Metabolome and Proteome analysis unveils the mixotrophic response of marine diatom.

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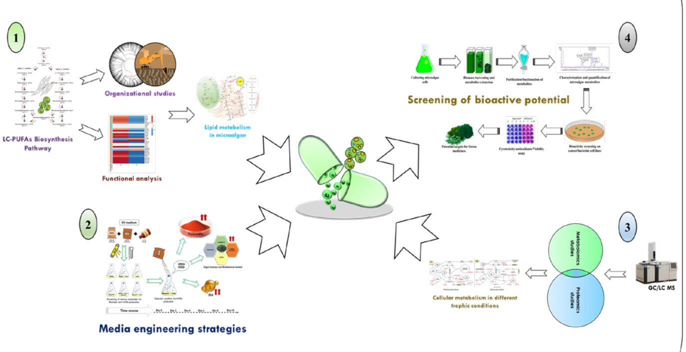
Background

Mixotrophy is a viable strategy for enhancing biomass production and growth rates in microalgae. However, the underlying process of carbon distribution in the mixotrophic state remains elusive. *Phaeodactylum tricornutum*, a marine diatom, enriched in high value added biorenewables (HVABs) was selected to study mixotrophy benefiting cellular metabolism in terms of growth and lipid production. In this context, metabolomics and proteomics datasets were integrated to elucidate the fundamental mechanism involved in carbon distribution in the cell. Our findings offer an overview of *P. tricornutum* cellular metabolism in mixotrophy, providing prospects in terms of metabolic and protein targets for genetic modification for the generation of biofuels and HVABs.

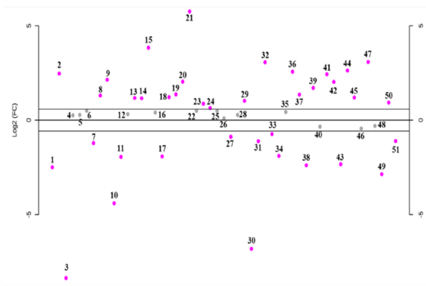
Workflow



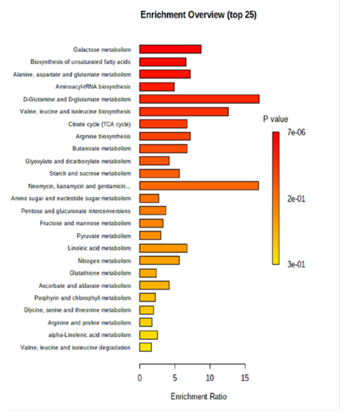
Key findings

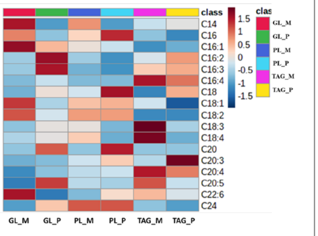
- This research will deliver a novel, optimised biotechnological process, tested at industry relevant scales, to aid lithium recovery from geothermal brines.
- The addition of *Sporosarcina pasteurii* for metal precipitation changes the pH of the medium, causing an increase due to the release of ammonia in the chemical process.
- The initial concentration of urease (at time point 0hr) is high in the bacterial inoculum (O.D 0.4) this reflects in the precipitation of most of the metals at very start of the experiment.
- In a simple synthetic brine solution, 100% of the calcium precipitates, 40% of the magnesium precipitates, while lithium still remains the same.
- In complex synthetic brine *S. pasteurii* precipitated (100%) calcium, (40%) magnesium, (60%) manganese, (100%) Strontium and (99%) lithium remains in solution.

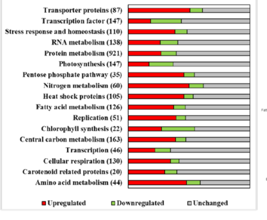
Observations

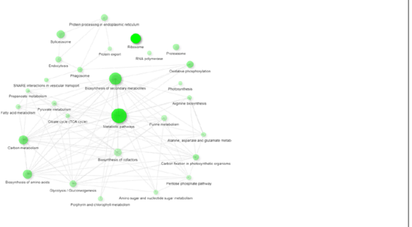


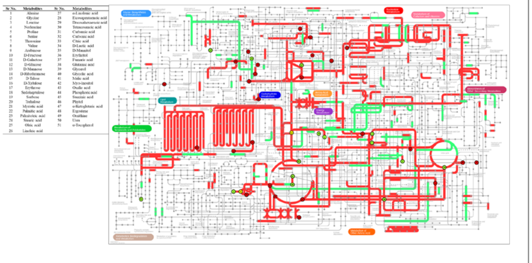
Sr No.	Metabolites	Sr No.	Metabolites
1	Alanine	27	α-Linolenic acid
2	Glycine	28	Eicosapentaenoic acid
3	Leucine	29	Docosahexaenoic acid
4	Norleucine	30	Tetracosanoic acid
5	Proline	31	Carbamic acid
6	Serine	32	Carbonic acid
7	Threonine	33	Citric acid
8	Valine	34	D-Lactic acid
9	Arabinose	35	D-Mannitol
10	D-Fructose	36	Erythritol
11	D-Galactose	37	Fumaric acid
12	D-Glucose	38	Glutamic acid
13	D-Mannose	39	Glycerol
14	D-Ribofuranose	40	Glycolic acid
15	D-Talose	41	Malic acid
16	D-Xylulose	42	Myo-Inositol
17	Erythrose	43	Oxalic acid
18	Sedoheptulose	44	Phosphoric acid
19	Sorbose	45	Succinic acid
20	Trehalose	46	Phytol
21	Myristic acid	47	α-Ketoglutaric acid
22	Palmitic acid	48	Ergostene
23	Palmitoleic acid	49	Ornithine
24	Stearic acid	50	Urea
25	Oleic acid	51	α-Tocopherol
26	Linoleic acid		

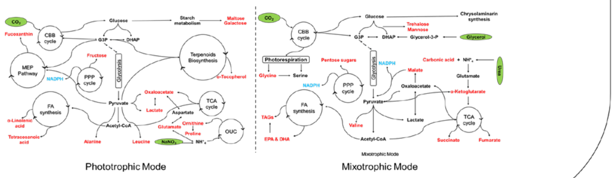












Phototrophic Mode Mixotrophic Mode

Microbial processing of geothermal brines for effective Lithium extraction process

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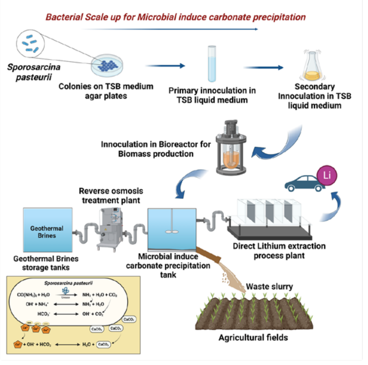
Research question

- Global technological developments have increased the need for lithium, which is crucial for energy storage to achieve Net Zero goals.
- Meeting this demand requires a substantial intensification of mining and ore processing to maintain a continuous supply of lithium.
- Currently, approximately two-thirds of the world's lithium supply originates from brines extracted from salars or salt lakes, while research is underway in the United Kingdom and beyond to explore lithium extraction methods using geothermal waters high in lithium content.
- While there exists technology to extract lithium from brine, a significant challenge arises in mitigating scaling caused by the precipitation of other components, like silicates, iron, and manganese oxides, which can curtail the plant's lifespan and result in costly cleanings using harsh chemicals.
- The project aims to devise an environmentally sustainable and economically viable process that can reduce problematic elements in the brine without compromising lithium yield.

Background

- Previously microbial potential is explored for lithium extraction process. Our hypothesis states that microbial induced calcite precipitation (MICP) by urea hydrolysis can successfully be applied to lithium brines as an effective way for removing undesirable components at the start of the lithium extraction process.
- The objective is to reduce the problematic elements from the brine, retaining lithium. This can be achieved by using the ureolytic bacterium *Sporosarcina pasteurii.*
- Relevant metals can be measured in the brines over time during biological processing.
- The next step will be to scale up the process in a pilot-scale extraction system to test the feasibility of commercial lithium extraction.
- Overall, this study delivers a unique circular bioprocessing method to aid in the economic recovery of lithium.

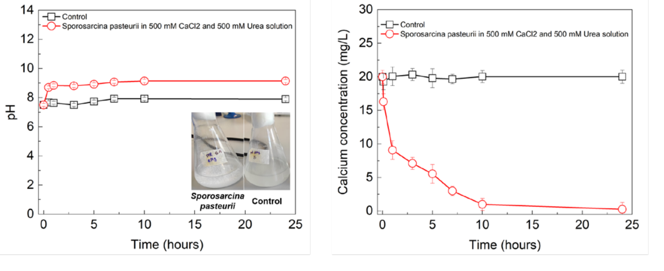
Process Design



Schematic representation of 1000 litre pilot plant setup for processing geothermal brines

Observations

Figure 1. Calcite precipitation experiments with *Sporosarcina pasteurii* in calcium chloride (500mM) and urea (500 mM) solution.



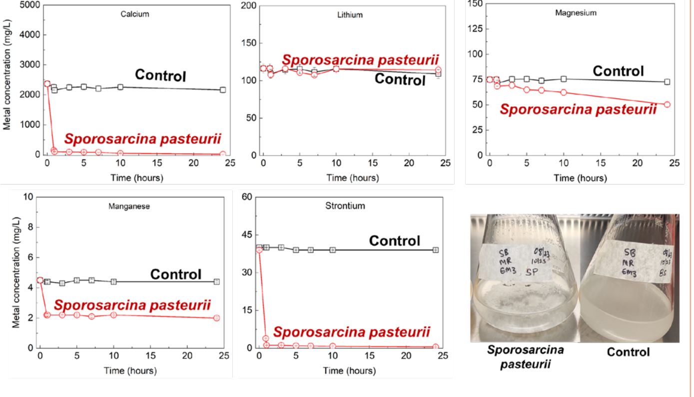


Figure 2. Metal precipitation experiments with *Sporosarcina pasteurii* in a synthetic complex brine solution.

Summary

- This research will deliver a novel, optimised biotechnological process, tested at industry relevant scales, to aid lithium recovery from geothermal brines.
- *Sporosarcina pasteurii* changed the pH of the medium, leading to an increase due to the release of ammonia in the chemical process.
- The initial concentration of urease (at time point 0 hr) was high (in the bacterial inoculum with O.D 0.4) this reflects in the precipitation of most of the metals at very start of the experiment.
- In a simple synthetic brine solution, 100% of the Ca precipitates, 40% of the Mg precipitates, while Li was still in the brine solution.
- In complex synthetic brine *S. pasteurii* precipitates (100%) Ca, (40%) Mg, (60%) Mn, (100%) Sr and (99%) Li remains in solution.
- The results highlights alternate application of biotechnology, having a potential to scaleup the lithium Biorecovery.

EBNet Environmental Biotechnology | University of Exeter | EM3 | Cornish Lithium | BBSRC | UK Research and Innovation

An E3B and EBNet BBSRC NIBB meeting - Bio-recovery of technology relevant metals | Manchester | December 12-14, 2023