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UpCycle Systems: M-Powered Farm Project

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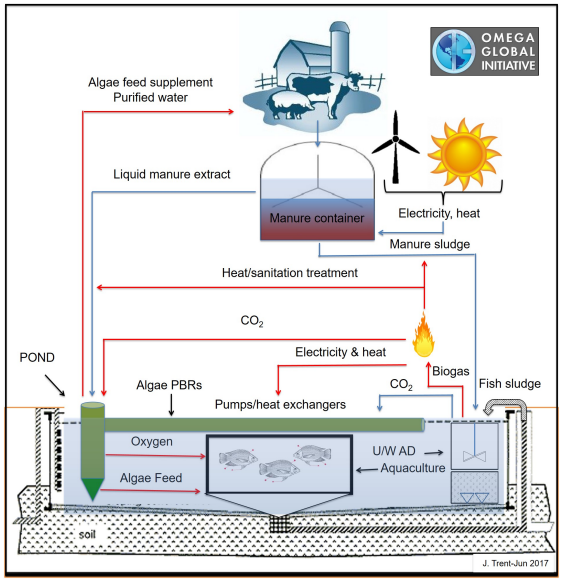
Abstract

The world is already facing shortage of vital resources in part due to climate change and in the future it will only get worse. People are now looking for solutions and finding ways to more efficiently use what we currently consider wastes as they are among the most promising resources. This idea is particularly relevant to farmers who already use manure from their livestock as fertilizer and for making biogas—we think they can do more.

The OMEGA Farm Project proposes to use ponds on farms to create a link between animal manure and energy, feed/food, and clean water to improve the overall efficiency and economics of animal farming. It works by dispersing manure from pigs, cows, or chickens in water to make a nutrient-rich liquid and a carbon-rich sludge. The liquid is clarified by electrocoagulation (EC) and used to cultivate fast-growing microalgae in photobioreactors (PBRs) floating in a nearby pond. The sludge is used for biogas and CO_2 production in anaerobic digesters (AD) on land or in the pond. The biogas produced in the AD is used for heat, electricity, and CO_2 that contribute to algae growth. The algae biomass is feed for the livestock on the farm or for caged fish grown in the pond. The algae and fish wastewater is processed by filtration and reverse osmosis to provide water for the livestock, while the retentate from the water purification is cycled back to the PBRs or to the AD. Water-cooled solar panels and wind turbines provide additional energy as heat and electricity.

Our experiments and calculations done during the internship support the feasibility of the OMEGA Farm concept. We measured nutrients (NH_3/PO_4) in the extracted liquid and calculated the amount of CO_2 produced in the AD plus combustion of biogas. Our results suggest the OMEGA Farm Project will help close loops between waste, food, water, and energy, which should improve the overall economics of animal farms.

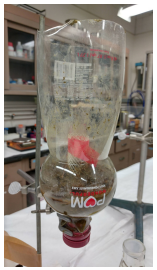


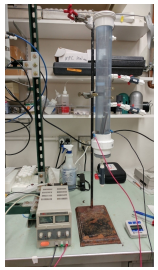
Methods

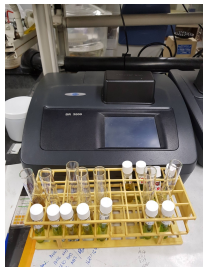
Calculations were made to determine if this systems approach to using manure on farms would be feasible. These calculations were made based on published data about the production and composition of animal manure (see table) and direct measurements in the laboratory.
In the laboratory, manure was mixed with water and ammonia was measured in samples after different treatments.

Animal	Cow	Pig
Manure per day, kg	50.00	5.50
% of dry matter (DM)	15%	8%
% of water	85%	92%
% of volatile solids (VS) in DM	72%	75%
% of total N in DM	2.10%	0.57%
% of total C in DM	35.6%	4.5%
% of total P in DM	0.41%	0.14%
% of VS to biogas	20%	
% of CH4 in biogas	65%	55%
% of CO2 in biogas	35%	45%
CO2 to algae ratio	1.87:1	
Algae production rate, g/(m²day)	15.00	

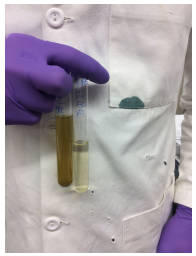
nutrient extraction method was utilized to test additional manure and water mixtures through the use of a column filter. The column contained a screw capped void in the centre, populated by holes which allowed the manure to filter through without blockage. The column was packed with 250 g of fresh cattle manure, filled with 500ml of water and capped for varying times (30 minutes/15 hours). After adhering to capped retention time, the contents were recovered through the bottom of the column, measured for pH using a reagent and poured into the electrocoagulation (EC) column. Each column flow through (FT) sample was allowed to coagulate for 10 or 15 minutes and then removed through valves surrounding the column and through a pipette from the top and tested for pH. Finally, the nutrient levels of all samples were measured using a Hach DR-3800 machine.



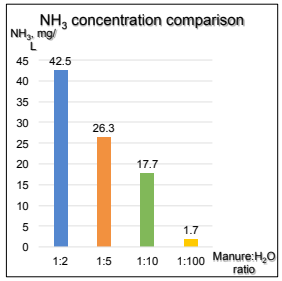


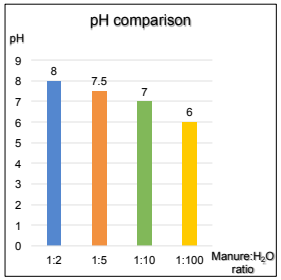


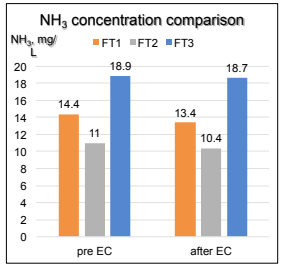
Results

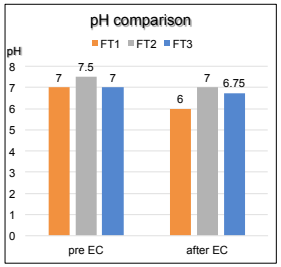


Animal	Cow	Pig
Manure weight, kg	1.00	1.00
DM, kg	0.15	0.08
Water, kg	0.85	0.92
VS, kg	0.11	0.06
Total N in DM, g	3.15	0.46
Total C in DM, g	53.40	3.60
Total P in DM, g	0.62	0.11
Total biogas, g	21.60	12.00
Total CH_4, g	14.04	6.60
Total CO_2, g	46.17	23.55
Total algae from CO_2, g	24.69	12.59
Surface for algae, m²	1.65	0.84
Algae per animal, g	1234.49	69.26









Conclusions

A manure:H_2O ratio of 1:2 demonstrates that we keep more than enough nutrients (e.g. NH_3) through the filtration method we designed while maintaining a consistent pH in the goldilocks zone for microalgae. Our electrocoagulation method which allows us to clear the mixture to increase transmissivity and optimize algal growth has shown to not hinder nutrient content or pH and maintains a contaminant free composition. We have determined from our results that by using our closed loop method, we can harvest an ample amount of microalgae, gasses and energy to make the system viable, closed and potentially profitable.

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Acknowledgements

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