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### SCREENING OF QATARI MICROALGAE AND CYANOBACTERIA FOR APPLICATION IN CO<sub>2</sub> UTILIZATION

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CO<sub>2</sub> fixation by phototrophic microalgae and cyanobacteria is seen as a possible global carbon emissions reducer, which could also be applied to produce useful products. In Qatar, the prospect of using microalgae is very promising: high solar irradiance, large areas of non-arable land, and large amounts of CO<sub>2</sub> sources make it an ideal place for algae cultivation. Nonetheless, application of algae in the region is limited, primarily due to a lack of suitable algae which can grow under relevant outdoor conditions, such as high temperatures, increased salinities, as well as elevated CO<sub>2</sub> concentrations when using industrial CO<sub>2</sub> sources. Furthermore, such algae also need to be able to produce commercially valuable products. One of the most comprehensive resources for novel algae strains in the region is the Qatar University Culture Collection of Cyanobacteria and Microalgae (QUCCCM), which houses a large diversity of strains, the potential of which still remains largely unexplored. This research focused on evaluation of biomass productivity of four novel marine strains from this culture collection, under elevated temperatures and CO<sub>2</sub> concentrations. The strains were also evaluated for their carbon capture potential, as well as commercial potential, through biomass analysis. Two strains were identified as cyanobacteria (*Leptolyngbya* sp. and *Pleurocapsa* sp.) and two were identified as microalgae (*Tetraselmis* sp. and *Picochlorum maculatum*). As cyanobacterial strains in some cases are known to produce toxins, both cyanobacteria were analyzed for presence of genes for cylindrospermopsin, microcystin and saxitoxin production, and found to be negative for all three. All four strains were then cultivated under various temperatures, ranging from

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30 to 45 °C. The most productive strain was *Tetraselmis* sp., with a maximum biomass productivity of  $157.7 \pm 10.9$  mg L<sup>-1</sup> d<sup>-1</sup> at 30 °C, with a decreasing productivity for increasing temperatures. *Leptolyngbya* sp. showed an opposite trend, increasing in productivity from  $91.4 \pm 10.2$  to  $106.6 \pm 7.1$  mg L<sup>-1</sup> d<sup>-1</sup> with increasing temperature from 30 to 40 °C respectively. None of the strains were able to grow at 45 °C. The biomass of the four strains cultivated under different temperatures was analyzed for lipid, protein and carbohydrate content, as well as total carbon and nitrogen content. *Picochlorum maculatum* was found to have the highest lipid and protein content, with  $24.0 \pm 1.3$ ,  $28.0 \pm 1.4$  and  $27.0 \pm 1.4$  % (w/w) lipids and  $21.2 \pm 0.2$ ,  $23 \pm 0.1$ , and  $20 \pm 0.9$  % (w/w) proteins for cultivation at 30, 35 and 40 °C respectively. This strain also had the highest nitrogen content ( $12.2 \pm 0.05$  % at 40 °C) and carbon content ( $51.2 \pm 0.25$  % at 45 °C). Compared to *Picochlorum maculatum*, *Tetraselmis* sp. showed a slightly lower lipid content ( $25.6 \pm 0.64$  and  $22.5 \pm 0.78$  % for 30 and 35 °C respectively) and total carbon content ( $46.9 \pm 0.8$  and  $47.6 \pm 0.9$  % C (w/w) for 30 and 35 °C respectively), however due to the higher productivity, the carbon capture rate for *Tetraselmis* sp. was the highest of the tested strains, at 270 mg CO<sub>2</sub> L<sup>-1</sup> d<sup>-1</sup> at 30 °C. *Pleurocapsa* sp. showed the lowest nitrogen content, at 4.4% N (w/w) for 30 °C. There is indication that this strain is capable of fixing atmospheric nitrogen. This is very beneficial for large-scale cultivation, as it reduces the requirements for nitrogen fertilizer, which can greatly reduce costs and improve production sustainability. Furthermore, spectrophotometric analysis of *Pleurocapsa* sp. and *Leptolyngbya* sp. showed production of phycobilin proteins, which can have a high commercial value. The tolerance of the strains to increased concentrations of CO<sub>2</sub> in the gas phase was also studied for CO<sub>2</sub> concentrations ranging from 5% to 30% (v/v). With productivities of  $53.7 \pm 11.4$ ,  $162.2 \pm 5.4$ ,  $333.8 \pm 29.1$  and  $312.8 \pm 12.8$  mg L<sup>-1</sup> d<sup>-1</sup> for 5, 10, 20 and 30% CO<sub>2</sub> respectively, *Tetraselmis* sp. showed that a significant productivity increase could be obtained with increased CO<sub>2</sub> concentrations. *Picochlorum maculatum* showed a similar trend, with slightly lower productivities of  $67.1 \pm 0.2$ ,  $160.5 \pm 21.8$ ,  $244.1 \pm 20.9$  and  $219.9 \pm 15.6$  mg L<sup>-1</sup> d<sup>-1</sup> for 5, 10, 20 and 30% CO<sub>2</sub> respectively. *Leptolyngbya* sp. showed similar productivities for CO<sub>2</sub> concentrations ranging from 5-30%, indicating that the strain was not influenced by increasing CO<sub>2</sub> concentrations as were the other two strains. *Pleurocapsa* sp. on the other hand showed no growth at 30% CO<sub>2</sub>, and stable similar productivities at 5, 10 and 20% CO<sub>2</sub>. Overall, it can be concluded that for both microalgal strains (*Tetraselmis* sp. and *Picochlorum maculatum*) increased CO<sub>2</sub> concentrations resulted in a significantly increased productivity, and as of such they would be the most interesting to further investigate for direct coupling to enriched CO<sub>2</sub> gas sources, such as industrial flue gasses. Furthermore, besides having the highest productivities of the four investigated strains, *Tetraselmis* sp. is generally known to have promising characteristics for feed purposes (amino acid profiles and presence of omega-3 fatty acids) as well as for biofuel purposes due to high lipid amounts. Based on these results, *Tetraselmis* sp. is a very interesting candidate for CO<sub>2</sub> capture and production of valuable products in Qatar. Further investigation into this strain is necessary to confirm the presence of such components in this particular strain, as well as to identify conditions which increase specific product productivity, and the capability of direct coupling to industrial flue gas.