Exploiting *Galdieria sulphuraria* for the bio-recovery of Rare Earth Elements (REEs)

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Università degli Studi della Campania Luigi Vanvitelli

BBSRC bioscience for the future

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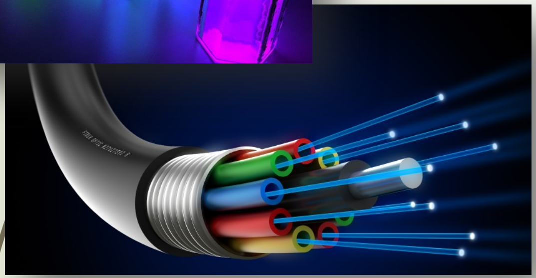
Geothermal sites & Rare Earth Metals

Rare earth metal concentrations present in different geothermal sites (Michard, 1989).

Country (location)	Cerium (Ce) conc. (mg/l)	Neodymium (Nd) conc. (mg/l)	Samarium (Sm) conc. (mg/l)	Europium (Eu) conc. (mg/l)	Gadolinium (Gd) conc. (mg/l)	Dysprosium (Dy) conc. (mg/l)	Erbium (Er) conc. (mg/l)	Ytterbium (Yb) conc. (mg/l)
USA (Salton Sea, California)	706	226	22.6	305	25	17.3	10.6	9.33
New Mexico (Valles Calders)	30–70	9.5–24.6	1.6–2.8	0.39–0.4	NA	1–1.5	0.9	NA
Italy (Larderello)	7.5–60.5	3.1–19.5	0.69–2.02	0.2–0.66	0.8	0–1.7	0.25–0.5	0.21–1.2
Italy (Northern Latium)	30	13	1.8	0.21	NA	0.7	NA	NA
Italy (Phlegrean Fields)	15	6	0.8	36	0.8	0.5	0.3	0.25

NA: not available.



Element	Use
Cerium (Ce)	Catalytic converters, colored glass, steel production
Neodymium (Nd)	Extremely strong permanent magnets, microphones, electric motors of hybrid automobiles, laser
Samarium (Sm)	Cancer treatment, nuclear reactor control rods, X-ray lasers
Europium (Eu)	Color TV screens, fluorescent glass, genetic screening tests
Gadolinium (Gd)	Shielding in nuclear reactors, nuclear marine propulsion, increases durability of alloys
Dysprosium (Dy)	Commercial lighting, hard disk devices, transducers
Erbium (Er)	Glass colorant, signal amplification for fiber optic cables, metallurgical uses
Ytterbium (Yb)	Improves stainless steel, lasers, ground monitoring device

Recovery of high-value metals from geothermal sites by biosorption and bioaccumulation

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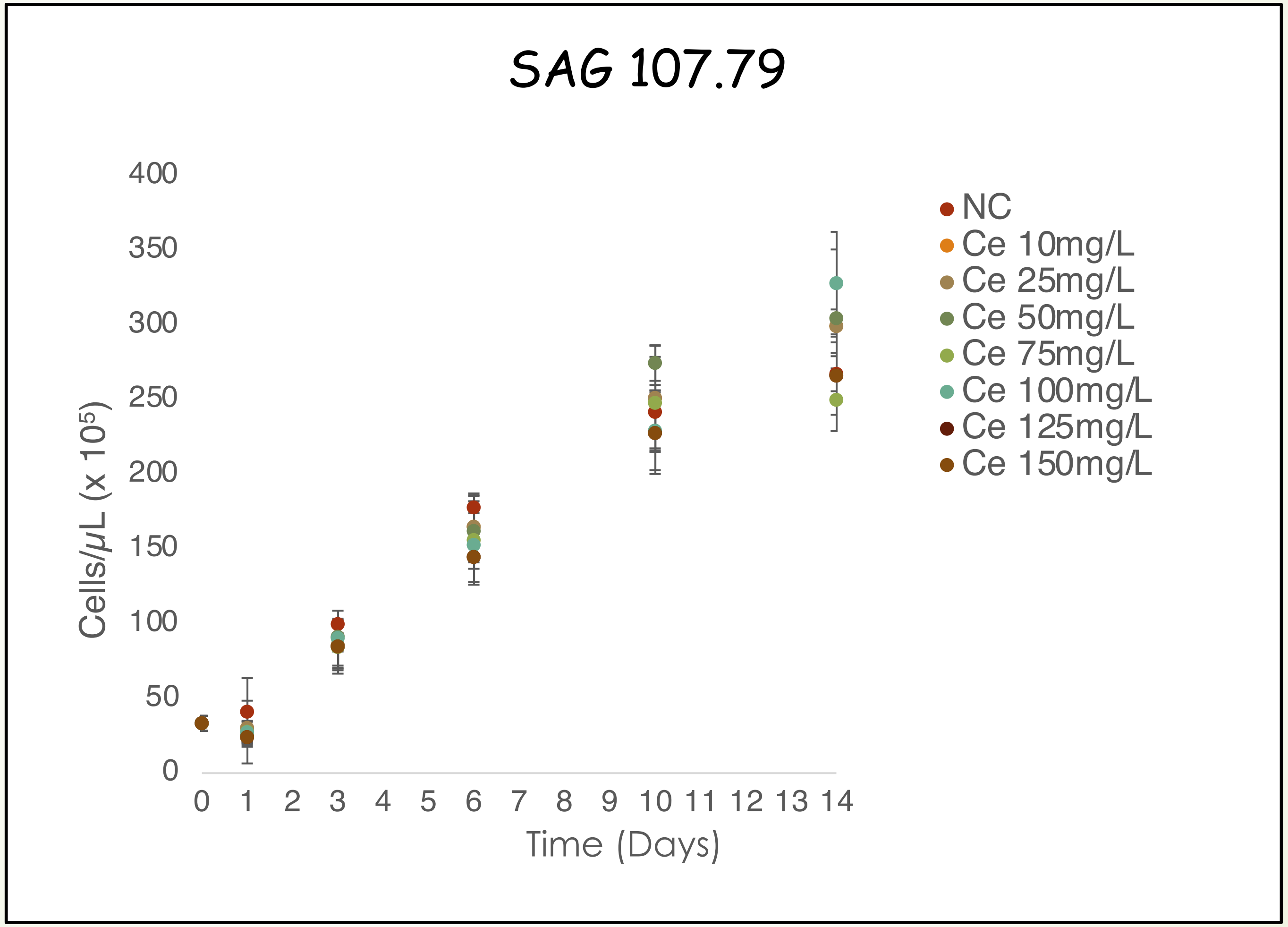
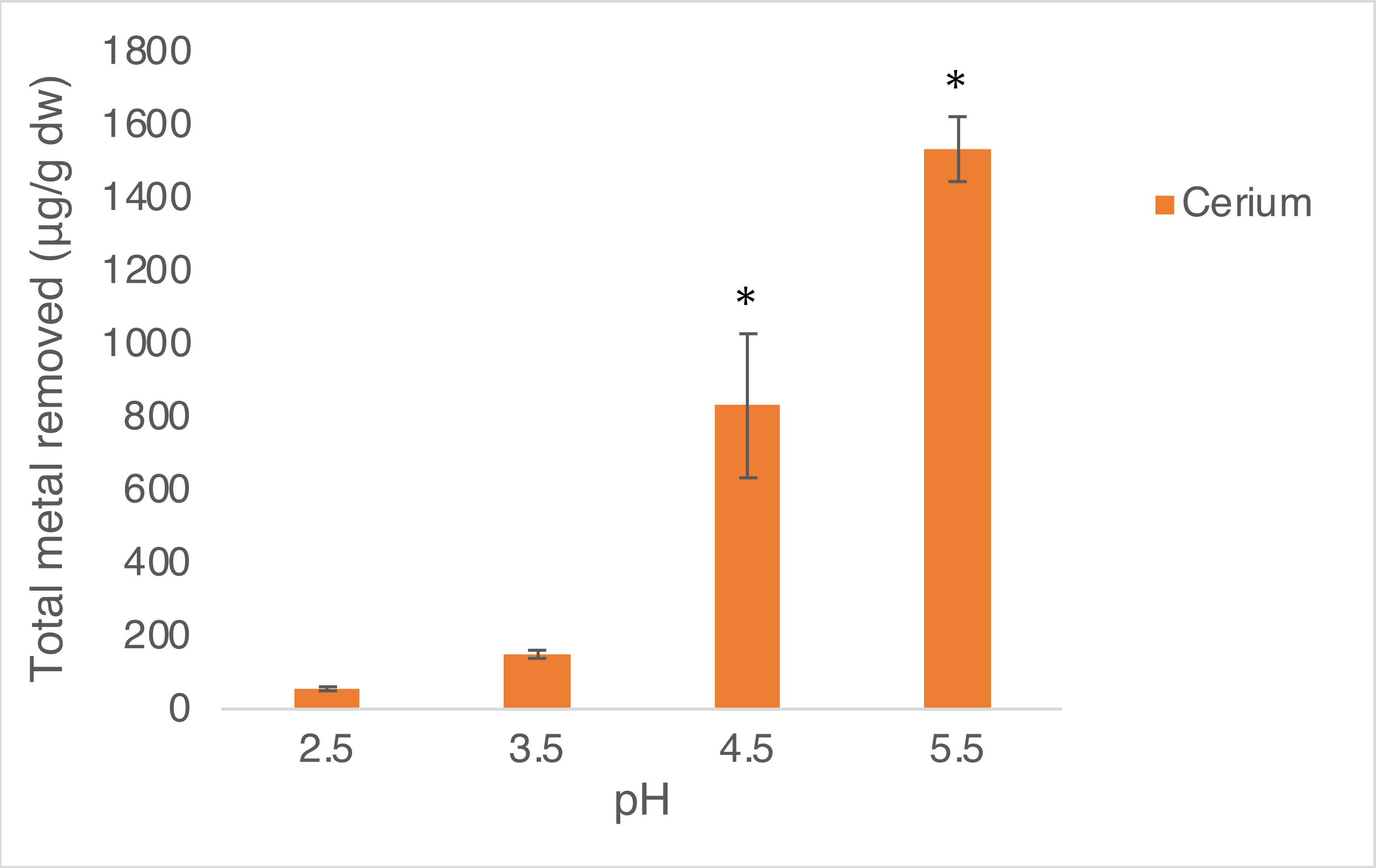
Physiological response to Cerium (III)

Cerium doesn't affect the growth rate



Physiological response to Cerium (III)

Cerium biorecovery

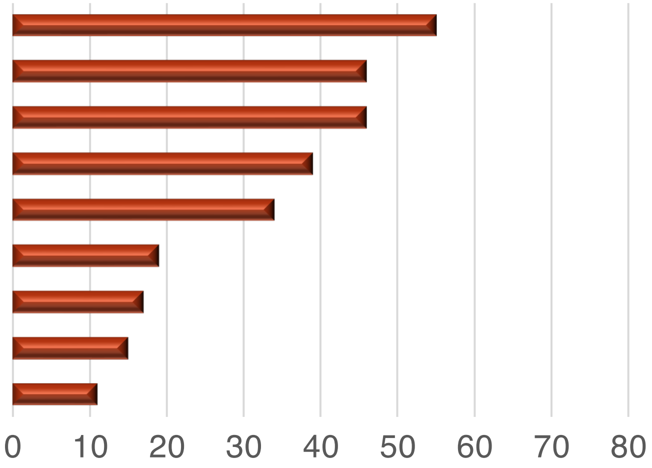


Physiological response to Cerium (III)

Transcriptomic response to Cerium

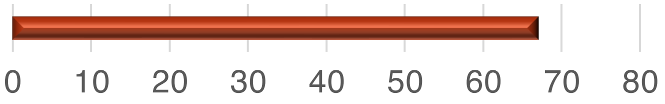
Biological processes

GO Name	GO ID	FDR
Oxidation-reduction process	GO:0055114	1.23E-04
Organonitrogen compound biosynthetic process	GO:1901566	0.044
Carboxylic acid metabolic process	GO:0019752	0.033
Transmembrane transport	GO:0055085	0.012
Carbohydrate metabolic process	GO:0005975	4.24E-05
Amide biosynthetic process	GO:0043604	0.044
Generation of precursor metabolites and energy	GO:0006091	0.038
Purine ribonucleotide metabolic process	GO:0009150	0.031
Ribonucleotide biosynthetic process	GO:0009260	0.044



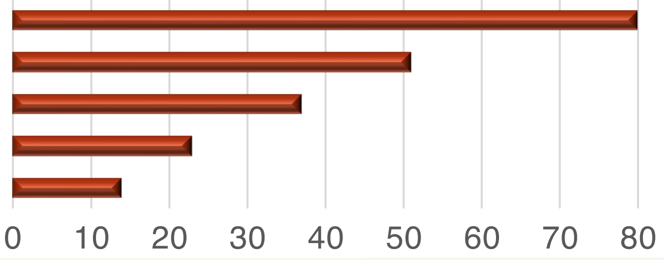
Cellular components

GO Name	GO ID	FDR
Cytoplasm	GO:0005737	0.024



Molecular Functions

GO Name	GO ID	FDR
Nucleotide binding	GO:0000166	0.049
Oxidoreductase activity	GO:0016491	0.001
Transmembrane transporter activity	GO:0022857	0.013
Ligase activity	GO:0016874	0.023
Hydrolase activity, acting on glycosyl bonds	GO:0016798	0.044



- Dehydrogenase
- Peroxiredoxin
- Mercuric reductase

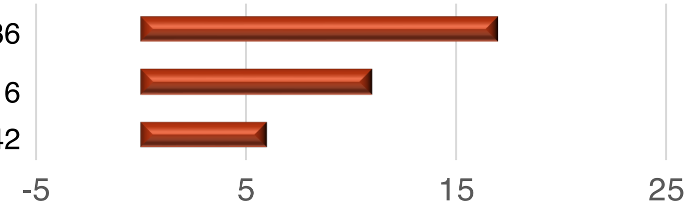
- Galactosidase
- Glucosidase
- Pyrophosphatase
- kinase
- Hydrolase activity, acting on glycosyl bonds

Physiological response to Cerium (III)

Transcriptomic response to Cerium
Interaction of pH and metal

Biological processes

GO Name	GO ID	FDR
Phosphate-containing compound metabolic process	GO:0006796	0.036
Cellular protein modification process	GO:0006464	0.016
Ribosome biogenesis	GO:0042254	0.042



Cellular components

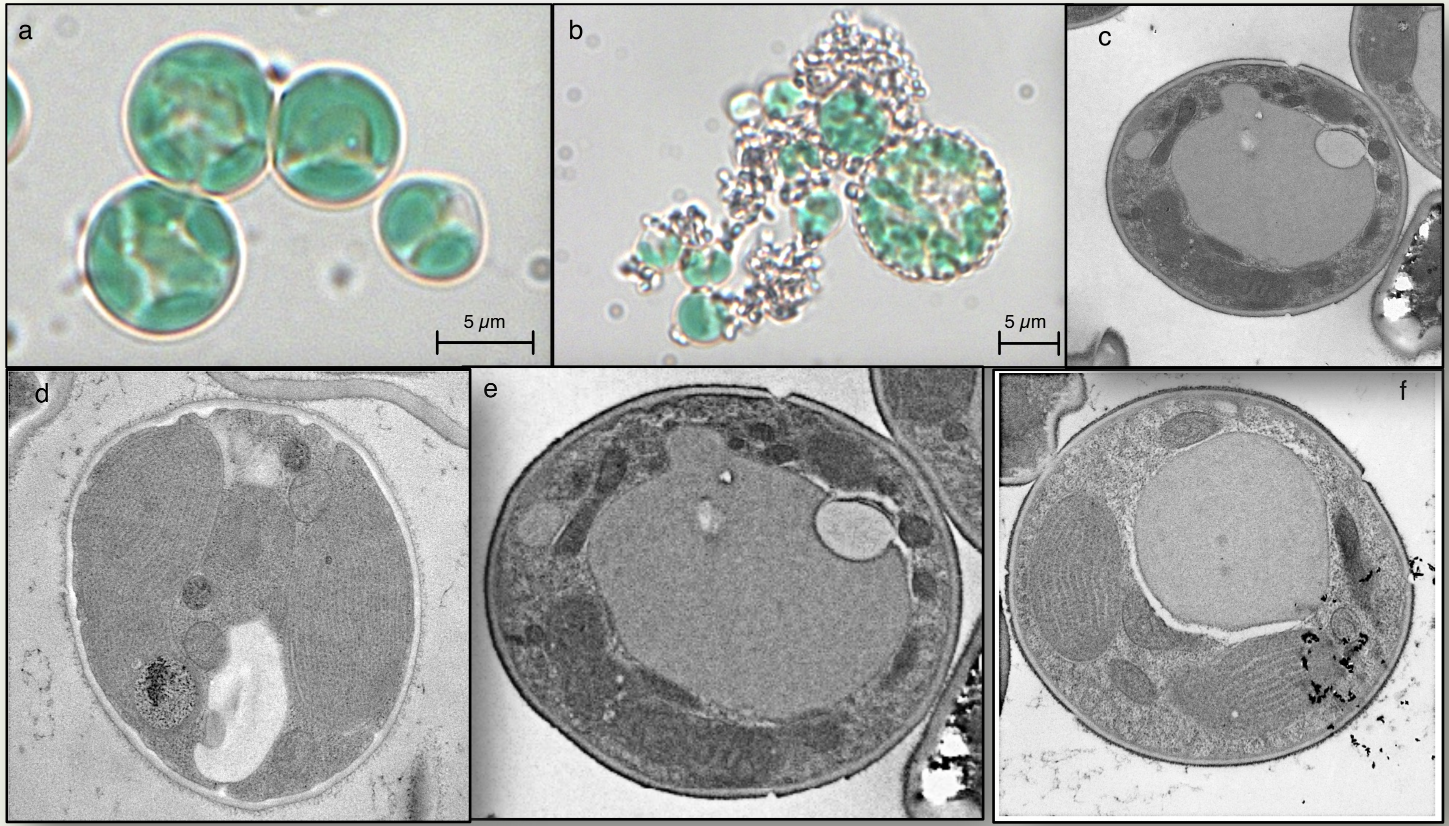
GO Name	GO ID	FDR
Nucleolus	GO:0005730	0.042

Molecular Functions

GO Name	GO ID	FDR
ATP binding	GO:0005524	0.016
Helicase activity	GO:0004386	0.042

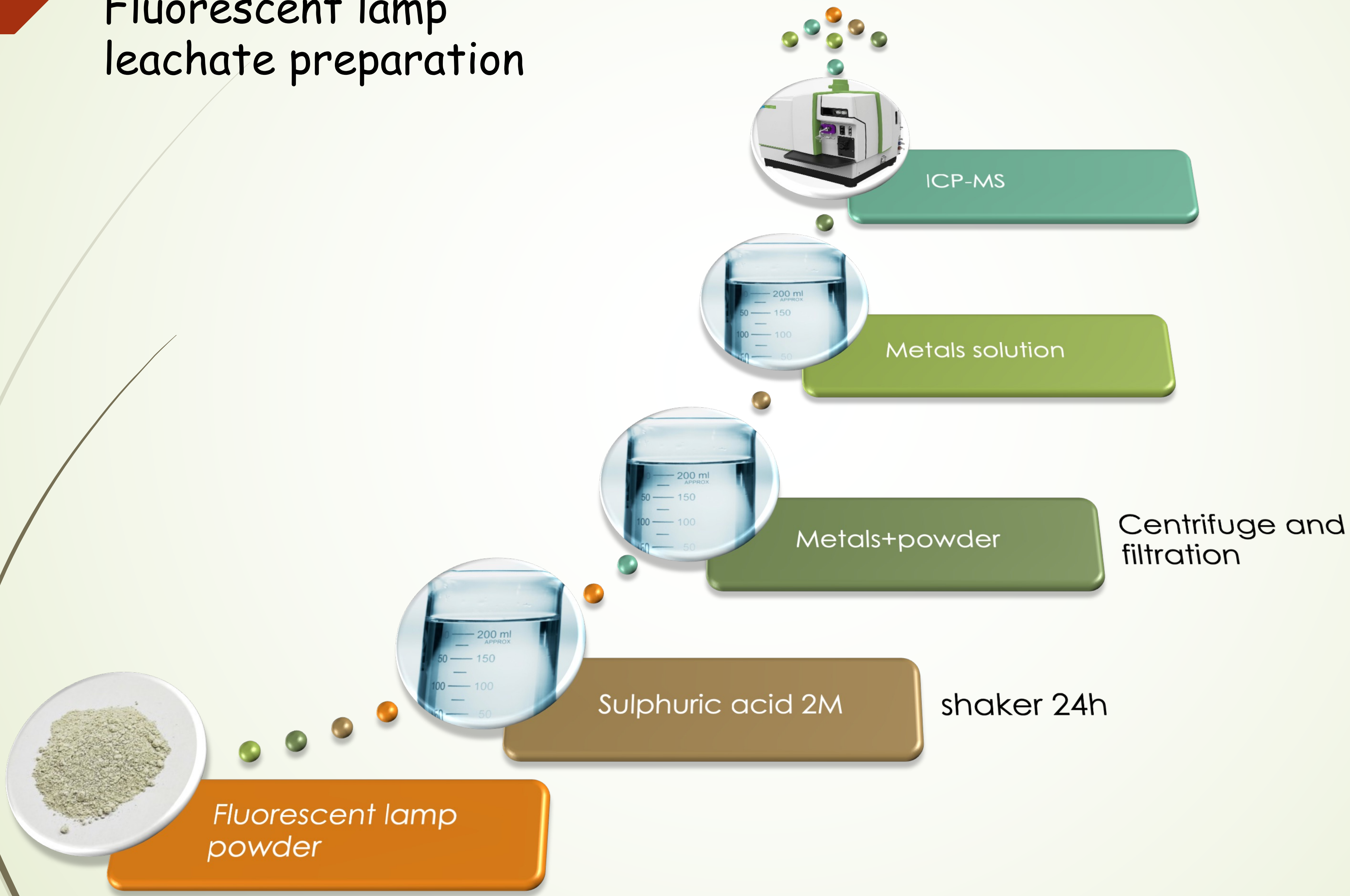
Physiological response to Cerium (III)

Light Microscope and Serial Block Face-SEM micrographs



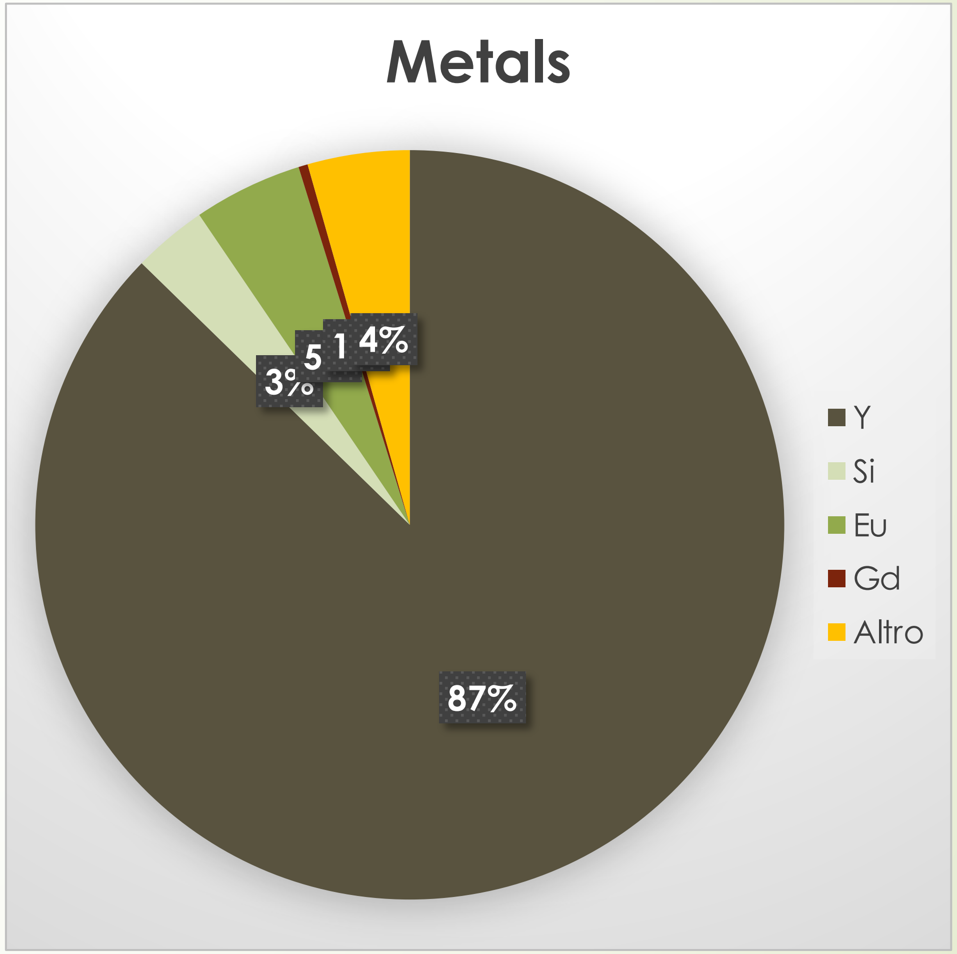
Biosorption of rare earth elements from luminophores

Fluorescent lamp leachate preparation



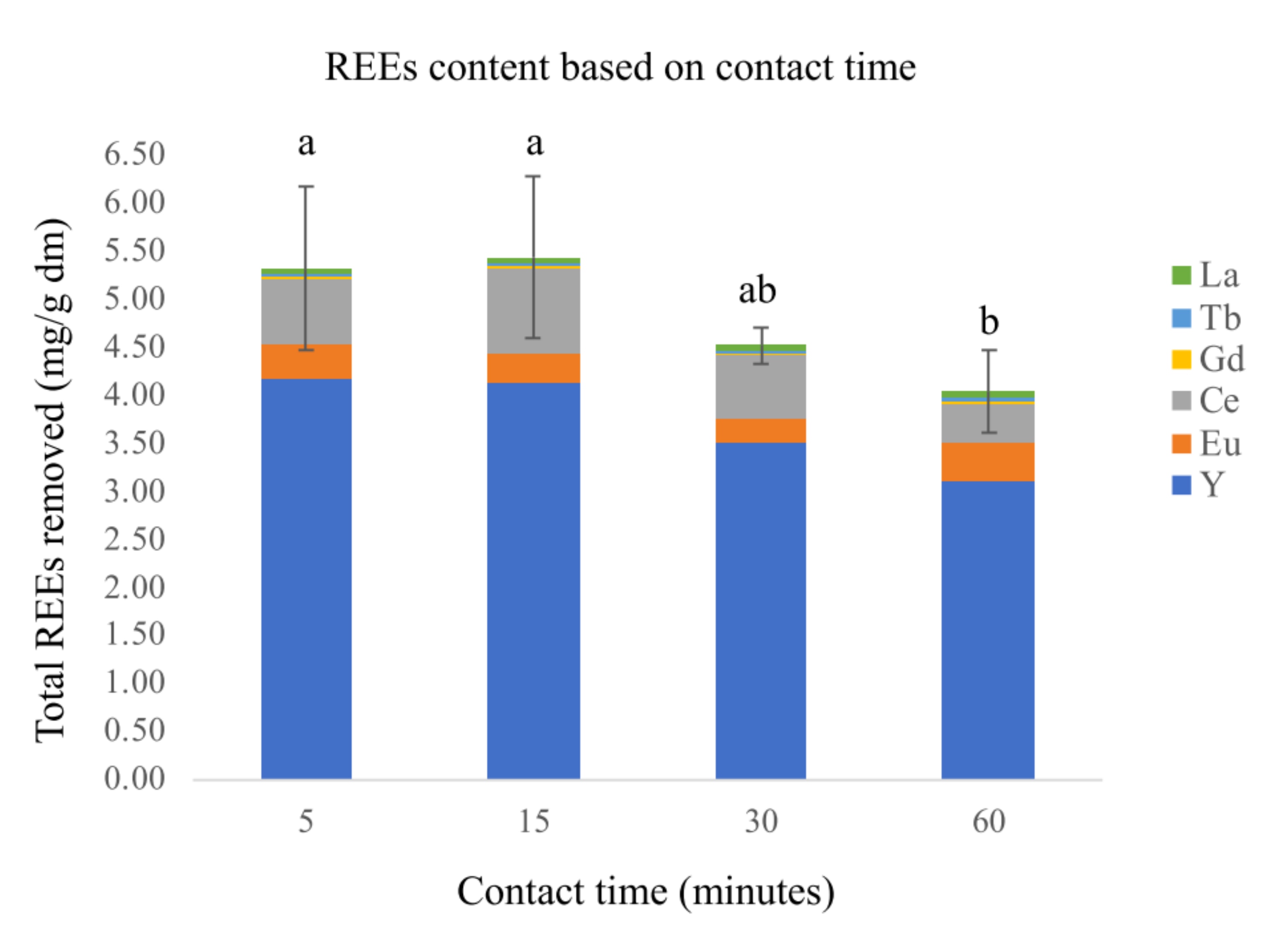
Biosorption OF RARE EARTH ELEMENTS FROM LUMINOPHORES

Metals	ppb	Standard deviation
Ce 140	31,63	± 1,58
Eu 153	966,29	± 48,31
Gd 159	92,36	± 4,62
Tb 159	28,98	± 1,45
Y 89	17921,15	± 896,06
B 11	76,58	± 3,83
Ba 137	27,08	± 1,35
Cu 65	64,01	± 3,20
Fe 54	110,49	± 5,52
Ga 69	0,60	± 0,03
Li 7	1,75	± 0,09
Mn 55	114,99	± 5,75
Mo 98	3,23	± 0,16
Ni 58	12,52	± 0,63
Ni 60	12,90	± 0,65
Pb 208	2,03	± 0,10
Sb 121	69,39	± 3,47
Si 28	649,42	± 32,47
Sr 88	341,01	± 17,05



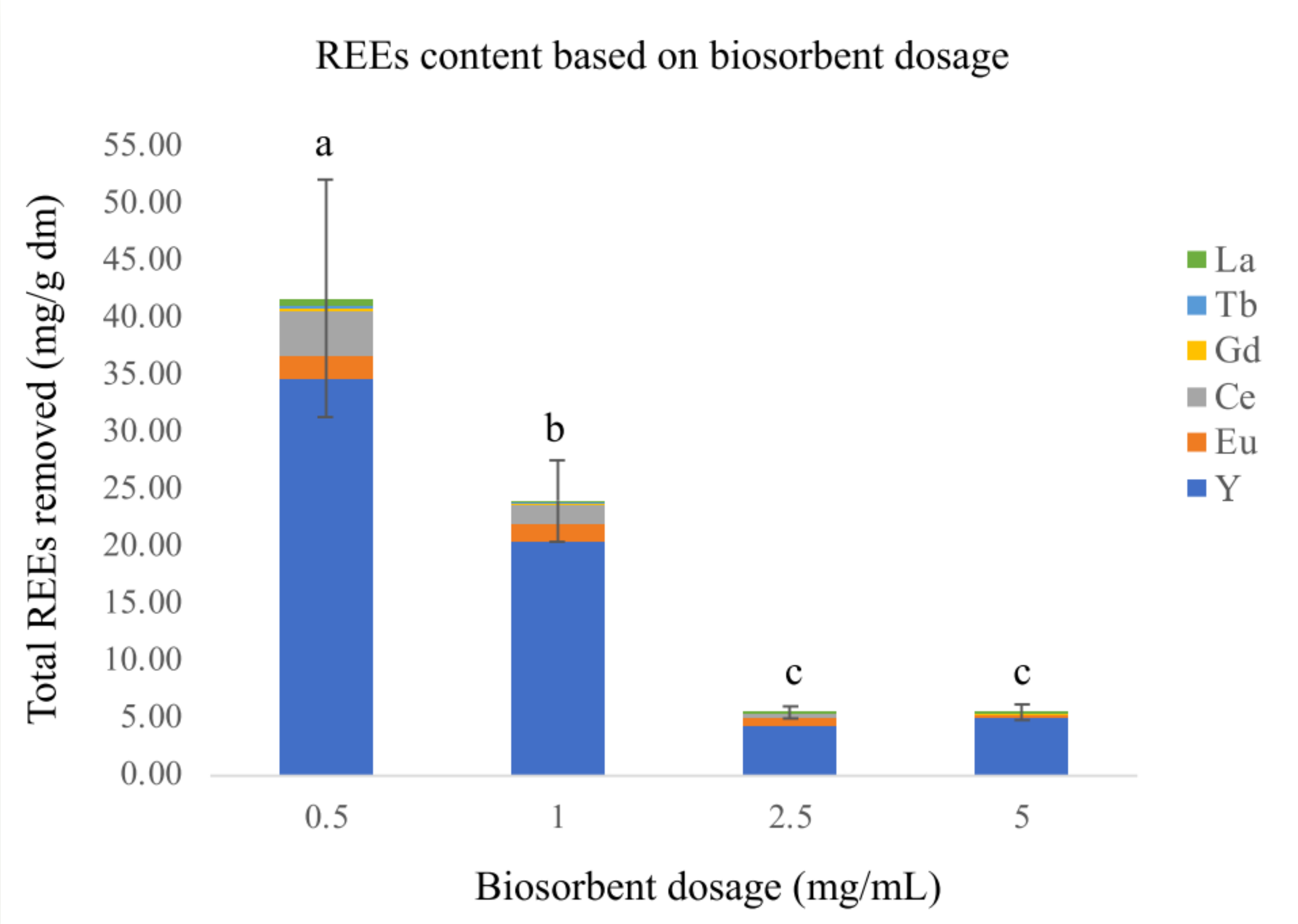
Biosorption of rare earth elements from luminophores

Results-Contact time



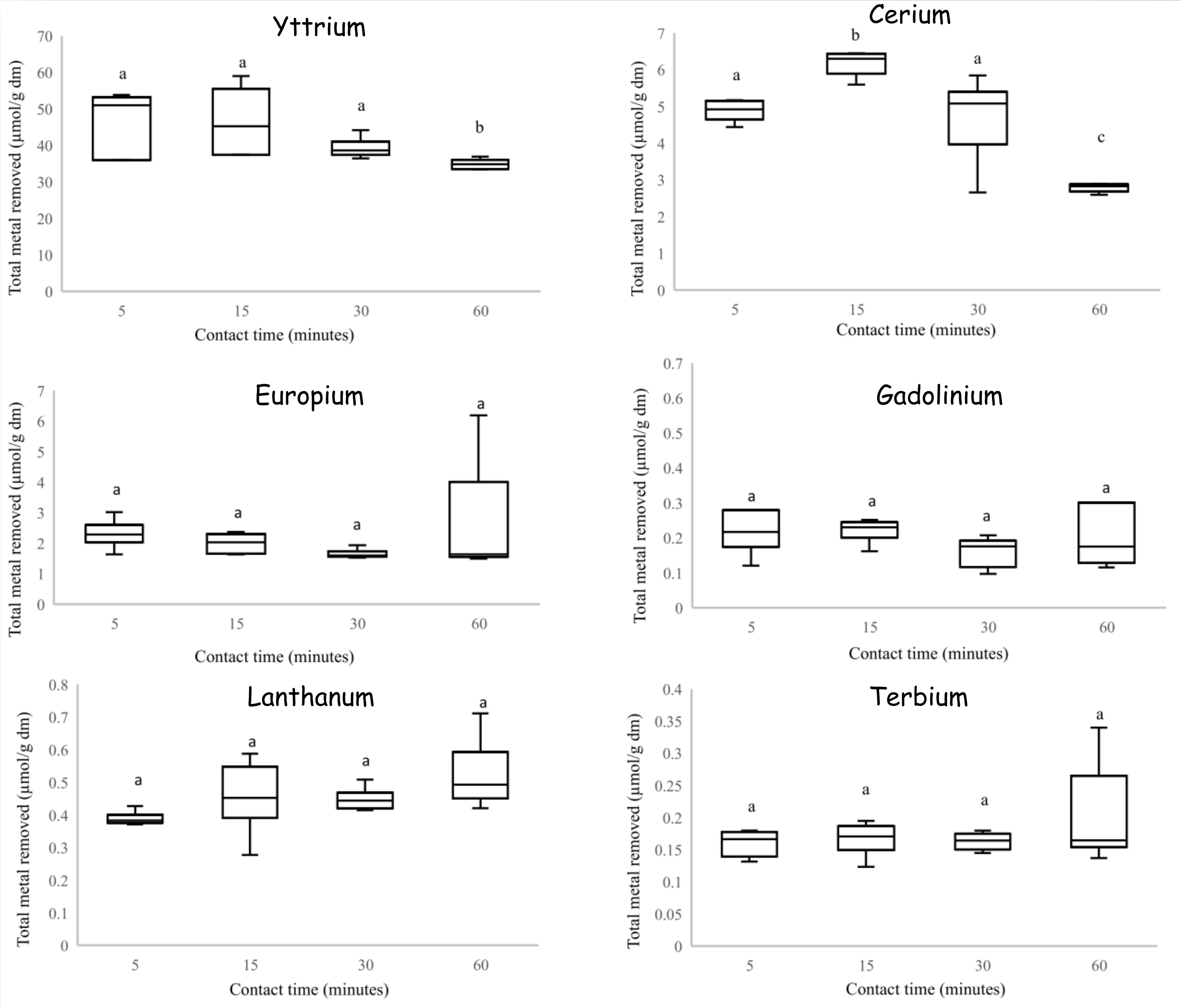
Biosorption of rare earth elements from luminophores

Results-Biosorbent dosage



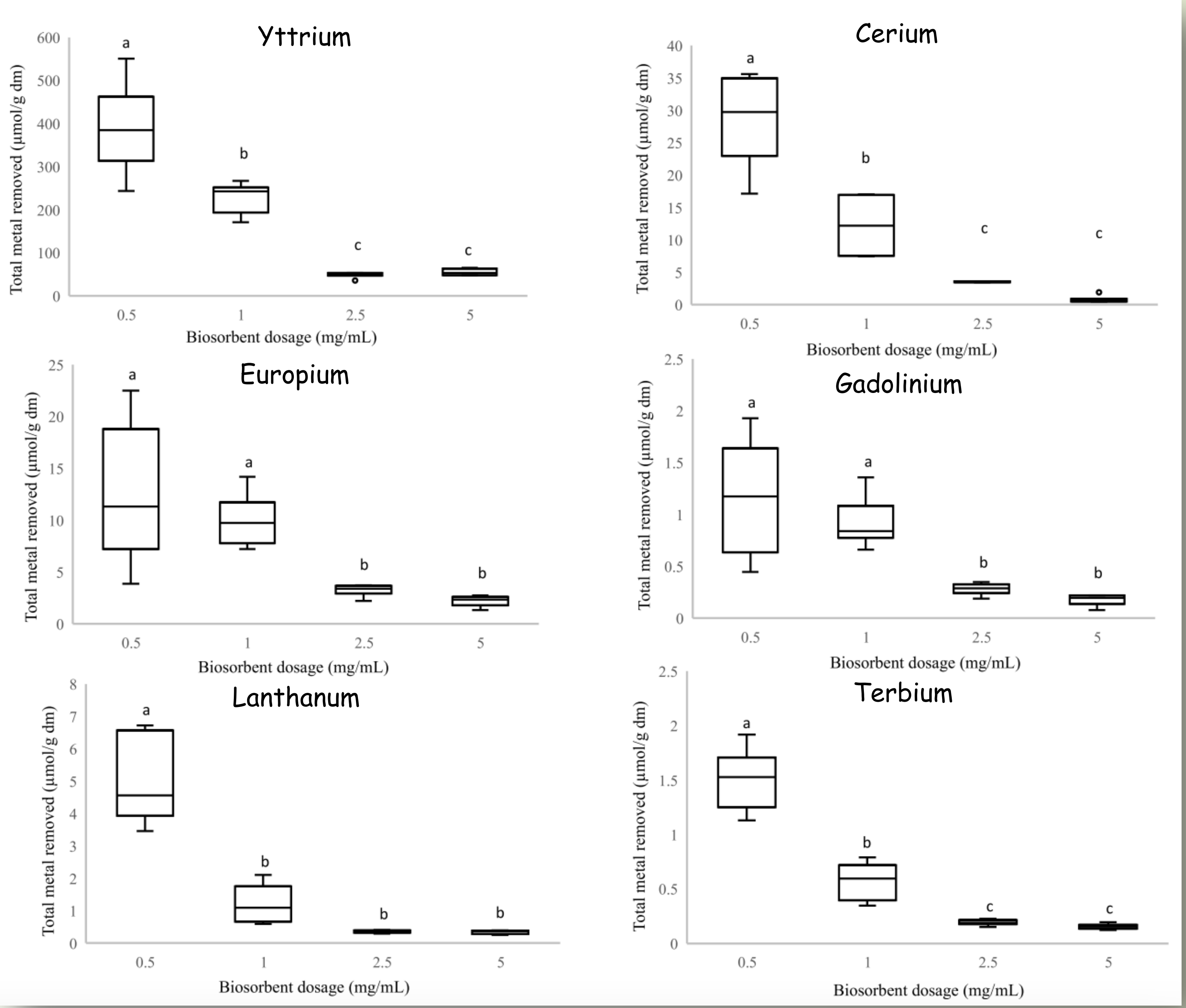
Biosorption of rare earth elements from luminophores

Results-Contact time



Biosorption of rare earth elements from luminophores

Results-Biosorbent dosage



Future perspectives

1. Optimization of leachate concentration to achieve 100% of biosorption efficiency

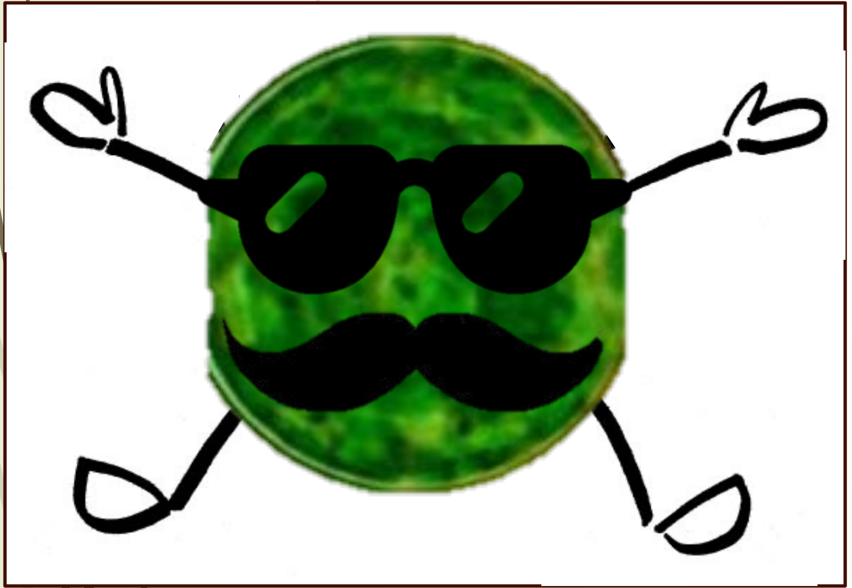
2. Understand the selectivity of the cell wall functional groups using the Nuclear Magnetic Resonance (NMR)

3. Ultrastructural Characterization of the cell walls of *G. sulphuraria*

4. Develop methods to recover metals from the biosorbent and regenerate it to be used multiple times

4. Double exploitation of *G. sulphuraria* for wastewater, REEs treatment and production of valuable compounds

Thank you for your attention!!!



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