

Emerging Algae Product and Business Opportunities

Abstract

Algae, ranging from single-celled microalgae to large seaweeds, are the simplest and most abundant form of plant life, responsible for more than half of the world's primary production of oxygen. They form the base of the food chain with many living things depending upon them.

The most important product that can be made from algae is biofuels. More than hundreds of companies worldwide are already working on algae biodiesel production over the past years. These companies have now started to realize that it could take much longer than originally expected to derive fuels from algae. Hence, as a starting point, many of these companies are exploring venturing into high value, non fuel products from algae. This allows them to generate profits fairly early into their venture while at the same time ensuring that they are able to continue with their efforts in sustainable fuel production.

Algae are already being used in diverse product applications. This white paper from Oilgae explores the various non-fuel business opportunities from algae and their current and future market scope. The article also provides insights on the industries which can synergistically benefit from algae energy opportunities.

This white paper has been published in conjunction with the recently published “Oilgae’s Comprehensive Report on Attractive Algae Product Opportunities”

Read about the report from here - www.oilgae.com/ref/report/non-fuel-algae-products.html

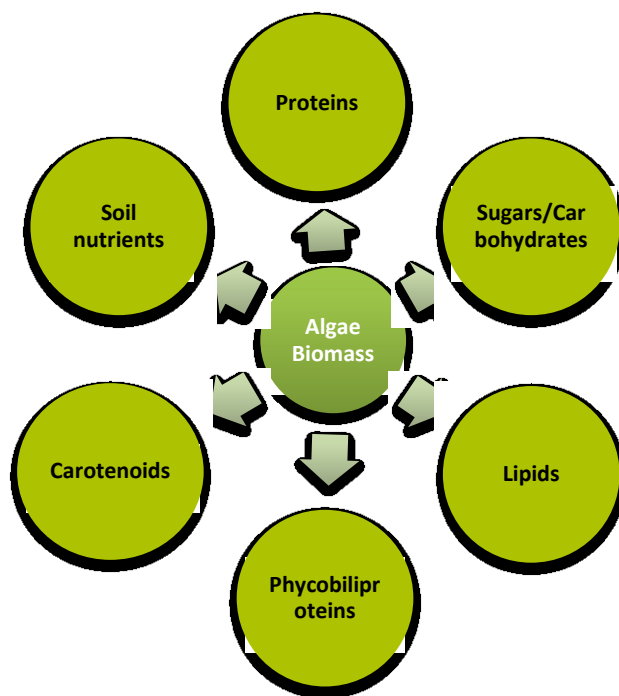
Algae Biomass Composition and Product Possibilities

All algae primary comprise of the following, in varying proportions: proteins, carbohydrates, fats and nucleic acids.

Macroalgae produce only small amounts of lipid, which function mainly as structural components of the cell membranes, and produce carbohydrates for use as their primary energy storage compound. In contrast, many microalgae produce lipids as the primary storage molecule.

Algae oil content ranges from 5-70%, protein content ranges from 10-50%, and carbohydrate content ranges from 25-40%. While the lipid from algae is extracted for biodiesel production, the carbohydrate content of algae can be converted to bioethanol, and the remaining protein can be used as animal feed.

Algae can also biosynthesize, metabolize, accumulate and secrete a great diversity of primary and secondary metabolites, many of which are valuable substances with potential applications in the food, pharmaceutical and cosmetics industries.



Algae Biomass Composition

Table 1: Overview of Algae Products and Applications in Diverse Industries

Nutraceuticals	Pharmaceuticals	Algae as/in food
<p>Single Cell Protein</p> <ul style="list-style-type: none"> ▪ Spirulina ▪ Chlorella <p>Poly unsaturated fatty acids</p> <ul style="list-style-type: none"> ▪ DHA ▪ ARA ▪ GAL ▪ EPA <p>Pigments/Carotenoids –</p> <ul style="list-style-type: none"> ▪ Beta carotene ▪ Astaxanthin ▪ Lutein ▪ Lycopene ▪ Zeaxanthin ▪ Canthaxanthin ▪ Chlorophyll ▪ Phycocyanin ▪ Phycoerythrin ▪ Fucoxanthin <p>Vitamin Supplements</p>	<ul style="list-style-type: none"> • Osmoregulators • Drugs • Antioxidants • Anti-microbial agents (antibacterial, antifungal, antiprotozoal, anti-viral agents) • Anti-tumor agents , Anti-obesity and anti-diabetic agents • Anti-inflammatory agents • Anti-adhesive therapies • Therapeutic delivering agents 	<ul style="list-style-type: none"> • Puddings, Sauces and Creams • Beverage/Juice • Sweet biscuits • Chocolates • Dark colored baked products • Edible coatings • Food colouring agents • Cheeses and butter or margarines • Food gels • Food Packaging • Agar, alginates and carrageenans (as gelling and/or thickening agents) • <i>Macroalgae food</i> - Nori or purple laver, Aonori or green laver, Kombu or haidai, Wakame, quandai-cai, Hiziki , Mozuku, Sea grapes or green caviar, Dulse Irish moss or carrageenan moss, Winged kelp, Ogo, ogonori or sea moss
Feed	Cosmetics	Pollution Control
<ul style="list-style-type: none"> • Aquaculture Feed • Cattle and hog feed • Pet food ingredient (aquarium food and speciality pet foods) 	<ul style="list-style-type: none"> • Anti-cellulite • Skin care, sun protection and hair care • Tooth paste, Shaving cream • Lotions and creams • Antibacterial cream 	<ul style="list-style-type: none"> • Wastewater treatment and nutrient credits • Biofilters for fish pond effluents • Heavy metal biosorption • CO2 capture and Carbon Credits • Soil additives, conditioners and fertilizers
Chemicals	Novel applications in other industries	
<ul style="list-style-type: none"> • Defoamers • Inks • Algae based resins • Speciality chemicals like Propyl butyrate, Butanoletc • Stable isotopically labeled compounds • Dyes and colourants 	<ul style="list-style-type: none"> • Paints -Paints seeded with the diatoms • Construction -Algae / sand composites as substitutes for mortar, brick, concrete, asphalt and other civil engineering applications • Lubricants -Dielectric fluids and lubricants • Electronics -Algae based Batteries • Textiles -Algae derived oleic oil for textile lubrication (Solazyme), Alginate Fibre for fabrics 	

Algal products can be classified into three categories based on monetary value:

- High Volume, Low Value Products
- Low Volume, High Value Products
- Medium Value Products

Table 2: Overview of the prominent products from algae, classified on the basis of their market values

High-value	Medium-High value	Low to Medium value
<p>Nutraceuticals</p> <p>a) Astaxanthin b) Beta carotene c) Omega-3 fatty acid (DHA and EPA) d) CoenzymeQ10</p> <p>Cosmetics</p> <p>a) Anti-cellulite b) Skin Anti-ageing and sensitive skin treatment – Alguronic acid</p> <p>Pharmaceuticals</p>	<p>Nutraceuticals</p> <p>- Spirulina and Chlorella</p> <p>Hydrocolloids</p> <p>- Agar, Alginate, Carrageenan</p> <p>Chemicals</p> <p>- Paints, Dyes and Colourants</p>	<p>Fertilizer and Animal Feed</p> <p>a) Aquaculture feed (Shrimp feed, Shellfish Feed, Marine Fish Larvae cultivation) b) Animal Feed c) Fertilizer</p> <p>Substitutes for Synthetics</p> <p>a) Biopolymers and Bioplastics b) Lubricants</p> <p>Bioremediation</p> <p>a) Wastewater treatment and nutrient credits b) CO2 capture and carbon credits</p>

Current and Emerging Potential for Algae-based Value Added Products

Algae can be cultivated to produce a wide range of end products. With several algae based products already existing in the market, new products are likely to be developed in the next decade.

In most cases, products derived from algae need to break into established markets dominated by other, often petrochemical feedstocks, and compete with well-established supply chains (e.g. for fuels and plastics). However, some product groups exist (such as hydrocolloids or feed for fish hatcheries) which can only be derived from algae, or where algal products have functional advantages over alternatives.

This section provides insights on the various current and emerging products of algae, its applications and market potential.

Current Algae Products

Currently the only algal products in the general market are specialty products and some 'ceuticals'. For microalgae, these include pigments, omega-3 and -6 fatty acids, vitamins and whole algae as speciality food / feed items and for cosmetics; for macroalgae they encompass speciality food / feed, fertilizers and hydrocolloids.

The global algae biomass market is worth between US\$ 5- 7 billion. From this total, the health food sector accounts for US\$2 billion and the aquaculture applications account for US\$ 0.7 billion.

Prominent Algae Products in the Market

- ✚ Spirulina
- ✚ Chlorella
- ✚ Astaxanthin
- ✚ Beta Carotene
- ✚ Omega 3 Fatty Acids
- ✚ Algae Cosmetics,
- ✚ Hydrocolloids - Agar, Alginates, Carrageenans,
- ✚ Food Applications
- ✚ Animal and Fish Feed
- ✚ Fertilizers

Commercially produced algae

• Spirulina

Spirulina is a type of blue-green algae that is rich in protein, vitamins, minerals, and carotenoids, antioxidants that can help protect cells from damage. Some of the key health benefits of using Spirulina are:

- ✚ Boosts the immune system
- ✚ Improve digestion
- ✚ Reduce fatigue
- ✚ Build endurance
- ✚ Detoxifier – cleanses the body
- ✚ Boosts energy levels
- ✚ Controls appetite
- ✚ Improved cardiovascular function
- ✚ Better liver and kidney functioning
- ✚ Reduces inflammation and allergies

Market Value: The global spirulina market size is just about 10,000 metric tons per year. **The market price of Spirulina is US\$20/kg in 2010**

• Chlorella

Chlorella is a type of single-celled green algae that has the highest source of chlorophyll compared to any other existing plant species.

Chlorella is considered as a complete food, because of its important role in detoxification and its high content of protein, vitamins, and minerals including carotenoids (astaxanthin, canthaxanthin, flavoxanthin, loraanthin, neoxanthin and violaxanthin), enzymes (pepsin) and chlorophyll.

Chlorella is now widely available as a food supplement in tablet, granule or liquid form and as colourants.

Market Value: The production of Chlorella as a human health supplement accounted for about 2000 tons per year in 2009. **The market value for Chlorella is US \$44 per kilogram in 2010.**

Carotenoids

- **Astaxanthin**

Astaxanthin is a naturally occurring high-value ketocarotenoid pigment with excellent antioxidant effects.

Astaxanthin finds its use in the nutraceuticals, and pharmaceutical industries and in food coloration applications. Astaxanthin is also used as an animal feed additive to impart coloration to salmonids (salmon and trout), as well as to red sea bream and Tai. Astaxanthin is also used in cosmeceutical applications in protection against skin aging.

Market Value: The current global market size of natural astaxanthin for the human market is estimated to be about \$200 million. This is predicted to hit \$700 million by 2017. **The average market price of Astaxanthin is US\$ 2500/kg.**

- **Beta Carotene**

Beta carotene is a carotenoid derived from algae. In human beings, carotenoids can serve several important functions.

Beta carotene is mainly used as a colorant and as a source of provitamin A for the fortification of multivitamin juices, beverages for athletes, food supplement preparations, health foods, etc.

Market Value: Beta-carotene has the largest share of the carotenoids market. Valued at \$247 million in 2007, this segment is expected to be worth \$285 million by 2015, a CAGR of 1.8%.

Omega – 3 Fatty Acids

Omega-3 Fatty Acids have gained considerable importance due to their association with the prevention and treatment of several diseases like atherosclerosis, thrombosis, arthritis, cancers, etc. The omega-3 fatty acids include Docosahexaenoic acid (DHA) and Eicosapentaenoic acid (EPA). The conventional source of EPA and DHA is marine fish oil, however, research studies have proved that higher amount of EPA and some DHA can be produced by the use of algae.

Market Value: Global demand for omega 3 ingredients was estimated to be worth \$1.56 billion in 2010 and is expected to cross \$4 billion in 2018.

Algae Cosmetics

Microalgae extracts can be mainly found in face and skin care products (e.g., anti-aging cream, refreshing or regenerant care products, emollient and as an anti-irritant in peelers). Microalgae are also present in sun protection and hair care products.

Algae compounds that are used in the cosmetics include mycosporine like amino acids, polysaccharides, phycobilin pigments, etc.

Phytoene and Phytofluene are emerging colorless carotenoids used in cosmetics which are said to have effective and beneficial activities for beauty applications, specifically in protection against UV and oxidative damage.

Market Value: The global demand for organic personal care products was over \$7.6 billion in 2012 and is expected to reach \$13.2 billion by 2018, growing at a CAGR of 9.6%

Animal and Fish Feed

Microalgae can be incorporated into the feed for a wide variety of animals ranging from fish (aquaculture) to pets and farm animals, due to its high protein content. Aquaculture is said to be one of the fastest growing markets of algae. Microalgae are used as essential live feeds and supplements in the aquaculture of larval and juvenile animals including oyster spat, juvenile abalone, finfish larvae and rotifer. For instance, astaxanthin and canthaxanthin derived from algae are used for colouring the flesh of farmed salmon.

Market Value

- The global animal feed market is expected to exceed 1.5 billion tons per year by 2020, 15 percent of which (220 million tons) is protein.
- The global market for aquaculture was valued at \$135.10 billion in 2012 and is expected to reach \$195.13 billion in 2019, growing at a CAGR of 5.1% from 2013 to 2019.

Fertilizers

Currently, macroalgae (i.e., seaweeds) are used as a plant fertilizer and to improve the water-binding capacity and mineral composition of depleted soils. Microalgal biomass could in principle serve the same purpose. Furthermore, plant growth regulators could be derived from microalgae.

Food Applications

Edible Sea weeds

Seaweed is consumed habitually in many countries in South-East Asia. Some of the common edible sea weeds have been outlined in the Table 1.

Hydrocolloids

The hydrocolloids extracted from sea weed include agar, alginates and carrageenans. Hydrocolloids are mostly used in the food industry as gelling and thickening agents.

Market Value: The global hydrocolloids market was worth \$3.30 billion in 2010, mostly dominated by gum arabic.

- Emulsifiers command between \$3-8 /kg, while gelling agents are worth \$5-22/kg.
- Carageenan had a European market value of \$127.9 million in 2012, with prices between \$10-12/kg.
- Agar had a European market of \$29.6 million in 2012 with prices between \$20-23/kg

Emerging and Novel Algae Products

As mentioned earlier, several high-value microalgae products are already well established in the market place and there are clear opportunities for additional new products to have a significant potential in the future. Research and commercial programs around the world are now exploring more avenues to develop high-value co-products from algae, from animal feeds to antibiotics to specialty chemicals.

<p>Emerging algae products include:</p> <ul style="list-style-type: none"> • Nutraceuticals and Pharmaceuticals • Textiles • Chemicals • Biopolymers and Bioplastics • Lubricants 	<p>Novel Algae Products in research/pilot stages which may have a significant potential in the future:*</p> <ul style="list-style-type: none"> • Paper • Paints • Construction • Dielectric fluids
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***Owing to the scope of the white paper, algae products in research/pilot stages are not discussed in detail.**

Emerging algae products

Nutraceuticals and Pharmaceuticals

Use of algae, especially the cyanobacteria (blue-green algae), for antibiotics and pharmacologically active compounds has received ever increasing interest. There are a range of pharmaceutical products derived from algae. Some of them include:

- Antimicrobials, Antivirals & Antifungals
- Antioxidants
- Anti tumor and Anti diabetic agents
- Neuroprotective Products
- Therapeutic proteins
- Drugs
- Fluorescent Pigments (Ex: Phycobiliproteins)

Some of the Emerging Algae Bioactive Compounds used in Pharma are:

- **Lutein**- 'Lutein' is a carotenoid extracted from algae, which is receiving increasing interest because of its potential role in preventing the onset of age-related macular degeneration (AMD) in the growing aging population. **The market value of lutein was around \$233 million in 2010 and is expected to reach \$309 million by**

2018 with a compounded annual growth rate of 3.6%

- **Zeaxanthin**- Zeaxanthin alone with Lutein is used for eye health and to help prevent cataract and AMD
- **Fucoxanthin**- Fucoxanthin is a carotenoid which possesses biological activities such as anti-obesity, anti-oxidant, antitumor, anti-diabetes and anti-inflammatory properties.
- **Phycobiliproteins** - Phycobiliproteins can be used in immunodiagnostics and similar assays. **Some very unique products that can be derived from microalgae such as heavy isotope labeled metabolites and phycoerythrin (from Red algae and cyanobacteria), used as fluorescent labels, could have values far exceeding \$10,000 per kg.**

Chemicals

The production of chemicals from microalgae is an emerging field of biotechnology. Chemicals that are obtained from algae (both micro and macroalgae) include products in categories such as:

- Biopolymers
- Bioplastics
- Biolubricants
- Solvents
- Dyes and colourants
- Biofuels
- Agrochemicals
- Epoxides
- Aldehydes
- Acids
- Commodity chemicals
- Food additives
- Defoamers
- Inks

Some of the biofuel companies which diversified into algae chemicals business include Solazyme, Blue Marble Biomaterials, Aquaflow, Solix and BASF.

The building blocks for producing chemicals come from sugars, carotenoids, phycobilins, fatty acids and hydrocarbons present in algae.

For instance, Cyanobacteria such as *Spirulina* and *Synechocystis* produce polyhydroxyalkonates (a phycobilin) such as poly-3-hydroxybutyrate (P3HB) which can be used as a source of production of biodegradable plastics.

Market Value

A 2008 USDA report estimated that global chemical sales, excluding pharmaceuticals, would reach \$2.183

trillion by 2025, estimating a 3 to 6 percent annual growth rate. The report, focused on biobased products, also found that 9-13% of 2010's chemical sales were bio-based and it projected this sector would grow to 22 to 28 % (\$ 483 billion to \$614 billion) by 2025.

Algae based added value commodities such as lactic acid, polyhydroxyalkanoates (both used e.g. for production of bioplastics) and butanol price ranges from US \$1300 to US \$7000 per tonne.

Textiles

Macroalgae-based fibers provide a unique raw material to manufacture special clothing, such as fireproof gear, medical uniforms and protective clothing with military applications. The cost of production of alginate fiber varies from \$8,000 to 10,000 per ton. There is an increasing demand for algal pigments for their use as natural colours in textiles and as printing dyes.

Market Value

The natural fiber composite materials market to grow to US \$531.3 million in 2016 with an 11% CAGR over the next five years.

Biopolymers and Bioplastics

Algae serve as an excellent feedstock for plastic production owing to its many advantages such as high yield and the ability to grow in a range of environments. Companies active in the field of algae biopolymer research are Dow, Petro Sun and Cereplast.

Market Value

The global market for bioplastics is set to grow by 8-10% annually, increasing its value from \$1bn (€0.6bn) in 2007 to \$10bn (€6.4bn) by 2020.

Other Emerging Applications- Algal Bioremediation

Algae CO₂ Capture

Algae + CO₂ Emissions = Carbon Credits + Biofuels!

Algae present an interesting opportunity for companies that produce large CO₂ emissions. For power plants and other entities that are large scale emitters of CO₂, capturing CO₂ using algae provides the benefit of monetizing the carbon credits while at the same time producing biofuels.

Business Opportunities from Algae-based CO₂ Capture

Business opportunities exist both for companies that are CO₂ emitters as well as for external businesses such as consulting and engineering companies that are willing to work with power plants to make the algae-based CO₂ capture and biofuels production a reality.

Algae-based Waste Water Remediation

Algae + Wastewater / Sewage = Clean Water + Biofuels!

Some of the pollutants present in wastewater and sewage, such as nitrogen and phosphorus, are

nutrients on which algae thrive. From the above fact you get an excellent value proposition: Use algae to clean/biofilter nutrient-laden, CO₂ -laden and low-oxygen water and turn it in oxygen-rich, CO₂-low water as it flows back into the ecosystem, while simultaneously producing oil!

This is the powerful idea that has driven some companies to make serious efforts at growing algae in sewage for oil.

Business Opportunities from Algae-based Wastewater Remediation

Wastewater treatment using algae presents an interesting opportunity for companies and utilities that are in the business of treating industrial and domestic waste water. These companies employ expensive processes for wastewater treatment, some of which can be accomplished by growing algae and letting them do the job. This results in reduced costs to the company while at the same time producing saleable biomass.

As in the case of CO₂ capture, business opportunities exist both for companies that are in waste water & sewage treatment as well as for external businesses such as consulting and engineering companies that are willing to work with these utilities to make the algae-based wastewater treatment and biofuels production a reality.

Industries with Synergistic Benefits from Algae Energy Opportunities

As a result of the wide range of applications and end uses of algae, a number of industries could derive synergistic benefits from the algae energy industry. For these industries, cultivating algae could mean that they are able to add value to their existing business while at the same time producing biofuels.

A list of these industries and inputs on the synergistic benefits that can be derived are provided below.

List of Potential Industries

The list of industries for which it is attractive to explore investing in the algal energy domain owing to synergistic benefits:

Sewage & Water Treatment Companies

The industries listed below can use algae for the secondary stage of wastewater treatment

- ❖ Meat and Poultry
- ❖ Pulp and Paper, and Produce (i.e., Fruits & Vegetable)
- ❖ Textiles Dyeing
- ❖ Metal Finishing
- ❖ Dyes & Pigments
- ❖ Pharmaceutical
- ❖ Food & Dairy
- ❖ Biotechnology
- ❖ Starch & Cellulose
- ❖ Chemicals
- ❖ Pesticides & Insecticides
- ❖ Photography
- ❖ Fertilizers

Agriculture & Farming

- ❖ Traditional crops – If farming companies grow algae for biodiesel, they can use the de-oiled algae extract as bio-fertilizer.
- ❖ Algae farms – Existing algae farms can grow algae for fuel in addition to the end-product markets for which they are already cultivating algae.

Companies Producing Animal Waste

Many companies that produce large quantities of animal waste use the waste in digesters to produce methane, which in turn is used as a heating fuel. Using large quantities of methane gives out CO₂ which can be used to grow algae. Algae can also grow in the

liquid effluents released from the anaerobic digesters. The additional benefit these companies get is that they can use the de-oiled algae meal as animal feed.

The following is the list of companies producing animal waste that could specifically benefit from growing algae:

- ❖ Pork
- ❖ Poultry
- ❖ Meat
- ❖ Dairy

Polluting Industries

Industries that emit large amounts of CO₂ during their operations can use algae for CO₂ sequestration. They thus get two benefits: They are able to sequester CO₂ cost-effectively, and they get a fuel feedstock.

The following is the list of companies producing animal waste that could specifically benefit from growing algae:

- ❖ Coal Burning and Natural Gas Power Plants
- ❖ Petrochemicals
- ❖ Iron & Steel
- ❖ Cements
- ❖ Sugar
- ❖ Tyres
- ❖ Carbon Black
- ❖ Mining
- ❖ Aluminium
- ❖ Paper
- ❖ Inorganic Chemicals
- ❖ Fertilizers

Algae-based Products Manufacturers

Many industries that use algae use primarily the protein component of the algae. For these companies, algae fuel in the form of biodiesel presents an interesting opportunity: these companies can extract the oil (lipid) from algae for biodiesel and can use the deoiled algae cake rich in proteins for their products. For those industries that use the lipids in algae, they can consider using the left-over biomass for producing fuels such as ethanol or other hydrocarbons.

Chemical Industries

Following is the list of companies which can consider using algae as a source for their chemical requirements.

- ❖ Dyes and Colourants
- ❖ Paints and Coatings
- ❖ Biopolymers and Bioplastics
- ❖ Pharmaceuticals
- ❖ Textile
- ❖ Cosmetics
- ❖ Adhesives
- ❖ Surfactants

Feed Manufacturers

Microalgae are rich in protein and many strains possess a desirable amino acid profile. Many animal and fish feed companies are now beginning to explore algae as a protein source. One of the fastest growing segments of algae applications is the aquaculture. Indeed many fish feed manufacturers are now looking at algae as a source to displace the highly unsustainable protein source fishmeal in aquaculture.

Cosmetics Manufacturers

Algae has become an increasingly important ingredient for a cross-section of cosmetic and personal care ingredients, and is emerging as a segment with several opportunities for development. Cosmetics manufacturers can use algae in their products through three main routes: as raw materials; as bulk extracts for formulation; and as specialised functional ingredients. Each of these is associated with a different size of industry.

Pharmaceutical Companies

The major pharmaceutical compounds from algae which are currently being commercialized or under consideration for commercial extraction include carotenoids, phycobilins, fatty acids, polysaccharides, vitamins, sterols, and biologically active molecules for use in human and animal health. The vast untapped potential of algae in pharmaceuticals provides opportunities for many pharmaceutical companies to develop novel high value products from algae and benefit significantly.

Key Takeaways

- One of the most interesting products from algae that is being researched is biofuels. However many algae fuel companies are now exploring venturing into algae based value added products business, after having started to realize that it could take much longer than originally expected to derive fuels from algae.
- Algae can biosynthesize, metabolize, accumulate and secrete a great diversity of metabolites and bioactive compounds, many of which are valuable substances with potential applications in the food, pharmaceutical and cosmetics industries.
- Most of the products derived from algae need to break into established markets dominated by other, often petrochemical feedstocks, and compete with well-established supply chains (e.g. for fuels and plastics).
- Several high-value microalgae products are already well established in the market place and there are clear opportunities for additional new products.
- Currently the only algal products on the general market are speciality products and some 'ceuticals'. For microalgae, these include pigments, omega-3 and -6 fatty acids, vitamins and whole algae as speciality food / feed items and for cosmetics; for macroalgae they encompass speciality food / feed, fertilisers and hydrocolloids.
- Some of the emerging algae products include: algae pharmaceuticals, cattle and hog feed, fish feed, nutrition products, chemicals, bioplastics and lubricants.
- The global algae biomass market is worth between **US\$ 5- 7 billion**. From this total, the health food sector accounts for **US \$2 billion** and the aquaculture applications account for **US\$ 0.7 billion**.
- There are only two approved omega 3 based pharmaceuticals in the world, which together account for **US \$ 1.5 billion** sales.
- Algae products such as Spirulina and Chlorella, have significant benefits as potential single cell protein sources. But the market value of these products is not very high; Spirulina was sold at a price of **US \$20/kg in 2010 and Chlorella at a price of US \$44/kg in 2010**.
- Microalgae extracts are also employed in making anti-aging cream, refreshing or regenerant care products, emollient and as an anti-irritant in peelers. They are also present in sun protection and hair care products.
- Algae can also yield various carotenoids such as Astaxanthin, Beta carotene, Lutein and many more, which has potential applications in nutraceutical and pharmaceutical industries.
- Beta-carotene has the largest share of the carotenoids market. **Valued at US\$247 million in 2007, this segment is expected to be worth US\$285 million by 2015, a CAGR of 1.8%**.
- Algae also present an interesting opportunity for companies that produce large CO₂ emissions and for companies and utilities that are in the business of treating industrial and domestic waste water.
- Important considerations while investing in algae products business include: **size of the potential market, possible competing non algae sources and the time and cost of achieving approval for new products and their acceptance by the customer**.

Our Reports

[Comprehensive Oilgae Report](#)

A detailed guide for algae biofuels

A detailed report on all aspects of the algae fuel value chain, the Comprehensive Oilgae Report will be of immense help to those who are on the threshold of investing in algae biofuels. With algae fuels being the only source that can replace fossil fuels for transportation purposes, many investors are closely monitoring this field. The Comprehensive Oilgae Report will give you that extra edge in understanding the worldwide happenings in this field and in keeping you a step ahead of the rest.

[Oilgae Digest](#)

A concise guide to the algae fuels industry

This is for entrepreneurs and businesses who wish to get a basic understanding of the algae fuel business and industry dynamics. The Oilgae Digest was developed to provide background and insights on the key parameters driving the algae fuel business - technical and economic feasibility, real industry status, investments and costs, and business success factors. This report is a customized edition for those who wish to get a first level understanding of the critical drivers of the algae fuels industry.

[Oilgae Guide to Algae-based Wastewater Treatment](#)

Compiled by a diverse team of experts, with experience in scientific and industrial fields, the Comprehensive Report for Wastewater Treatment Using Algae is the first report that provides in-depth analysis and insights on this important field. It uses innumerable data and information from a wide variety of expert sources and market studies, and distills these inputs and data into intelligence and a roadmap that you can use.

[Comprehensive Report on Attractive Algae Product Opportunities](#)

The Comprehensive Report on Non-fuel Products from Algae is the only report that provides insights on the wide range of non-fuel applications of algae with both current and future prospects. It will provide entrepreneurs with an idea of how to derive more benefits from their algal energy ventures.

About Oilgae

Oilgae is the global information support resource for the algae fuels industry.

Started in 2007, Oilgae has today grown into one of the most well-known brands in the biofuels industry. The extent to which Oilgae and the site www.oilgae.com have influenced the algae fuels industry can be gauged by the fact that oil from algae is today generically known as Oilgae! We assist hundreds of individuals and companies around the world in their efforts to produce useful products from algae, through our site, research team and research reports.

Oilgae aims to be a critical catalyst for making algae fuels a commercial reality. Today, Oilgae has grown into a large web resource, has a strong team of brilliant and passionate people, and is assisting hundreds of individuals and companies around the world in their efforts to produce profitable products from algae.

Our Site

Our website (www.oilgae.com) is hugely popular in the algae biofuels domain. Thanks to a dedicated team of researchers and technical experts, our website has been on the forefront of the algae biofuels research since the inception of the site in 2005-06. It gets over 2500 focused visitors each day. Its mailing list is subscribed by 10,000 people and its club plays host to more than 2500 people including experts and CEOs from top firms. Oilgae's club (www.oilgae.com/club) and forum regularly witnesses lively discussions and healthy arguments on the latest developments on the field. Oilgae acts as the single stop destination for everything related to algae biofuels and by-products.