Waste Vitalization of Algae Processing

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Abstract— *Algal biodiesel is an attractive renewable source for jet fuel blend. It is available technically, but expensive. Energy efficiency and solid waste management became a global trend. Algal waste vitalization is a key factor in biorefinery concepts to enrich the process profits. The appropriate utilization path of algalcake is proposed via biochemical analysis. Approaches attaining high algae revenues are of great importance and discussed to apply in the near future.*

Keywords—Algal biodiesel, approaches, biorefinery, revenues, waste vitalization

I. INTRODUCTION

Algal biofuel (or algae-oleum) has attractive interest in recent years for jet fuel blend [1]. It prepared via transesterification "biodiesel" [2,3], hydrocracking "bio-oil" [4] or fermentation "bioethanol" [5] of algal biomass. Technically, algal biodiesel is available through series of consecutive reactions between the extracted oil and methyl alcohol over base or acid catalyst as excessively illustrated inliteratures [6,7]. Algal oil (or Oilgae) extraction is too costly process which can evaluate the sustainability of microalgae-based biofuels [8]. Commercial manufacturers use a combination of mechanical press and chemical solvents to maximize lipids leaching [9]. Microalgae as a potential renewable source for biofuel production has high lipids productivity (avg. 4000 gallon/acre/year) and oil content in range of 20-65%wt, hence huge amount of cake (35-80%wt) is generated after Oilgae extraction [10]. Nowadays, Algae-oleum is non-commercial; because of the high investments costs and the high demand on auxiliary energy for biomass followed by algal oil production, and biofuel manufacturing [11]. Feedstock cost is the bottleneck of biodiesel marketing on industrial scale; as it represents about 70-80% of total production cost [12,13]. Landfill is the common method for solid waste management (SWM) if there is no economical way to utilize it. Energy, materials and wastes management have a promising interests worldwide; to reduce greenhouse gases (GHGs), to improve energy efficiency and increase the facility productivity using NO COST OPTION [14]. Therefore, utilization of algal-waste for example as soil conditioner or solid biofuel (like bio-char) is a key factor in biorefinery concepts to improve the economic feasibility [15]. This paper highlights the different paths for algal waste utilization; in order to optimize its vitalization and enhance the algae revenues.

II. ALGAE PROCESSING FOR BIO-JET FUEL PRODUCTION

Algae are cultivated in open ponds [16] or closed photobioreactors (PBRs) [17] using Zarrouk medium [18,19]. Biomass can be collected at 21days old and separate through centrifuge. Algae biomass is dried using solar dryers before Oilgae extraction. Algal oil can be extracted by mechanical press to yield 10%wt [20] followed by chemical solvent usually hexane to obtain all lipids according to Bligh, E.G. and Dayer, W.J. [21]. Solvent is recycled and algae waste is subjected to further processing. Oilgae biorefinery is necessary to improve its properties and confirm the jet fuel standards. This is achieved via Oilgae hydrocracking process to yield directly bio-jet fuel, or transesterification into biodiesel followed by distillation above 120^{o}C to get the required cut and blend with petro-jet fuel [22]. Processing of algae for bio-jet fuel production is summarized in Fig. 1 [23].

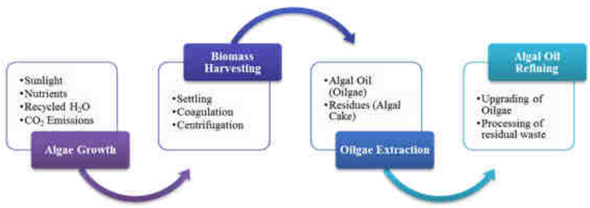

Fig. 1: Algal processing for jet fuel production

III. UTILIZATION OF ALGAL WASTE

Once Oilgae is produced, algal cake is dried at the sun and analyzed to determine the appropriate utilization path. Cultivation conditions and chemical composition of algal species find the vitalization way; because they are different as shown in Table 1 [24]. Algal waste can be recycled as nutrients into cultivation system or burned as solid biofuel without extra treatment.

3.1. Algal waste as bio-fertilizer

El Shimi, H.I. et al. [25] was used *Spirulina-platensis* as a feedstock to produce biodiesel for jet fuel blend. Biochemical analysis was carried out at Faculty of Agriculture, Cairo University, Egypt, and illustrated in Table 2. It's shown that *S.platensis* cake has a considerable amount of nitrogen (500 mg/100g), phosphor (900 mg/100g) and potassium (1475 mg/100g). These elements are the main nutrients for plant growth, so it is vital as promising plant nutrition element to be used as N-P-K fertilizer "bio-fertilizer". The advantages of fertilizers containing algae are greater than normal fertilizers alone; because approximately 33% of algal N was converted to plant available N within 21 days at 25°C in the soils. In the United States, the corn plants for example, received an added benefit from micronutrients and plant growth enhancers provided by the algae-fertilizers. The suggested price of algal cake as a bio-fertilizer is USD300/ton [11].

Table-1. Chemical analysis of algae species expressed on a dry matter basis (%)

Strain	Lipids	Carbohydrates	Protein
Prymnesium parvum	22-38	25-33	28-45
Euglena gracilis	14-20	14-18	39-61
Spirulina platensis	6-11	9-15	46-63
Spirogyra sp.	11-21	33-64	6-20
Porphyridium cruentum	9-14	40-57	28-39

When applying the bio-fertilizer to plant seeds, plant surfaces, or soil, it colonizes the interior of the plant and promotes growth by increasing the availability of primary nutrients (N, P and K) to the host plant. They add nutrients through the N-fixation, P-dissolving and stimulating plant growth through the synthesis of growth-promoting substances. The microorganisms "algal waste" in bio-fertilizers restore the soil's natural nutrient cycle and build soil organic matter. Through the use of bio-fertilizers, healthy plants can be grown, while enhancing the sustainability and the health of the soil. Additionally, they maintain the natural habitat of the soil, increase crop yield by 20-30%, substitute pesticides, chemical nitrogen and phosphor by about 25% and also provide protection against some soil-drought. Bio-fertilizers are cost-effective relative to chemical fertilizers.

3.2. Algal waste as animal fodder or poultry/fish diets

Algae containing valuable amount of protein like *Euglena gracilis* and *Spirulina platensis* is considered a promising animal fodder and soybean replacing as poultry (USD4000/ton) and fish diets (USD12000/ton), but more production and treatment facilities are required to achieve these goals. *Muriellopsis sp.* and *Chlorophyta* are cultivated in open ponds and PBRs were recommended to be a safe feedstuff for growing livestock animals [26]. Animal nutrition systems are considered the effective-costly component in modern animal production [27].

3.3. Algal waste as raw material for bioethanol production

Bioethanol production via sugars fermentation has more attention worldwide [28]. Algal waste of rich carbohydrates content like *Spirogyra sp.* and *Porphyridium cruentum* can be utilized to develop bioethanol production through acid hydrolysis, neutralization and yeast adaption [28]. Efficiency of algal bioethanol is estimated to be 66% compared to gasoline.

Table-2. Elemental analysis of Spirulina-platensis waste

Element	Value	Unit
Ca	400	mg/100 g algae
P	900	mg/100 g algae
Fe	70	mg/100 g algae
N	500	mg/100 g algae
K	1475	mg/100 g algae
Moisture	1.5	%wt
Ash	7.5	%wt

IV. RECOMMENDATION

A strategic plan is still required to maximize the profits from algae project according to the proposed algae strain. Fig. 2 illustrates the optimum path for algal biomass processing; in order to enrich its revenues.

V. CONCLUSION

Chemical composition of algal cake after biofuel production proved its vitalization path as animal fodder, poultry and fish diets feed, bio-fertilizer or as a bioethanol feedstock. Waste vitalization using NO COST OPTION is a promising global trend; to improve the process economics.

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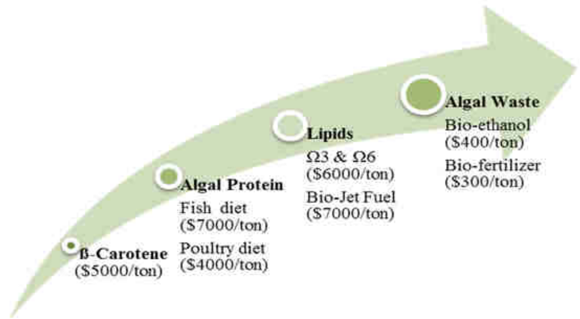

Fig. 2: Algae Revenues

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