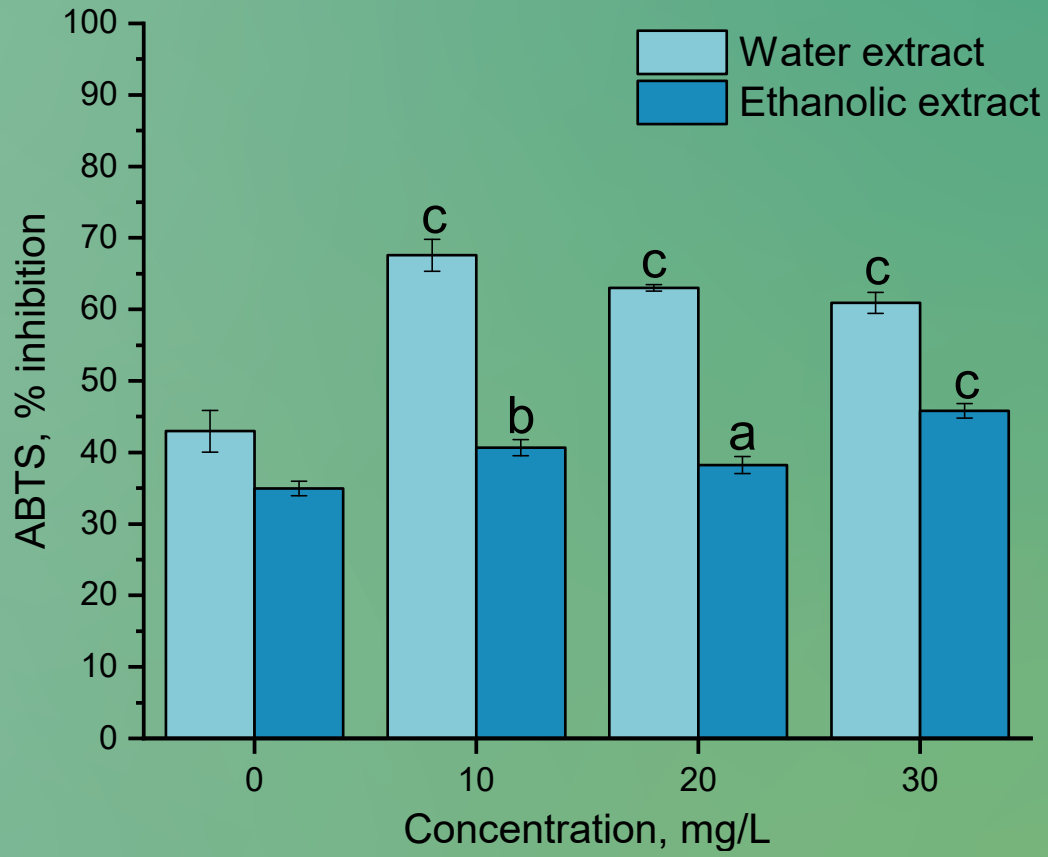



The effect of gadolinium on the amount of phycobiliproteins, chlorophyll α and β-carotene (a — p <0,0005, b — p <0,005, c — p <0,05)

# Bioaccumulation




The effect of gadolinium on the amount of lipids and MDA
(b — p <0,005, c — p <0,05)




The effect of gadolinium on the antioxidant activity
(a — p <0,0005, b — p <0,005, c — p <0,05)

# Conclusion

- A maximum sorption can be achieved at a pH of 3, temperature of 20°C, and adsorption time of 3 min
- The kinetics of the biosorption was better described by pseudo-first-order kinetic model, suggesting the physical nature of biosorption
- Equilibrium data were better presented by the Freundlich model, suggesting biosorption on the heterogeneous surface
- From a thermodynamic point of view, the process of gadolinium biosorption was spontaneous and exothermic in nature
- In the bioaccumulation experiments, gadolinium ions were almost completely accumulated from the cultivation medium and stimulated biomass growth
- Cyanobacteria *Arthrospira platensis* can be applied for gadolinium removal from wastewater through biosorption and/or bioaccumulation processes.
- The accumulated information, along with the data obtained for other rare earth elements, can be used for the development of the technology for the efficient treatment of effluents containing several rare earth elements

# *Thank you for attention!*