Algae~~,~~ – A Hope For Sustainable Living

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Abstract

Algae is a microorganism that comes to mind ~~when it comes to~~in the context of both present and future sustainable living in this present world at large. It has come a long way. Previously, Algae was referred to as a pollutant, a menace in the society and environment but now with advent of great discoveries and biotechnological advancement of Algae,   great benefits can be achieved from this organism, it has now been tagged as the "Green Gold". ~~This organism is said to have so many benefits which are enjoyed presently and with even greater hope for the future.~~ Cultivation of algae is not only safe but also requires less space ~~and~~ , is capable of more ~~productivity~~ production and yield as well as being cost effective~~,~~ .Algae ~~has~~ have the ability to power a whole building, be used as biofuels for vehicles, for electrical purposes, for decorations as well as supplements and antibiotics and as a health supplement for both humans and animals.~~a whole of achievement for a safer and healthier living in this environment~~. The production of biofuels from algae has been a strong achievement for the society considering the problems experienced in the conventional fuels from hydrocarbons. The aquatics are not left out because they serve as great feeds for fishes and other aquatic livestock. Algae is the way forward when it comes to sustainable living.

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Introduction

Algae are photosynthetic organisms that grow in a range of aquatic habitats, including lakes, pounds, rivers, oceans, and even wastewater. They can tolerate a wide range of temperatures, salinities, and pH values; different light intensities; and conditions in reservoirs or deserts and can grow alone or in symbiosis with other organisms (Basanti *et al*., 2008). Algae are broadly classified as Rhodophyta (red algae), Phaeophyta (brown algae), and Chlorophyta (green algae) and classified by size as macroalgae or microalgae. Macroalgae (seaweed) are multicellular, large-size algae, visible with the naked eye, while microalgae are microscopic single cells and may be prokaryotic, similar to cyanobacteria (Chloroxybacteria), or eukaryotic, similar to green algae (Chlorophyta). Microalgae can be a rich source of carbon compounds, which can be utilized in biofuels, health supplements, pharmaceuticals, and cosmetics (Das *et al*., 2011). They also have applications in wastewater treatment and atmospheric CO_2 mitigation. Microalgae produce a wide range of bioproducts, including polysaccharides, lipids, pigments, proteins, vitamins, bioactive compounds, and antioxidants (Brenan and Owende, 2010). The interest in microalgae as a renewable and sustainable feedstock for biofuels production has inspired a new focus in biorefnery. Growth enhancement techniques and genetic engineering may be used to improve their potential as a future source of renewable bioproducts. The positive impact of nutritious foods on the human health has been long realized, which has led to the development of several innovative functional ingredients and functional food products. Algae derived nutrients and bioactive compounds are being investigated for their potential biological activities (Batista *et al*., 2013., Nuno *et al*., 2013)

The algal metabolites are promising source of ingredients for the development of novel food products they are also good source of proteins, minerals, vitamins, amino acids, lipids, fatty acids, polysaccharides, nucleic acid, and carotenoids e.t.c which are of immense value as nutritional supplements (Tokuşoglu and Una, 2003., Priyadarshani and Rath, 2012). In view of this in recent years a lot of research has been carried out on the development of novel health foods from algal biomass. Algal biomass and extracts are used extensively in the formulations of gels, capsules, tablets, gums, bars, snacks, pastas, drinks, and beverages (Goh *et al* 2009). Algal biomass production can be improved through adopting innovative methods of enhancing biomass coupled to technological interventions for functional food application

The industrial cultivation of microalgae to produce biofuels and bioproducts has increased dramatically over the last few decades (Plaza *et al*., 2009). Algae are produced in quantity and sold directly as food and nutrient supplements, while their processed products or extracts are used in biopharmaceuticals and cosmetics (Luiten, *et al*., 2003., Michael, 2013., Pulz and Gross, 2004). The main applications of microalgae for aquaculture are associated with nutrition as sole component or as food additive to basic nutrients and for inducing other biological activities. Microalgae are required for larval nutrition either for direct consumption in the case of mollusks and peneid shrimp or indirectly as food for the live prey fed to small fish larvae (Muller-Feuga, 2000). Combination of different algal species provides balanced nutrition and improves animal growth better than a diet composed of only one algal species (Spolaore *et al*. 2006). In order to be used in aquaculture, a microalgal strain has to meet various criteria, such as ease of culturing, lack of toxicity, high nutritional value with correct cell size and shape and a digestible cell wall to make nutrients available (Raja *et al*. 2004; Patil *et al*. 2007). The significant role of microalgae in aquaculture hatcheries include cultivation of microalgal strains for broodstock conditioning, larval rearing and feeding of newly settled spat, as all developmental stages of bivalve molluscs are directly dependant on microalgae as a feed source. The planktonic larval stages of commercially important crustaceans are initially fed on microalgae. Farmed gastropod molluscs and sea urchins require a diet of benthic diatoms when they first settle out from the plankton, prior to transferring to their juvenile diet of macroalgae. The small larvae of most marine finfish species and some freshwater fish species also initially receive live prey in the presence of microalgae. These microalgae are allowed to bloom within the fish larval rearing tanks (green water) or are added from external cultures (pseudo-green water). Microbial conditioning by microalgae may extend to prevent cell-to-cell signalling (quorum sensing) by bacterial pathogens. In a laboratory screening study focused on microalgal strains commonly used in aquaculture, several of the tested strains interrupted signalling by pathogenic *Vibrio harveyii*, proving that such microalgae offer potential as aquaculture biocontrol agents

Benefits of Algae

Microalgae have demonstrated potential to meet the population's need for a more sustainable food supply, specifically with respect to protein demand. These promising protein sources present several advantages over other currently used raw materials from an environmental point of view. Additionally, one of the main characteristics of microalgae is the production of bioactive compounds with potential benefits for human health. Microalgae exploitation as a source of protein (bulk protein) and other valuable products within the food industry still presents some drawbacks, mainly because of the underdeveloped technologies and processes currently available for microalgae processing. The systematic improvement of the technology readiness level (TRL) could help change the current situation if applied to microalgae cultivation and processing. High maturity in microalgae cultivation and processing technologies also requires improvement of the economy of scale and investment of resources in new facilities and research. Antioxidative, antihypertensive, immunomodulatory, anticancerogenic, hepato-protective, and anticoagulant activities have been attributed to some microalgae-derived compounds such as peptides. Nevertheless, research on this topic is scarce and the evidence on potential health benefits is not strong. In the last years, the possibility of using microalgae-derived compounds for innovative functional food products has become of great interest, but the literature available mainly focuses more on the addition of the whole cells or some compound already available on the market. This review describes the status of utilising microalgae as an ingredient in innovative food products with potential health benefits.

As mentioned above, plant-based proteins are currently the main source of protein for food and feed. Expanding the cultivation area, changing the cropping frequency, and boosting yields could help meet the increasing food demand; however, crop production may be approaching a ceiling in terms of optimisation. Additionally, these practices could seriously deepen existing environmental problems derived from current cultivation systems, i.e., land degradation, loss of biodiversity, and deforestation (FAO, 2018). Animal-based proteins depend on the supply of appropriate and cost-effective plant-based proteins for feeds (FAO, 2018). Microalgae have arisen as a promising sustainable alternative protein source. By the middle of this century, algae may account for 18% of protein sources in a more diverse market. However, aspects related to food safety of algae are not well-known, namely the presence of contaminants, allergens, or hazardous substances generated during microalgae processing. Hence, the estimated time to market of microalgae and other protein sources differs (Van der Spiegel *et al*., 2013).

Nostoc, Arthrospira (usually denoted as *Spirulina* in the market), and *Aphanizomenon* are protein-rich microalgae that have been part of the human diet since thousands of years ago (Spolaore *et al*., 2006). Spanish chroniclers observed Aztecs consuming a blue-green cake made from *Arthrospira* (FAO, 2008). Exploiting microalgae for food and biochemical applications was suggested in 1952 at the Algae Mass-Culture Symposium, even if some progress had been made in the early 1940s. The first facilities for commercial production of *Chlorella* were developed in

Japan, whereas Mexico pioneered *Arthrospira* cultivation in the 1970s (Spolaore *et al*., 2006). Although the number of microalgae species in nature is estimated between 200,000 and 800,000, only a few are used in food applications. In the USA, the regulatory status of algae products and additives is under the responsibility of the Food and Drug Administration (FDA), which can assign GRAS status (Generally Recognized as Safe) to a product. In Europe, the competent authority of a member state makes a first assessment of a new product, which is later authorised by the European Commission (EC) if no objections are made by member states. In case of objections, the European Food Safety Authority (EFSA) is responsible for carrying out the safety assessment of the novel foods.

Microalgae as a source of bulk proteins are quite a new idea. Microalgae-based proteins could significantly contribute to meet the population's need for protein, with several advantages over other currently used protein sources. Microalgae-based proteins have low land requirements compared to animal-based proteins: <2.5 m^2 per kg of protein (Van Krimpen *et al*., 2013) compared to 47–64 m^2 for pork, 42–52 m^2 for chicken, and 144–258 m^2 for beef production (de Vries *et al*., 2010). Land requirements are also lower than for some other plant-based proteins used for food and feed such as soybean meal, pea protein meal, and others (Smetana *et al*., 2017). Furthermore, the usage of non-arable land for cultivation, minimal fresh water consumption, the possibility of growing in seawater, and the potential replacement of non-sustainable soy imports are some advantages of algae over other plant-based protein sources (FAO, 2008). When it comes to quality,*Chlorella* and *Arthrospira* accumulate high-quality proteins, having both species well-balanced amino acid profiles according to the WHO/FAO/UNU recommendations regarding human's requirements of essential amino acids (EAAs) (Becker, 2007., Chronakis and Madsen, 2011). The amino acid profiles of both species are similar to other conventional protein sources such as eggs and soybean (Becker, 2007). In general, microalgae as plants are deficient in sulphur-containing amino acids methionine and cysteine (Becker, 2007); however, some microalgae supplements showed to be deficient in other amino acids (Misurcova *et al*., 2014). A comparison between the amino acids profiles of several algal products, including commercially available products such as *Chlorella* pills and *Arthrospira* flakes, showed that some supplements can provide high amounts of EAAs. It is worth mentioning that the cultivation conditions or sources of the biomass used for these products can lead to differences in the amino acids profiles of the products (Misurcova *et al*., 2014). Nevertheless, during consumption, protein bioavailability becomes important. At this point, three different concepts need to be explained: bioaccessibility, bioavailability, and bioactivity (Carbonell-Capella *et al*., 2014). The bioaccessibility, usually evaluated by *in vitro* tests, represents the fraction of the compound released from the food matrix becoming available for absorption. Afterwards, the compounds may reach the systemic circulation and being utilised, which is referred to as bioavailability. The bioavailability is determined by *in vivo* tests. Finally, the bioactivity of a compound describes the physiological response, e.g., antioxidative, antihypertensive or anticancerogenic activities. The bioactivity can be evaluated *in vivo*, *ex vivo*, and *in vitro*. Based on these definitions, a compound can be considered bioaccessible, but not necessarily bioactive. Protein bioavailability from whole microalgae cells could be enhanced by applying pre-treatments to disrupt cell walls, which hinder degradation (Chronakis and Madsen, 2011).

Besides proteins, microalgae are source of several valuable compounds with health benefits such as carbohydrates, polyunsaturated fatty acids, essential minerals, and vitamins (Becker, 2007., Chronakis and Madsen, 2011, Wells, *et al* 2017), which can increase the nutritional value of food products upon incorporating. Polysaccharides and oligosaccharides are promising compounds with potential health benefits, arising attention in terms of prebiotic applications (Raposo *et al*., 2001., Moreno *et al*., 2017., Jutur *et al*., 2016). This association is based on the first definition of prebiotics as “non-digestible food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon, and thus improves host health,” given by Gibson and Roberfroid (Moreno *et al*., 2017.). *Arthrospira*, *Chlorella* and *Nannochloropsis* are not only a good source of proteins, but have been reported as important sources of polysaccharides or oligosaccharides, being proposed as potential probiotic candidates (Wells, *et al* 2017., Raposo *et al*., 2001., Moreno *et al*., 2017). Lipids, in particular long-chain polyunsaturated omega-3 fatty acids (ω-3 PUFAs), have been also suggested as valuable compounds with health benefits that can be incorporated into food products. α-linolenic acid (ALA; 18:3 n-3), eicosapentaenoic acid (EPA; 20:5 n-3), docosapentaenoic acid (22:5 n-3) and docosahexaenoic acid (DHA; 22:6 n-3) are some of the most important ω-3 PUFAs with health benefits for humans (Wells, *et al* 2017). EPA and DHA were for instance associated with the prevention or amelioration of cardiovascular or renal diseases. These long-chain EPA and DHA, considered as essential dietary nutrients, can be produced only by plants, thus consumers must incorporate them into their diet (Peltomaa *et al*., 2018). Microalgae are a valuable source of ω-3 PUFAs. *Arthrospira, Chlorella, Dunaliella, Haematococcus, Schizochytrium, Porphyridium cruentum*, and *Crypthecodinium cohnii* have GRAS status (Garcia *et al*., 2017). Most of the commercially available biomass is marketed as pills and capsules. *Arthrospira* and *Chlorella* are commonly consumed as food supplements, *Tetraselmis chuii* as a seafood flavouring agent, and the diatom *Odontella aurita* is consumed as a food supplement as it is rich in EPA (Van Krimpen *et al*., 2013). Some microalgae-derived products marketed are: β-carotene from*Dunaliella*, DHA from *C. cohnii*, and the blue colorant phycocyanin from*Arthrospira* (Garcia *et al*., 2017., Enzing *et al*., 2014).

Product	Microalgae incorporation	Addition	Benefit
Oil/water emulsions	*C. vulgaris* green and *C. vulgaris* orange (after carotenogenesis)	2% w/w	Techno-functional properties
Oil/water emulsions	*C. vulgaris* green, *C. vulgaris* orange (after carotenogenesis) and *H. pluvialis* (red, after carotenogenesis)	*C. vulgaris*: 0.25–2.00% w/w *H. pluvialis*: 0.05–2.00% w/w	Colouring and nutritional properties (antioxidative activity)
Vegetarian food gels	*C. vulgaris*, *H. pluvialis*, *A. maxima* and *D. vlkianum*	0.75% w/w	Techno-functional and nutritional properties (antioxidative activity, ω-3 PUFAs).
Vegetarian food gels	*A. maxima* and *D. vlkianum*	0.1–% w/w	Techno-functional and nutritional properties (ω-3 PUFAs).
Vegetarian food gels	*H. pluvialis* and *A. maxima*	0.75% w/w	Techno-functional properties
Frozen yogurt	*Arthrospira* sp.	2–8% w/w	Nutritional properties
Dairy products (fermented milk)	*A. platensis*	3 g/L	Nutritional properties
Natural and probiotic yogurt	*A. platensis*	0.1–0.8% w/w	Techno-functional properties and nutritional properties.
Yogurt	*Chlorella* sp.	0.25% w/w extract powder and 2.5–10.0% extract liquid	Techno-functional properties and nutritional properties.
Processed cheese	*Chlorella* sp.	0.5 and 1.0% w/w	Techno-functional properties and nutritional properties.
Cookies	*C. vulgaris*	0.5, 1.0, 2.0, and 3.0% w/w	Colouring agent
Biscuits	*I. galbana*	1 and 3% w/w	Techno-functional properties and nutritional properties (ω-3 PUFAs)
Biscuits	*A. platensis*	*A. platensis*: 0.3, 0.6 and 0.9% Phycocyanin extract: 0.3% w/w to wheat flour	Nutritional properties
Biscuits	*A. platensis*	1.63, 3, 5, 7, 8.36% w/w	Techno-functional and nutritional properties (protein, fiber content and antioxidative activity)
Biscuits	*A. platensis*, *C. vulgaris*, *T. suecica* and *P. tricornutum*	2 and 6% w/w	Techno-functional properties and nutritional properties (antioxidative activity)
Cookies	*H. pluvialis*	Astaxanthin powder 5, 10, and 15% w/w	Techno-functional properties and nutritional properties (antioxidative activity)
Bread	*Dunaliella* sp.	Whole biomass, biomass after b-carotene extraction and, biomass after b-carotene and glycerol extraction: 10% w/w	Nutritional properties (protein content)
Bread	*O. amphibian and A. platensis*	5% w/w microalgae protein in flour	Techno-functional properties and nutritional properties
Bread	*A. fusiformis*	1 and 3% w/w in flour	Nutritional properties (proteins and mineral content)
Bread	*A. platensis*	11% w/w in flour	Techno-functional properties and nutritional properties (proteins and mineral content)
Bread	*Arthrospira* sp.	2, 2.5, and 3% w/w in flour	Nutritional properties (protein content)
Bread	*I. galbana*, *T. suecica*, *S. almeriensis*, and *N. gaditana*	0.47 % w/w in flour	Techno-functional properties
Gluten free bread	*A. platensis*	2, 3, 4, and 5% w/w in flour	Nutritional properties (proteins content)
Extruded snacks	*Arthrospira* sp.	0.4, 1.0, 1.8, 2.6, and 3.2% w/w	Techno-functional properties and nutritional properties (proteins content)
Pasta	*C. vulgaris* green, *C. vulgaris* orange (after carotenogenesis) and *A. maxima*	0.5, 1.0, and 2.0% w/w in flour	Techno-functional properties and nutritional properties
Pasta	*I. galbana* and *D. vlkianum*	0.5, 1.0, and 2.0% w/w in dry weight	Techno-functional properties and nutritional properties (ω-3 PUFAs)
Pasta	*A. platensis*	5, 10, and 20% w/w in flour	Techno-functional properties and nutritional properties (antioxidative activity)
Pasta	*D. salina*	1, 2, and 3% w/w in flour	Techno-functional properties and nutritional properties

Some Common Benefits of Algae in Food Production Industries (Carporgno and Alexander, 2018)

Recent Innovations of Algae for Sustainable Living

You might recall that green scum left on the neglected fish tank or a smelly pond when you hear about algae. But these tiny green organisms that are often found in wastewater has a great potential to secure our future in many ways (Kashvan, 2017)

One way in which humanity is beginning to deal with dwindling energy reserves is by accessing biomass fuels. These fuels, such as algae, are made through a process similar to the conversion of oil from organic materials. The main difference is that biomass fuels take days instead of millions of years. This potential for rapid production, combined with the potential to produce an infinite amount of biomass, leads to a theoretically infinite energy source (Brant, 2018).

An alga, microalgae in particular, has unique capabilities of producing energy from the sunlight through photosynthesis, just like plants. And, in this process, they consume CO_2 from the atmosphere and release oxygen, making it ideal for clearing up the mess created from our fossil fuels. But what is even more interesting with microalgae is its ability to produce fuel. Some of these microorganisms produce oils in order to store the energy and it is possible to use this oil as fuel for our cars and even as an alternative protein source for us! With such a great potential, this symbiotic process is not too far from becoming a reality. Algae-powered innovations are already happening in many ways, and they are worth giving a look to imagine how our future can become more sustainable with the new "**Green Gold**" (kashvan, 2017).

In the twentieth century, oil was black gold. But as we march deeper into the twenty-*first* century, we could have a lucrative new fuel on our hands. One that's blue-green and sometimes a little smelly. It's found in wastewater, but it's capable of powering jets. Its **algae**.

To be specific, it's actually microalgae. Though it looks like green scum or strands of hair floating on the water, microalgae is actually made up of microscopic, single-celled organisms capable of photosynthesis, like plants. They slurp in sunlight, and convert it to energy. They're also able to suck up carbon dioxide emitted by power plants and cars, turning it into oxygen. So they run on solar power and they scrub the air, both of which are very appealing qualities for a post-oil world. But the real lure of microalgae is its ability to produce fuel. Some of these minuscule, aquatic microorganisms produce oils to store energy. Scientists can convert that oil into fuel for cars, trucks, trains, and planes. This is better for the environment than fossil fuels, because it's carbon neutral: The plants draw down as much carbon as they put out. Plus, algae are a renewable resource, meaning we can make more and more of it forever.

The whole system is so efficient that the US Department of Energy says algae fuels could be running any machine that's dependent on diesel today.

And this isn't some scifi, pie-in-the-sky fuel source that we hope to have someday. It's already here. Back in 2011, United Airlines made history with the first algae-powered passenger flight from Chicago to Houston.

Japan is also pursuing algae as a biofuel source. A company called Euglena Co. — named by Prime Minister Shinzo Abe has his "favoritestartup" — has partnered with Isuzu Motors to produce a fleet of ecofriendly buses that run on microalgae. They also plan to fuel a commercial flight of their own using only algae biofuel by the 2020 Olympic Games in Tokyo.

Here in the US, scientists have been researching algal biofuels since the late 1970s, but it's only been in the last six years or so that funding from places like the Department of Energy has kicked back up again. Why the sudden interest? Because there's no arguing with the benefits.

Because of its energy-producing properties, and because of the fact that algae grow quickly (doubling their number in a matter of hours), researchers want to harness it for a greater good.

"We are aiming to commercialize in the near future," says Naoto Mukunoki, a spokesperson for Euglena. "The fuel derived from euglena is very light, and doesn't harden in the sky's low temperature. This is the same characteristic of kerosene, or existing jet fuel." Which could make carbon-spraying planes way less harmful for the environment. Another plus: You can also grow algae in places where you couldn't grow anything else, like brackish waters or wastewater.

We could even stick algae ponds next to power plants that release carbon dioxide into the air, using their $C0_2$ emissions to power those algae ponds. Did I mention it's homegrown? There's no import cost, so we can save money and improve the environment right here at home (Lufkins, 2015).

It's even got an edge over other biofuels. Take corn-based ethanols, for example. While those veggie-derived ethanols can already power vehicles, the Department of Energy says that microalgae could produce up to 60 times more oil per acre than plants grown on land. The DoE also says some researchers pin algae's potential productivity as anywhere from 10 to 100 times higher than biofuels made from feedstocks.

Algae-Powered Vehicles

The handmade wooden motorcycle by Ritsert Mans and Peter Mooij is an excellent example of using as many natural materials as possible including the algae oil that powers it. The energy-producing capabilities of microalgae make it a potential candidate to fuel our vehicles and are already being widely recognized. Algaeus, the plug-in hybrid Toyota Prius in 2009 was just the beginning. In 2011, United Airlines introduced the first algae-powered passenger flight from Chicago to Houston. Japan has already considered developing a fleet of buses powered by algal oil and energy companies are already working on ways to produce algae biofuel at a lower cost to serve as an alternative to conventional petroleum products (Kashvan, 2017).

Algae Furnishings

In a not too distant future, we humans will need to learn to live with nature and not against it. The project "Living Things" is an effort in this direction that celebrates the beauty and qualities of microalgae, creating a symbiosis between humans and microorganisms within the built environment. Consisting of custom glass bioreactors designed as household furnishings, the project demonstrates three vignettes that function differently in each space by cultivating *Spirulina* algae. These furnishings also function as a lighting and heating elements for the occupants and simultaneously provide heat, light and air supply for the microorganism living inside (Kashvan, 2017)..

Algae-Powered Buildings

While there are numerous concepts that boast about the ability of algae to power buildings, there's one that is actually utilizing this capability. The international design firm Arup, worked with Germany's SSC Strategic Science Consultants and Austria's Splitterwerk Architects to develop the world's first algae-powered building dubbed as BIQ House. The building features a bio-adaptive algae façade that not only helps in maintaining the required amount of solar shading, but it also captures solar thermal heat and biomass that can be used to power the building (Kashvan, 2017)..

Algae-Powered Street Lamps

The self-powered lamp by Pierre Calleja utilizes the energy-producing capabilities of microalgae to offer light through natural process and simultaneously absorb CO_2 from the surroundings. The lamp runs completely free of electricity and uses the energy produced by algae's photosynthesis process. Pierra explains in his TED Talk that a single lamp has the capability to absorb at least a ton of carbon from the air in a single year, while illuminating the low-light areas (Kashvan, 2017)

Biodegradable Algae Water Bottles

Algae isn't just restricted to be used as a biofuel or CO_2 absorber, it is equally useful in developing sustainable materials. The biodegradable water bottle designed by Ari Jonsson is an attempt in this direction. It uses a mixture of powdered agar and water with a capability to break down once it is empty. Being an all-natural alternative to plastic, drinkers can also chew the bottle if they like the taste and is safe for both humans and the environment (Kashvan, 2017).

Algae as Health Food Supplement

Microalgae are already successful in specialty food market. Spirulina, one of the types of algae is gaining popularity as a health food supplement. It is also marketed as an alternative to fish oil since fish gets the omegas by eating plankton. By extracting omega-3, omega-7 fatty acids directly from the crops. Microalgae are also seen as a livestock feed for animals due to its valuable nutrient composition.

Algae-Powered Eco City

Forget about fuelling your car or powering up your house with algae, the co-founders of ecoLogicStudio, Claudia Pasquero and Marco Polleto has already envisioned an eco-friendly city. They are experimenting the possibilities of building an entire town in Simrishamn, Sweden which will be centered on algae production and research that would eventually drive tourism. The project aims to harvest the algae for energy and food while keeping the environment pollution-free. A map of the project's design can be viewed at Simrishamn Marine Center.

Algae Curtain

In Lille, France, the "Algae Curtain-a" is a living metabolic textile installation made up of transparent tubes that are knotted together to form architectural drapes. During the daytime, living algae is pumped in these tubes to photosynthesize and produce bio-fuel that can be used for local energy requirements, while also providing shading to the occupants sitting nearby.

Algae Bulbs

Designer GyulaBodonyi has harnessed the power of green algae in a light bulb. **Algae projects** have already been seen powering **power entire buildings**, but Bodonyi's concept brings green power to the public on a more user-friendly scale. With the Algae bulb, algae powers a single LED activated by a tiny air pump and hydrophobic material able to create a teeny-tiny power house for light (Zimmer,2013). Although small in size, if Algae Bulb is employed on a large scale, it holds the potential to save a significant amount of energy. Aside from providing a light source with renewables, the bulb also sucks up carbon dioxide, helping to alleviate greenhouse gases one bulb at a time (Zimmer, 2013). The tear-shaped bulb is made up of an air pump, LED, hidrophob container, PC Shell, and air outlet. The system sucks in carbon dioxide and water through the pump near the E27 screw-top, and as the air passes through the bulb.While **algae flourishes**, it gives off oxygen, which in turn powers the tiny LED inside.

When the AlgaeBulb is not illuminated, it appears to be a dark green; a result of the **colony of microalgae** living within. When illuminated, it gives off a slightly green tinge on the interior, making for a green bulb that is literally "green."

The Future Use of Microalgae in Hatcheries

The high production cost of microalgae remains a limitation to many hatcheries. A good selection of microalgal species is also available to support the aquaculture industries (Lopez Elias *et al*., 2003). Apart from improvements in the cost-effectiveness of on-site algal production, an alternative is the centralization of algal production at specialized mass culture facilities using heterotrophic methods or photobioreactors to produce cheaper algal biomass. These technologies could be combined with post-harvest processing such as spray drying or algal concentration to develop off-the-shelf algal biomass for distribution to hatcheries (Lopez Elias *et al*., 2003). Although genetically engineered the microalgae has been studied in its application for biofuel production and bioremediation of heavy metals, there is a less research on its application in aquaculture. The insertion of genes determining the nutritional parameters into microalgae can increase the quality of fish in aquaculture (Sayre *et al*., 2001). A combined effort to standardize a genetically modified microalgae aided with a controlled bioprocess system will lead to an improvement in the status of aquaculture

Conclusion

Algae which were previously seen as a pollutant or a menace in the environment have now been further researched on and the result is alarming. It has been discovered that this particular organism can be very useful to the world at large and help in the protection and survival in future on earth ranging from its importance in production of biodiesel which is environmental friendly too its use in powering certain appliances and even a building not to mention its nutritional benefits. This particular organism can be seen to help control the green house effect which we are currently facing on earth. It's potential in increasing the nutrient qualities of food and can serve as supplements must not cease to be mentioned. These algae currently can change the world for the better and can increase the guarantee for future survival. Algae are of great importance and its commercialization will go a long way to boost the economy.

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