Remediation of Agricultural Wastes to Grow Algal Biomass for Nutritional Supplements and Animal Feed

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Microalgae

- Microalgae is a very attractive biomass as it has a short growth rate, and can be grown easily in large amounts.
- Microalgae have been the source of an extremely large library of novel compounds.
- Many species of microalgae have been shown to be good sources of fatty acids, sterols and carotenoids.

Credit: CSIRO ScienceImage

Credit: Dr. Matt Julius

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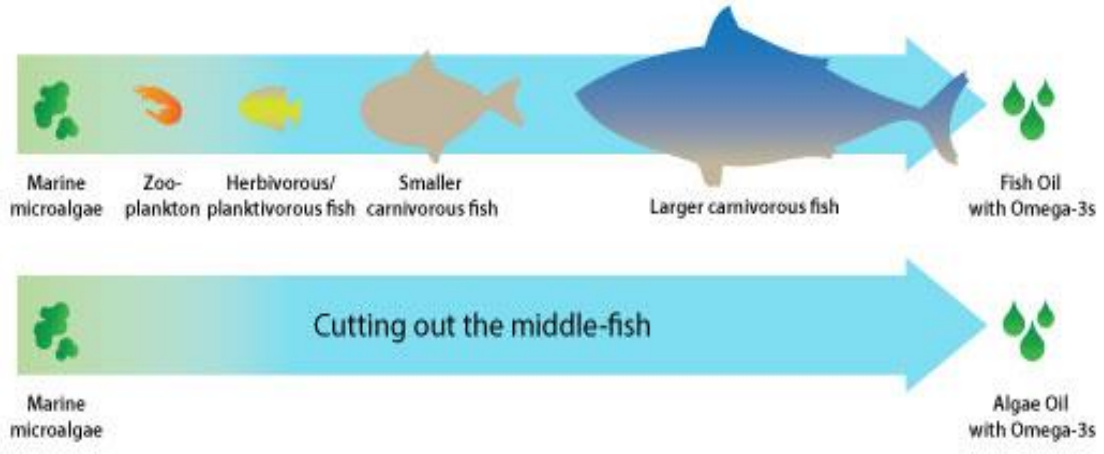
Fatty Acids

- Microalgae is also known for its high lipid production. The lipids and other compounds it produces, such as sterols and carotenoids, make it attractive for industries such as biofuels.
- The extraction of lipids, in particular fatty acids, from microalgae is one of the main focuses of this project
- They are essential for normal human development and can have positive effects on human health when incorporated into a balanced diet.



Credit: Cellana

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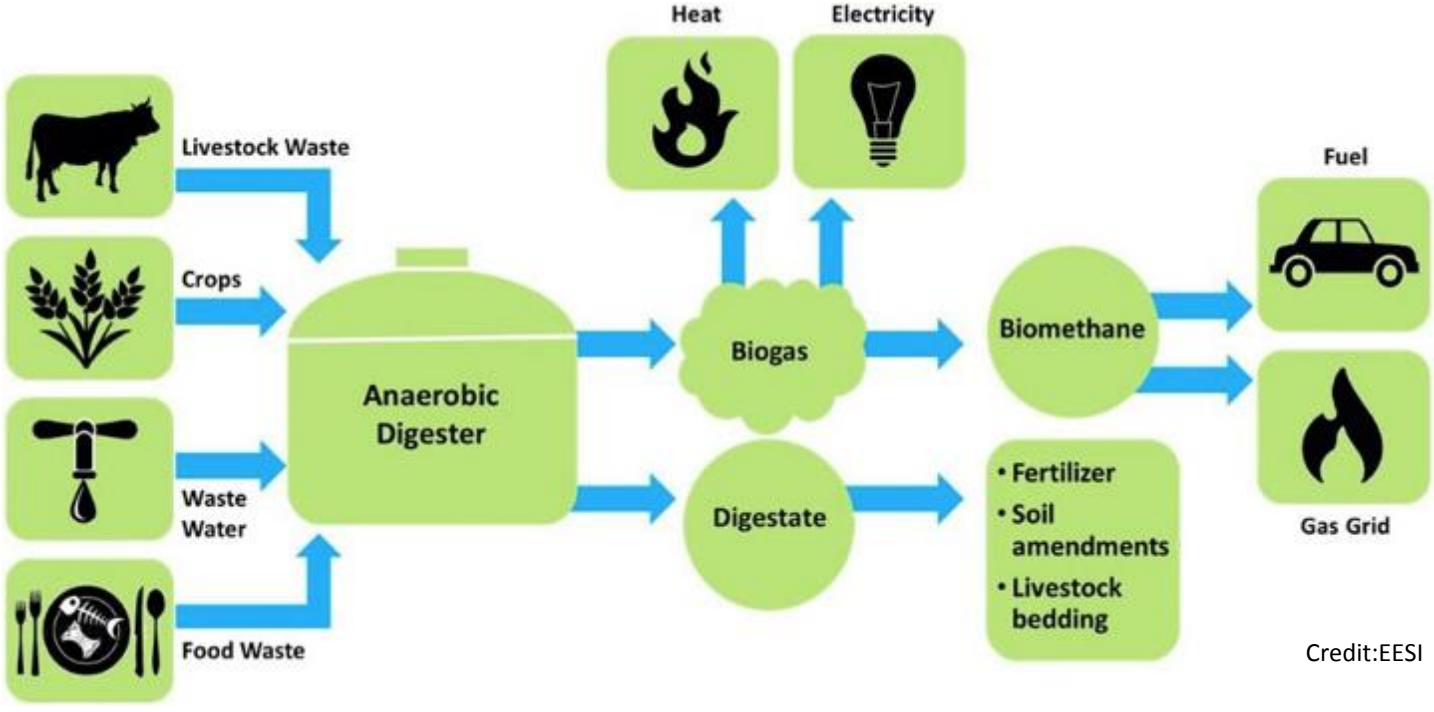
Anaerobic Digestate

- Growing microalgae can be an expensive and energy intensive, to increase the efficiency we can repurpose an existing waste stream as biofertiliser.
- Anaerobic digestion is a growing industry, especially in Northern Ireland, with 69 plants currently operating in the region and nearly 200 currently under construction or having received planning permission.
- This will supply a large amount of electricity but also produces almost a million tonnes of effluent which needs to be dealt with.



Credit:EESI

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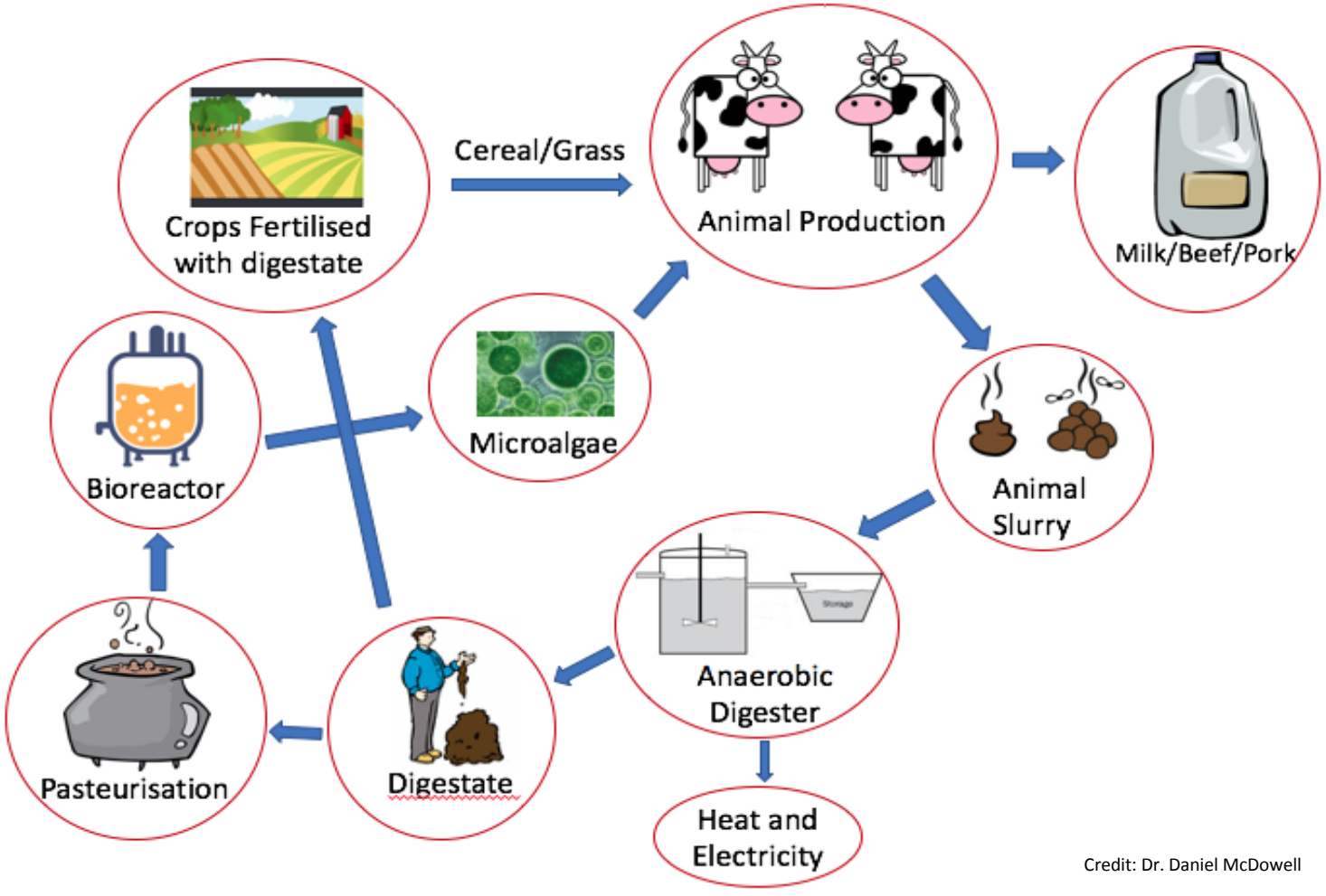
Project Summary

This project is a study of the nutritional value of microalgae grown using an alternative biofertiliser, anaerobic digestate.

Objectives:

- Quantify and analyse the effluent of the anaerobic digester.
- Directly compare with a purchased F/2 media as a growth medium for microalgae
- Compare the nutritional value of the algae from each growing method, such as fatty acids and pigments.



Credit: Dr. Daniel McDowell

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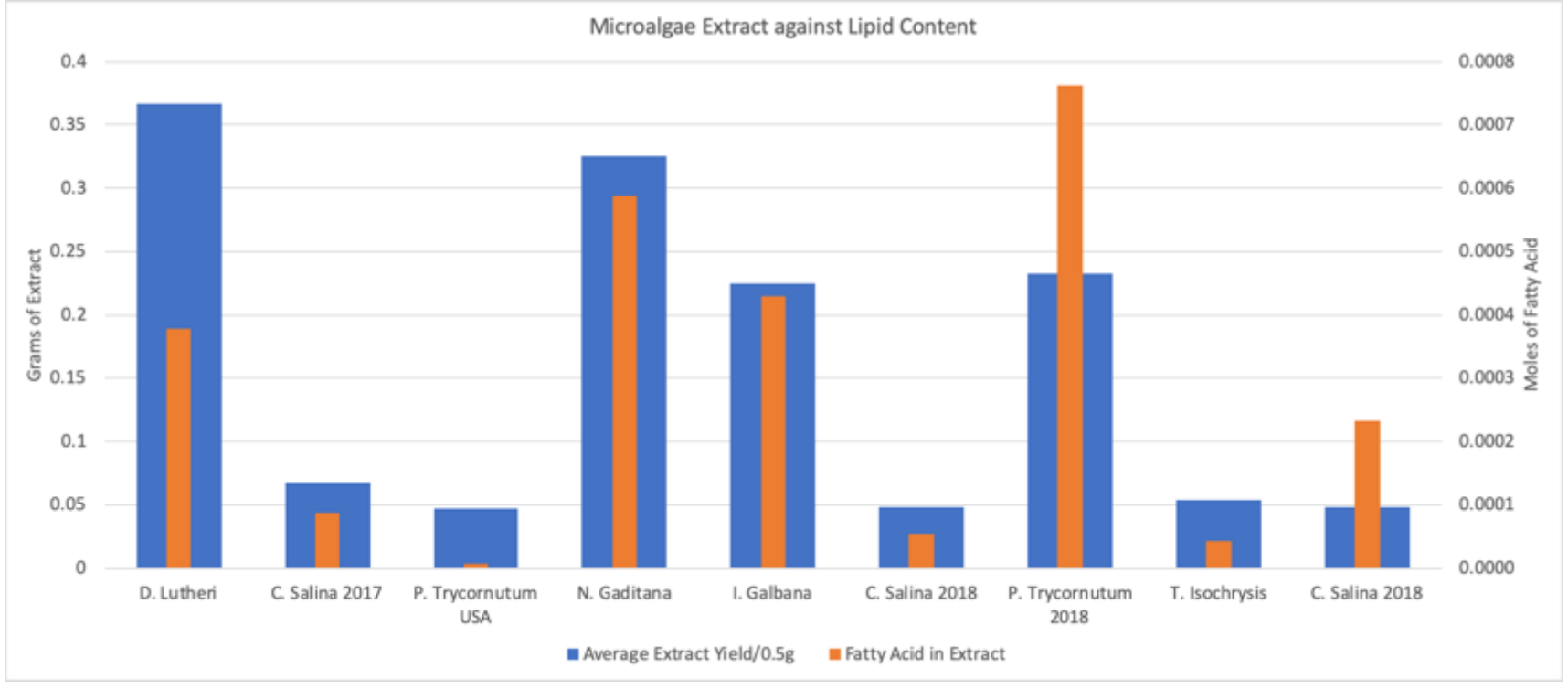
Fatty Acid Extraction

- The microalgae samples were analysed via NMR for their total lipid content.
- It was to serve as a bench mark for the extraction of fatty acids when compared to other methods, such as supercritical extraction.
- This data was also useful when determining which species to cultivate in the large scale experiments.



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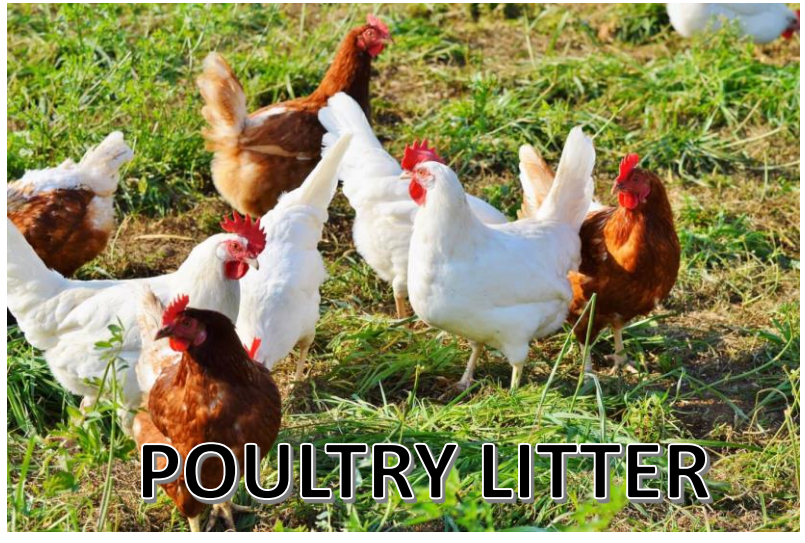
Digestate Analysis

- Analysis of the effluent produced by the AgriAD anaerobic digestion has been undertaken since early 2017, with the samples having been collected and analysed by ICP, AutoAnalyzer, TGA and CHNS.
- 3 feed stocks that vary depending on the plant output and seasonal availability of the feedstocks.

Credit: Lallemand Animal Nutrition

Credit: Undark



Credit: PETA

- Long-term analysis is needed to get a comprehensive analysis of the composition of the digestate.

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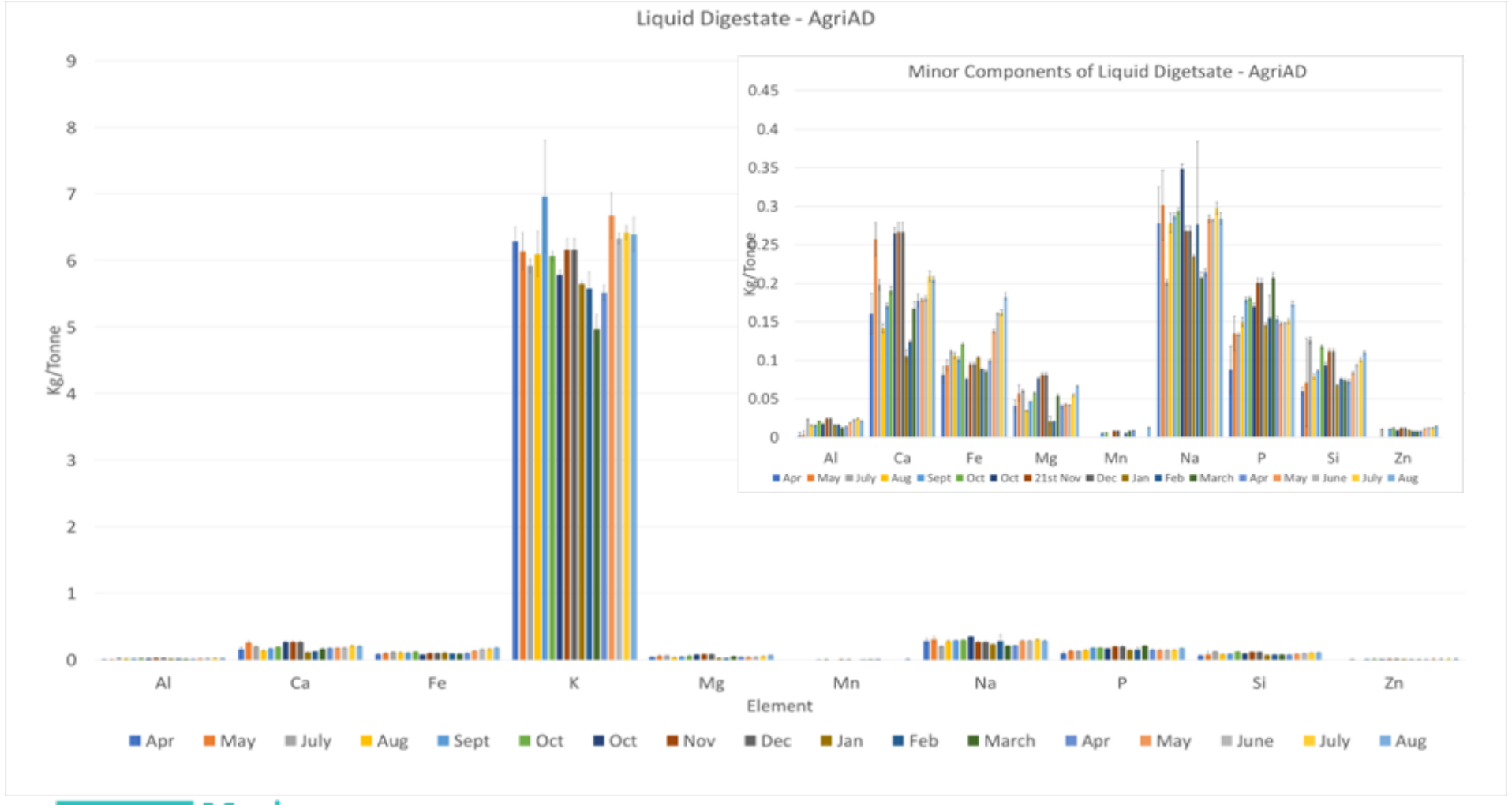
ICP Analysis of Digestate



- For analysis the liquid was dissolved in water (1:100) and then submitted for ICP.

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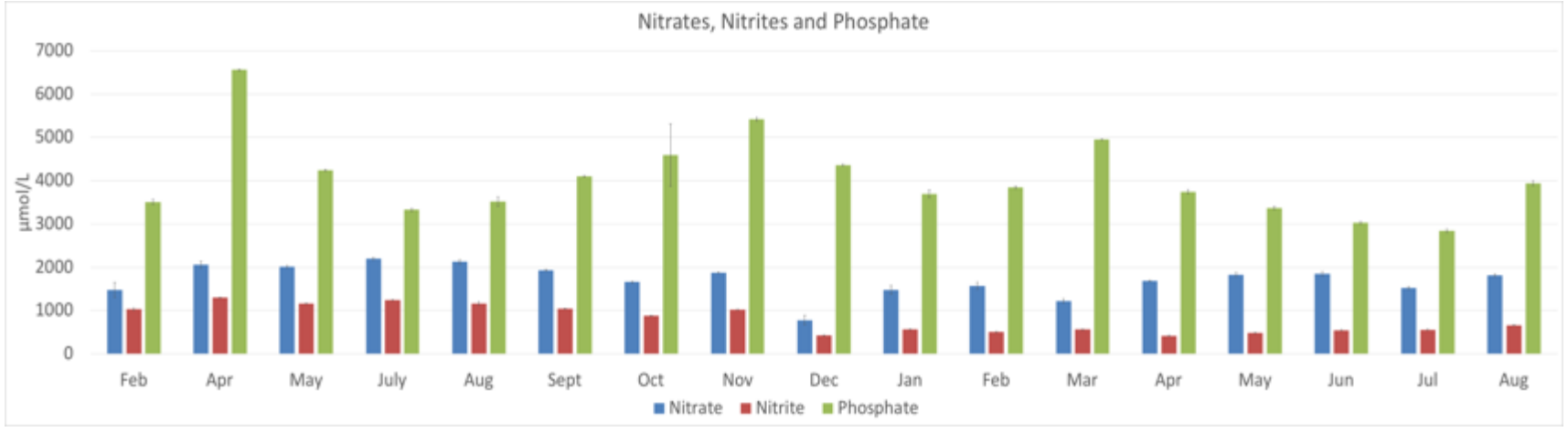
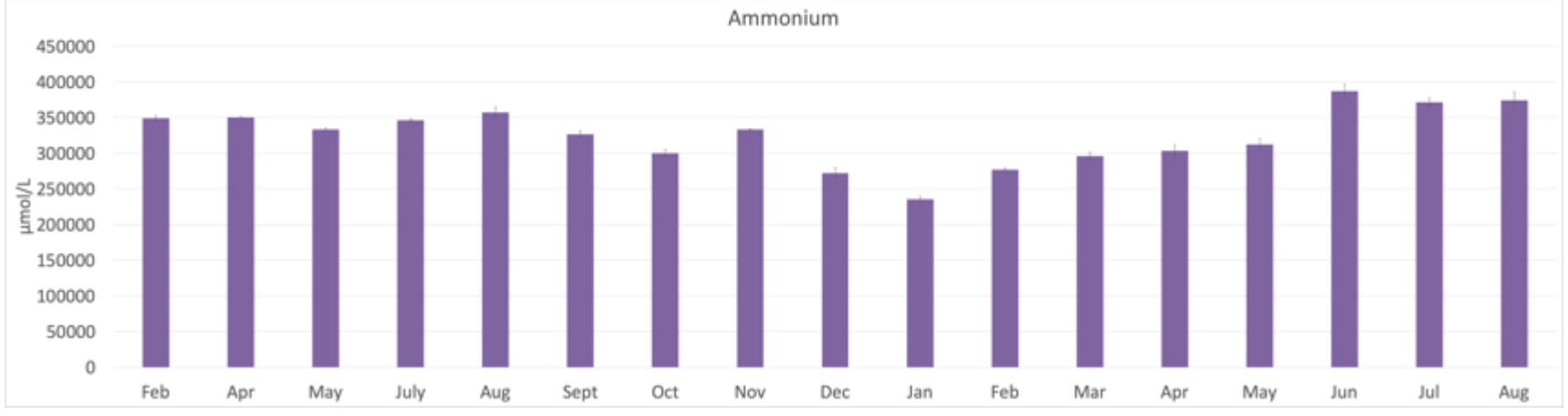
Auto Analyzer





- Inorganic nitrogen and phosphates are very important substrates for the cultivation of microalgae and plants in general.
- The analysis of Nitrates, Nitrites, Phosphate and Ammonia has highlighted a significant amount of ammonia.

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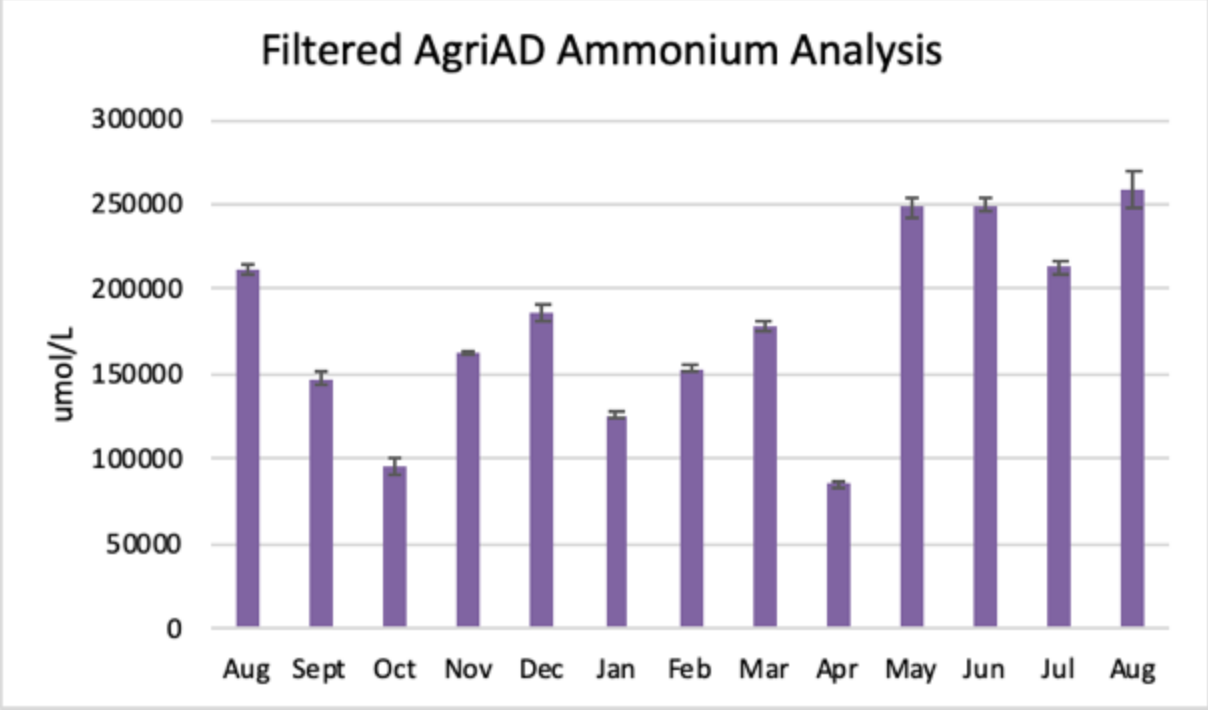
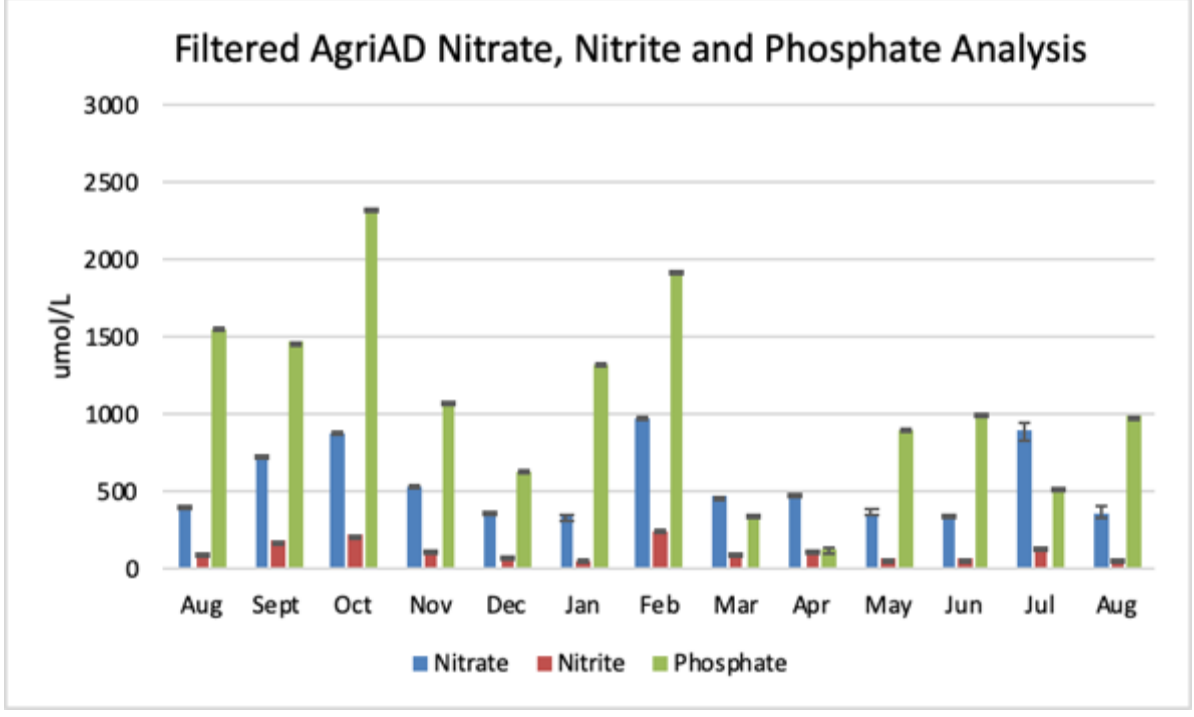
Filtered Effluent AutoAnalyzer Analysis

- The effluent has also been filtered and treated with activated charcoal to remove any pigment for the microalgae cultivation.
- This was also analyzed to see how the treatment with charcoal effect the nutritional value of the digestate.





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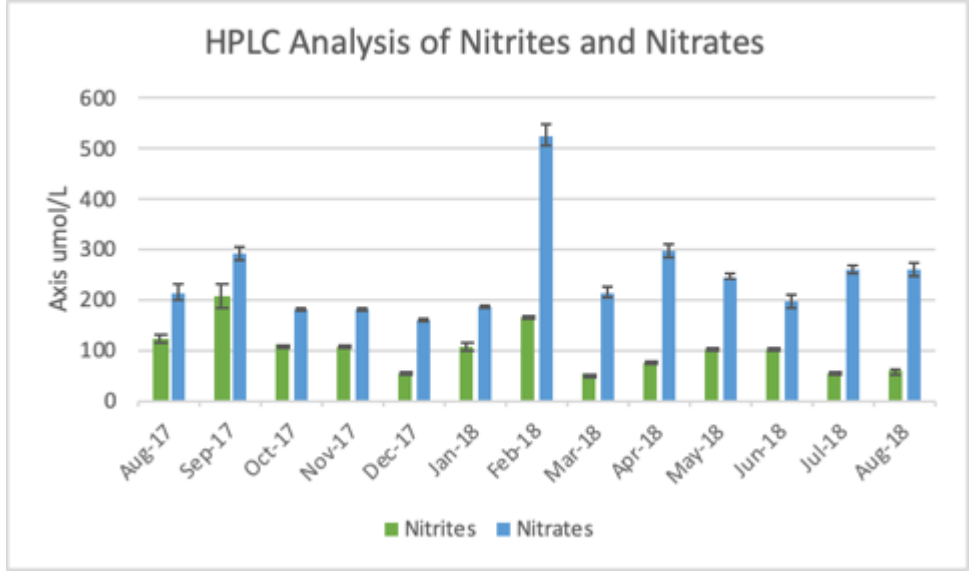
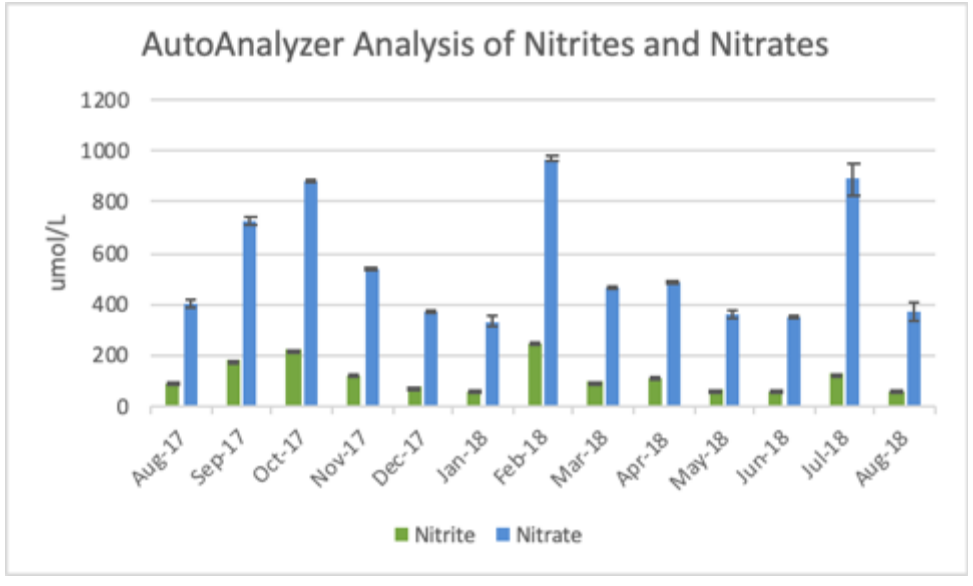
HPLC Analysis

- The digestate is also being analysed for nitrates and nitrites on the HPLC as a validation of the autoanalyzer results.
- These results have been run on filtered and charcoal treated digestate.
- The results so far are consistent with what was found while previously looking at the nitrites and nitrates, in that there is not much variation month to month between the samples, though the results show less present.





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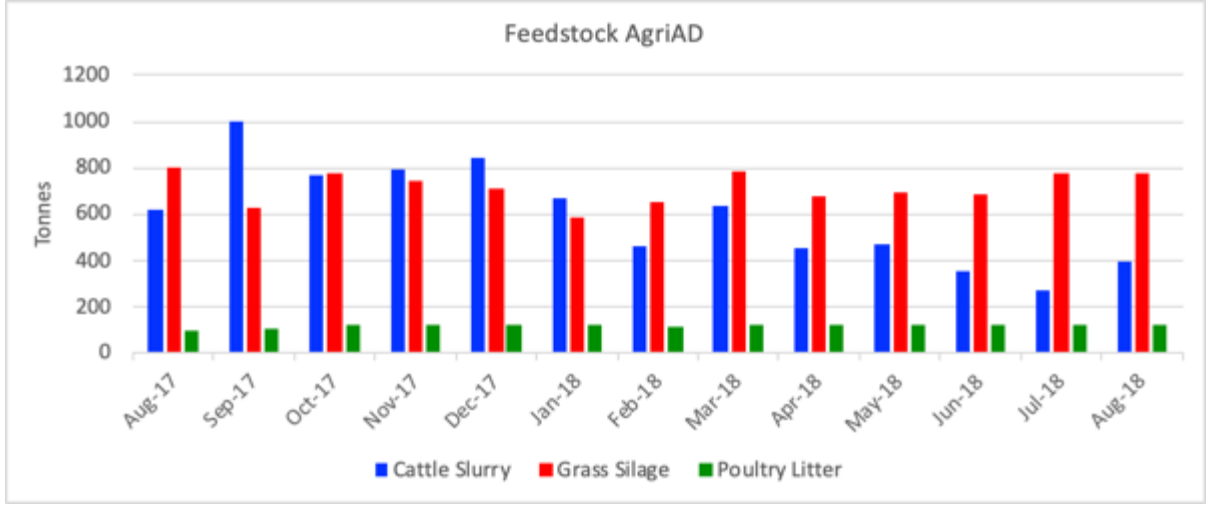
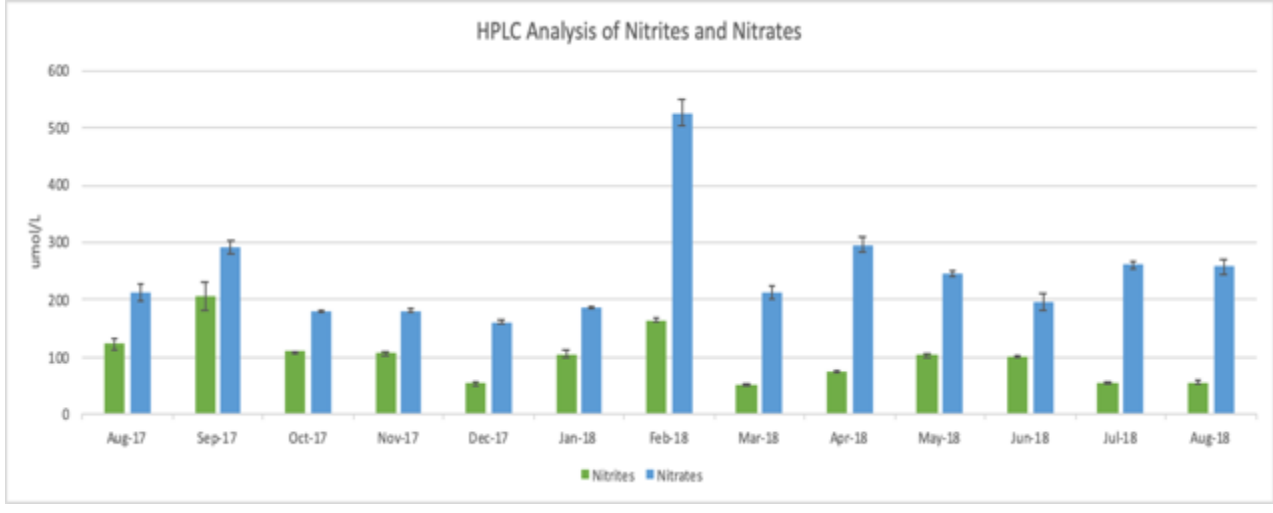
Analysis of AgriAD Digestate

- The feedstocks have been plotted against the HPLC analysis of the nitrites and nitrates, and no correlation has been found.
- Work is currently ongoing to explain the spike in nitrates in February, plans include studying the stability of the digestate as well as the plant set up.





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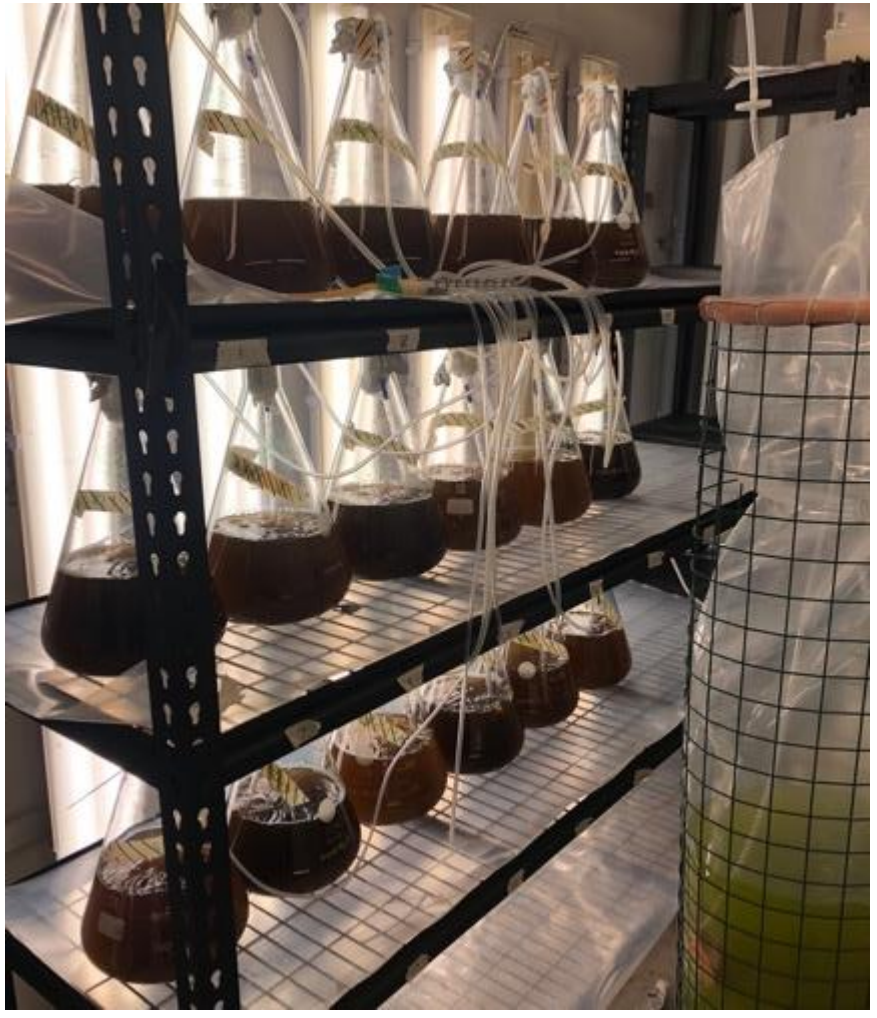
Microalgae Cultivation

- Microalgae, P. *Tricornutum,* was cultivated with 1% AgriAD digestate and F/2 media with different levels of phosphate present in the media, for the analysis of fatty acids.
- The additional phosphate was added as previous studies have shown that increasing the ratio of phosphates to organic nitrogen can increase the amount of fatty acids produced by the cells.



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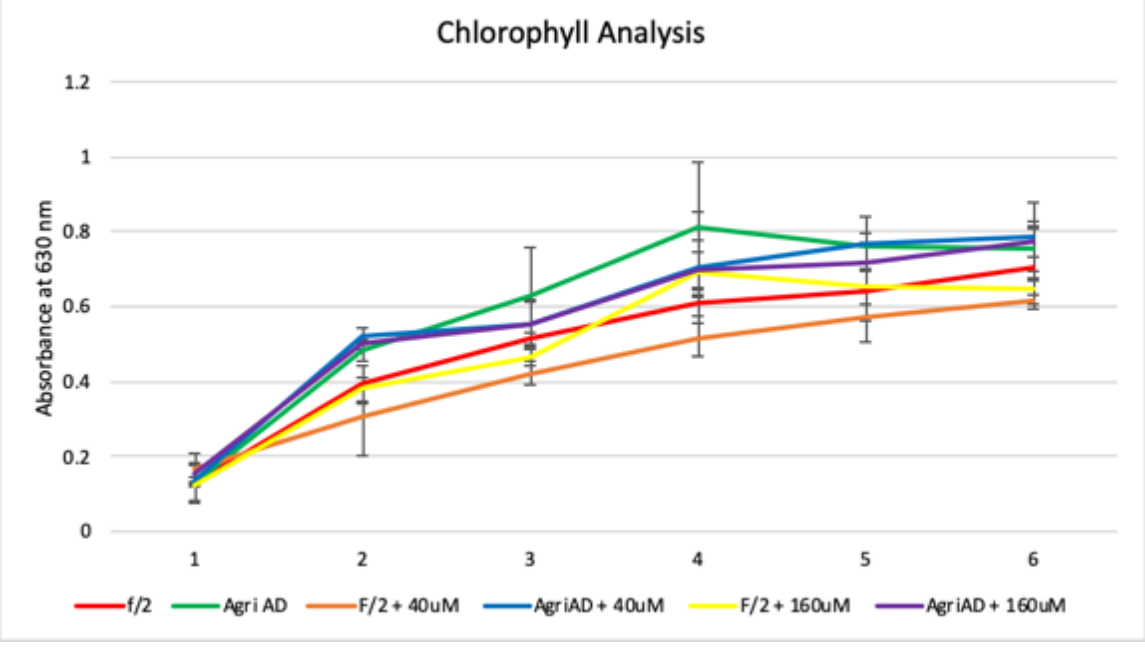
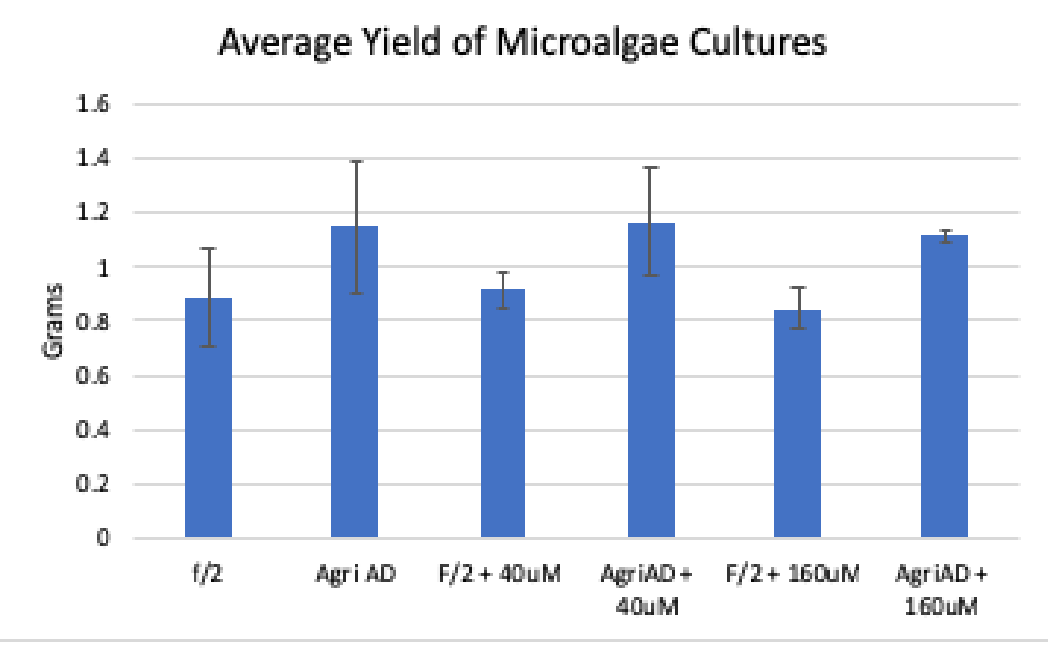
Growth Curve of Microalgae

- This graph shows the growth of microalgae over the experiment, measured by analysing the chlorophyll.[1]
- The growth was monitored in order to correctly determine the best time to harvest the microalgae.
- The harvest takes place once growth of the microalgae plateaus.





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1. B. P., Butterwick, C., Heaney, S. I. & Talling, J. F. Talling (1982) A comparison of eight methods for estimating the biomass and growth of planktonic algae. *Br. Phycol. J.* **17**, 69–79 (2007).

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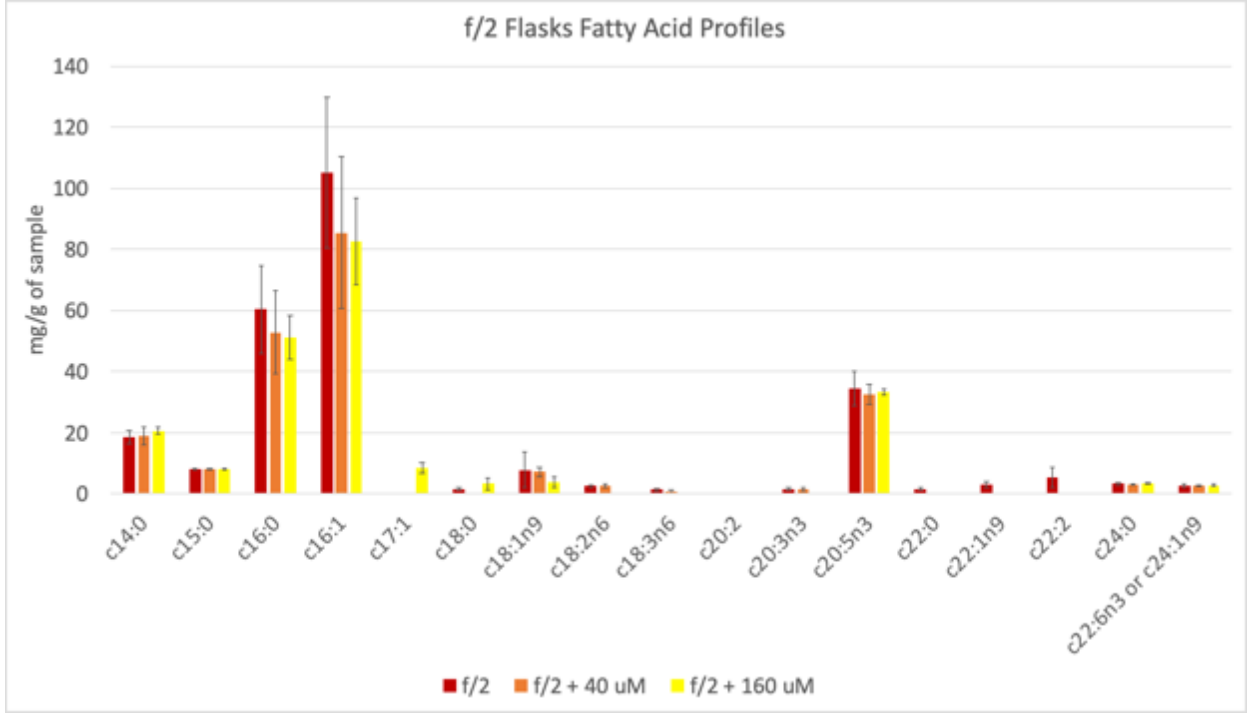
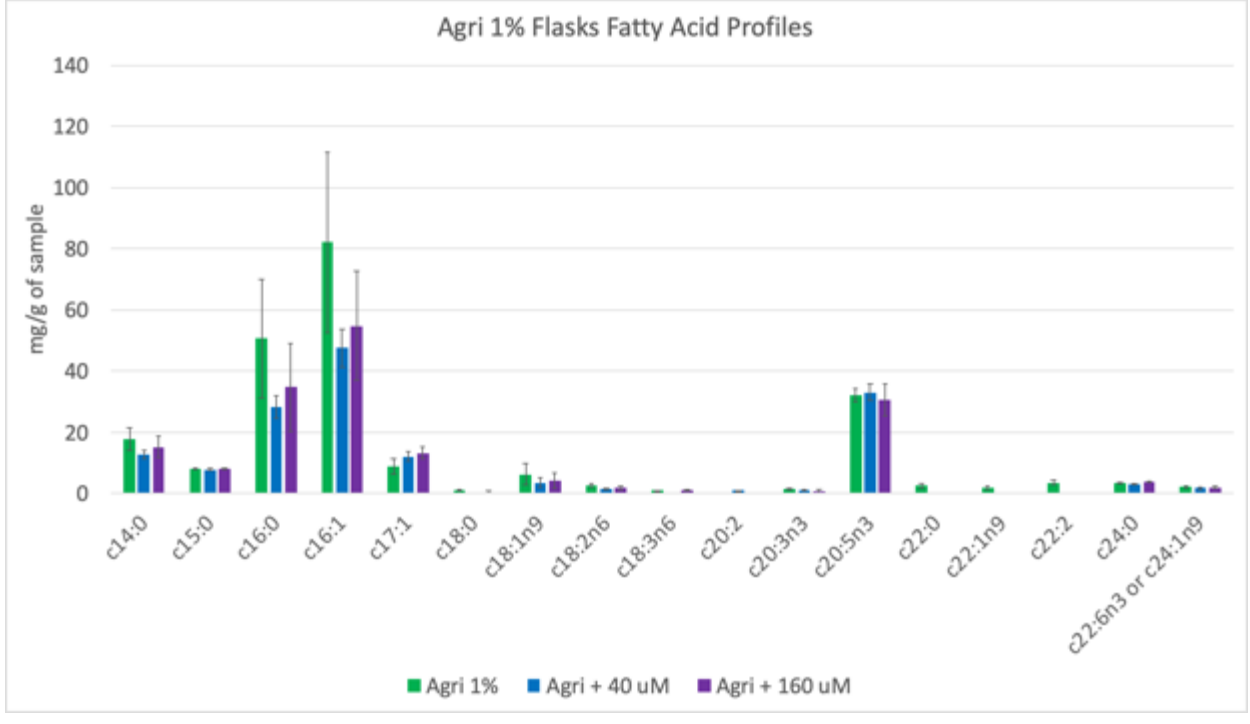
Fatty Acid Profiles

- The fatty acid profiles of the microalgae were obtain by extracting the fatty acids using a direct derivatisation method and analysed using gas chromatography (GC-FID).
- The graphs show the fatty acid profiles of each of the conditions and the total fatty acid content.





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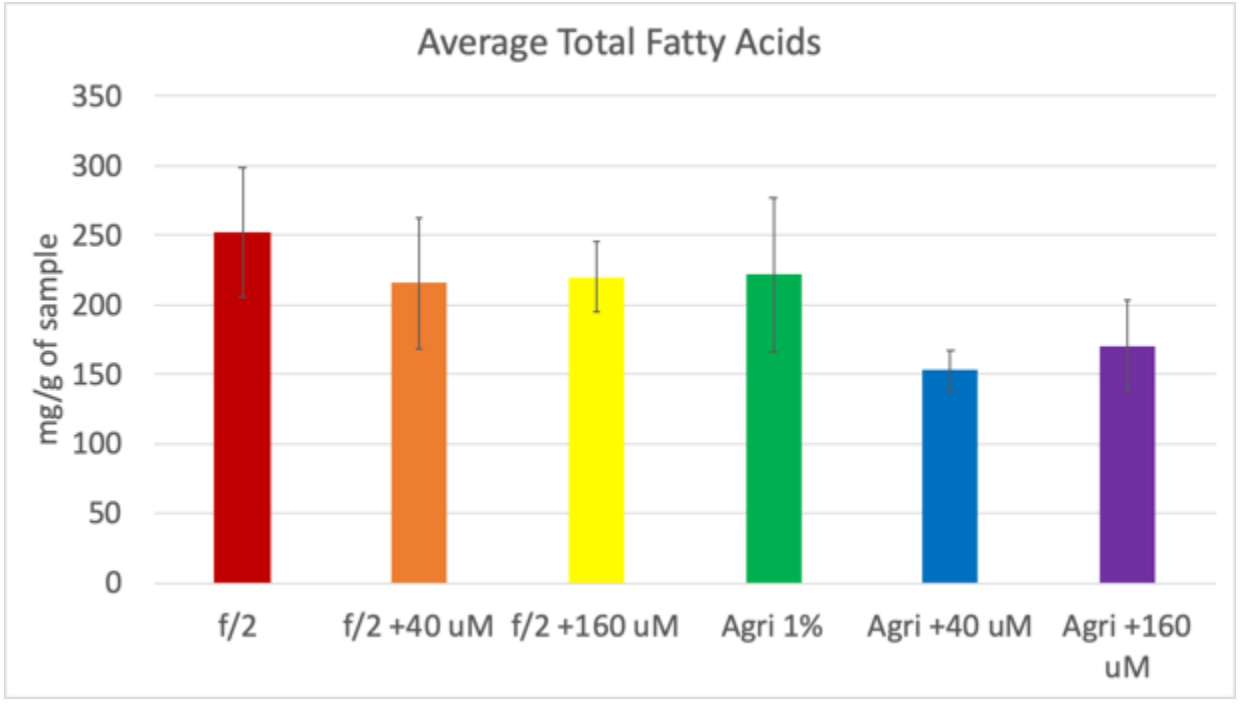
Microalgae Cultivation

- The fatty acids present in microalgae were fairly consistent across the varying conditions but the amounts produced were not.
- In both the f/2 media and the AgriAD media the additional phosphates seem to negatively affect the amount of fatty acids produced.
- This show us that the digestate in a 1% solution has an appropriate amount nutrients and though it does not out perform the traditional media it is at least comparable in this instance.



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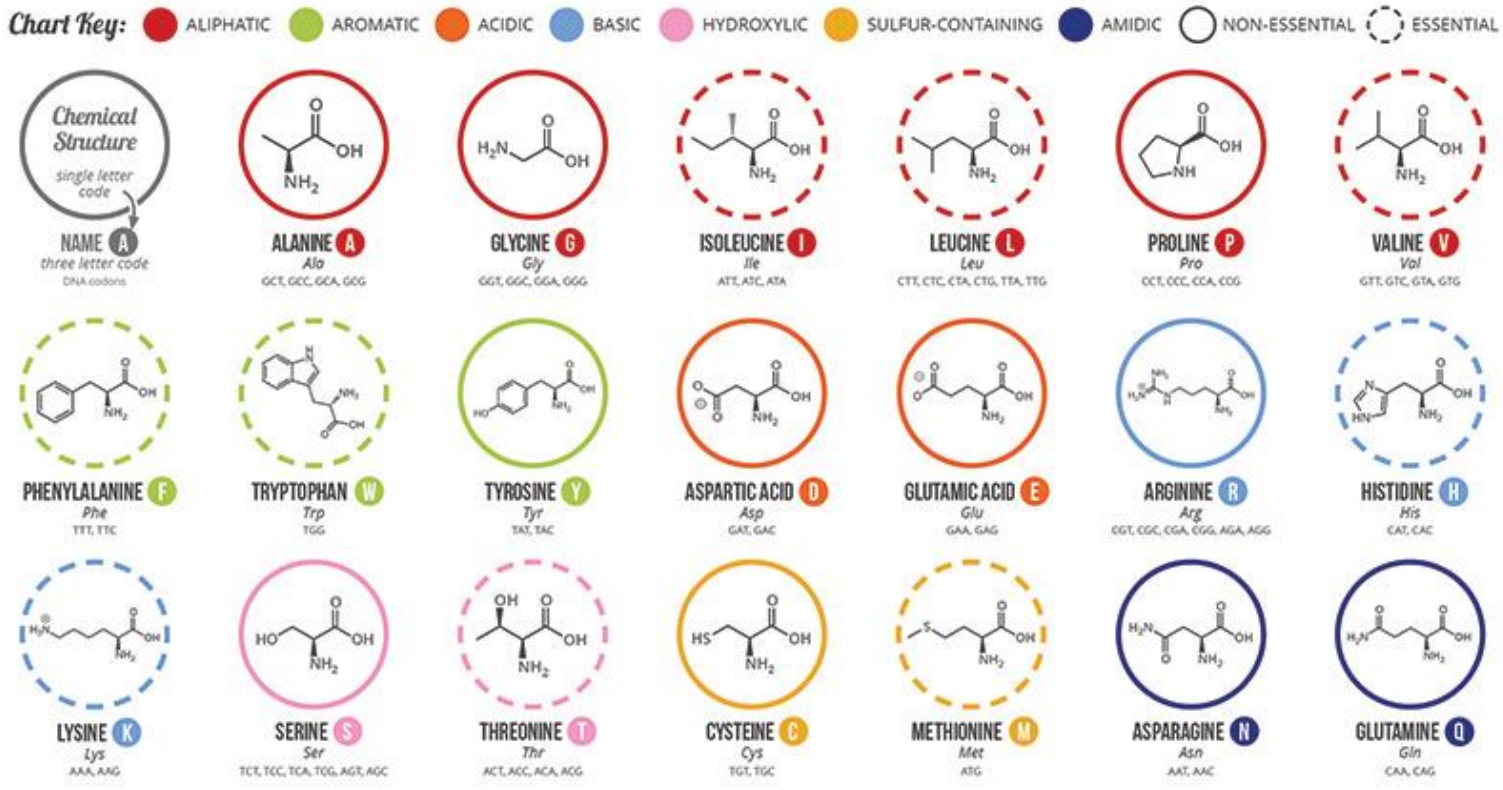
Amino Acid Analysis

- Another product of algae is amino acids, both in peptide and polypeptide form.
- Analysis of the amino acids in algae would allow a profile to be built and see if it would be a benefit to industry (like the animal feed market).
- The microalgae would also provide the added benefits of the other bioactive compounds they produce, including fatty acids, which has been analysed in this project, amongst others.



Credit: Microbiology Notes

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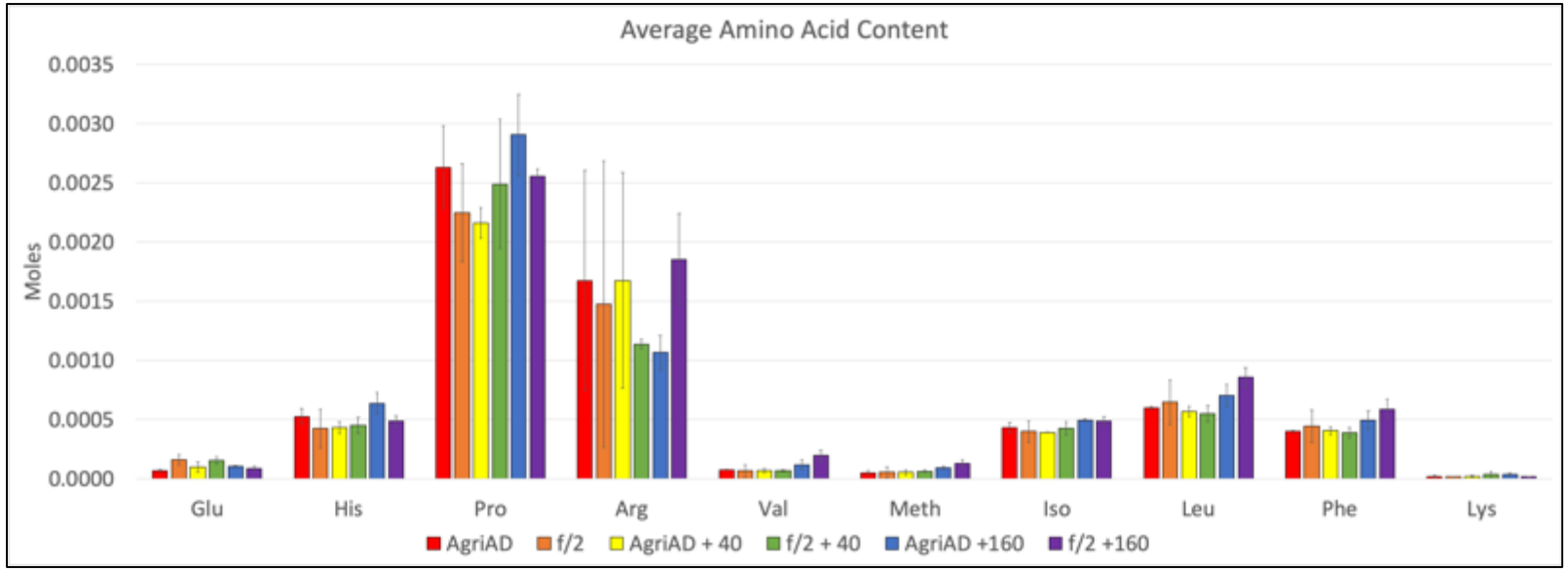
Amino Acid Analysis

- Amino acid analysis has also been completed on this algae.
- Essential amino acids proline and arginine have been found to be most abundant in all cultivation conditions.
- Lysine is not very abundant which is disappoint as this is in high demand in industry. This could be attributed the species though, not the growth conditions.



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Conclusion

- A comprehensive profile of the effluent from AgriAD was completed. The results from all analysis have been shown to be surprisingly consistent, despite the varying feedstock.
- The effluent is abundant in various nutrients that is needed for microalgae cultivation.
- Microalgae has been successfully cultivated with the 1% effluent in QML and has had the fatty acid content analysed via GC and amino acid content analysed via HPLC

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Thanks For Your Attention

Acknowledgments

Thanks to my funding body DAERA,
And to everyone in Lab 03.404

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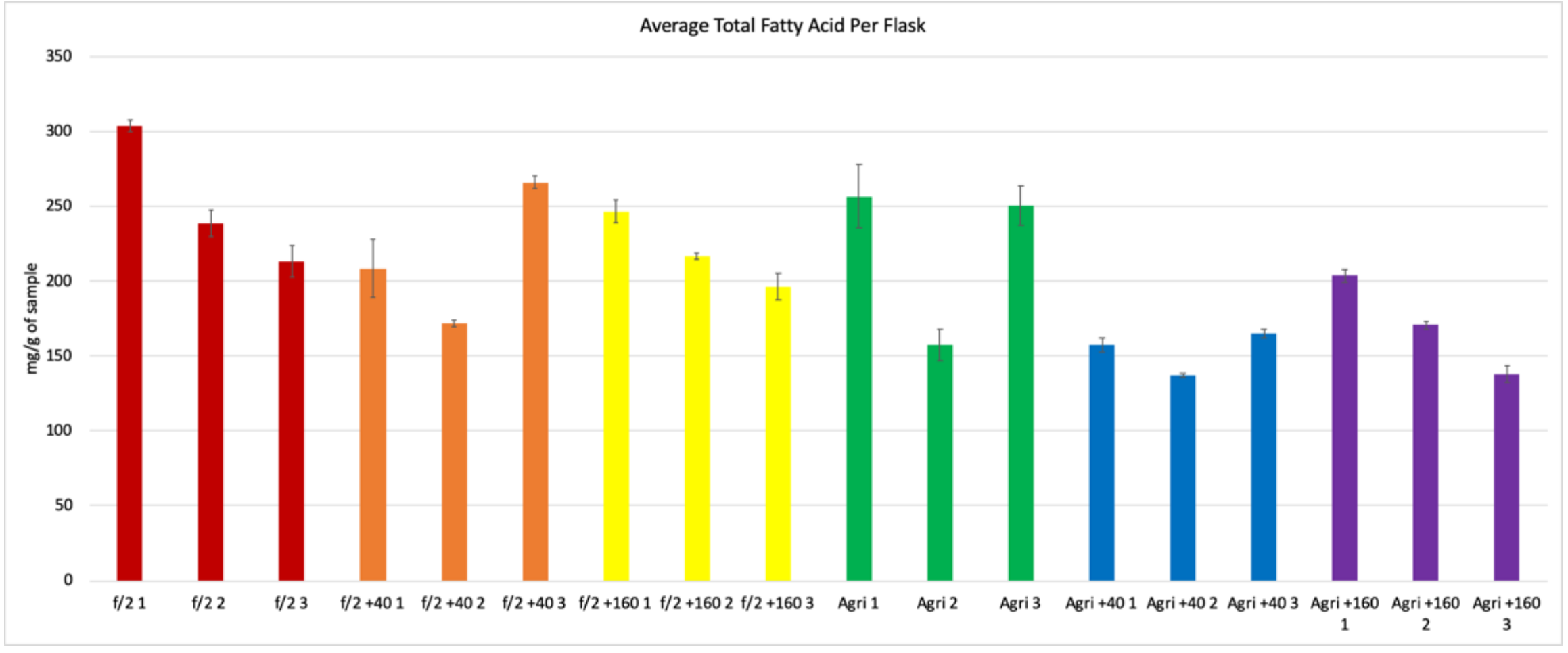

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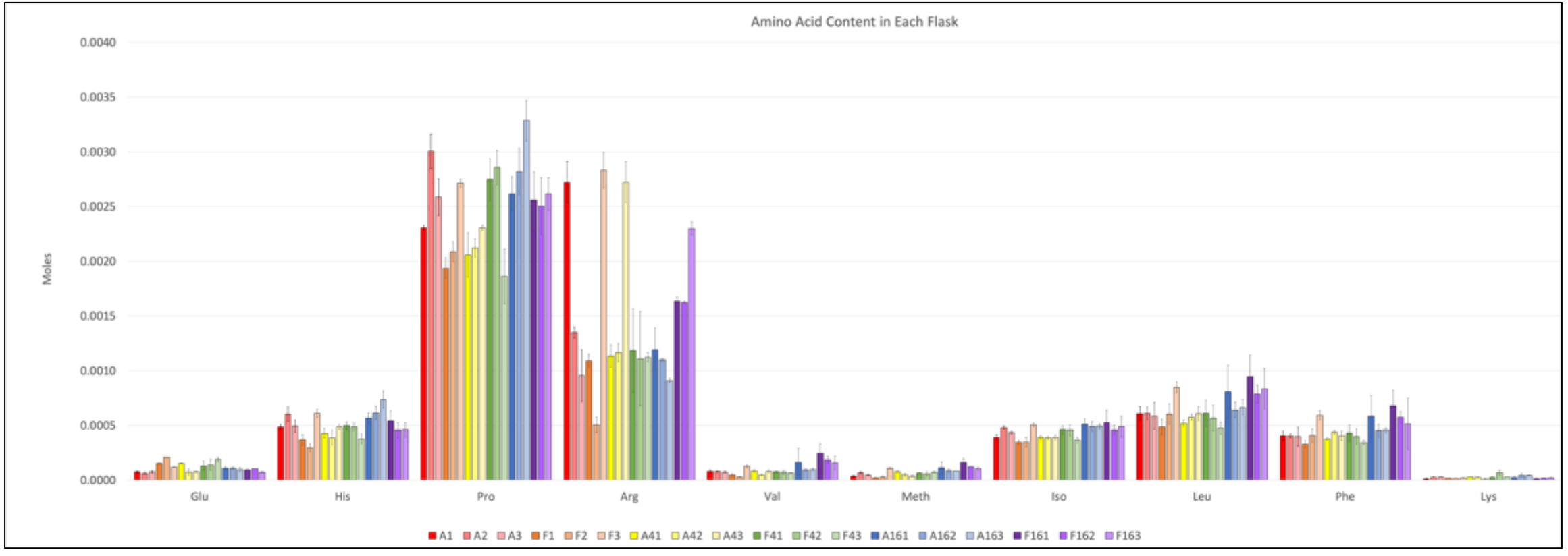

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