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Biodiesel production from microalgae grown on domestic wastewater: Feasibility and Egyptian case study

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ABSTRACT

Biodiesel has been identified to be a suitable biodegradable substitute to petro-diesel. The Egyptian consumption rate of fossil diesel is approximately 37 kt per day from which 50–60% are imported. Using algal biofuels has led to a potential techno-economic assessment of 1.0 million ton (MT) biodiesel to be produced from microalgae grown on domestic wastewater via heterogeneous transesterification catalysis using sodium orthosilicate (Na_4SiO_4) as catalyst in order to minimize the diesel shortage in Egypt and mandating B5 by 2020. Process equipment and units required have been sized with an accuracy of ± 20%. Mass balance, total capital investment (TCI), total production cost (TPC) and economic potential (EP) have all been assessed based on the marketed biodiesel price of US$1000 per ton and an evaluated *Nannochloropsis sp.* algal biomass cost of US$400 per ton. An algal biodiesel project of 1.0MT has been proven to be feasible with return on investment (ROI) and pay-back period of 41% and 2 years, respectively. A break-even analysis has disclosed that the cost of algal biodiesel that renders the project feasible is should be above US$843 per ton while the cost of algal biomass should not exceed US$461 per ton. Furthermore, sensitivity analysis was evaluated on variations in microalgae lipids content using ROI and payback time. The results obtained using Tornado Chart recommended that the minimum oil content should be 35% for profitable algal biodiesel business. Finally, a comparison between the investigations of algal biofuel versus Jatropha *curcas* biodiesel was performed, and positive prospects were detected for industrializing algal biodiesel whenever Brent Crude Oil Spot exceeds US$100 per barrel.

1. Introduction

As he energy demand is growing worldwide, about 80% of the total energy consumption is delivered from petroleum, natural gas and coal with an increase in greenhouse gases emissions that must be reduced by 10% in 2020 according to the European Union planned targets [27] (EIA statistics, 2016) and the annual consumption of fossil-based fuels is expected to rise by approximately 90% in 2030 [23]. In this respect biofuel, as a green renewable alternative, can help filling the global energy gap. Algal biodiesel has recently been used in blending with petro-diesel in levels exceeding 5% to [3]. Its industrial production can be achieved by lipid extraction followed by alkaline or acidic transesterification process using homogeneous or heterogeneous catalysts (Chisti, Y., 2007). In-situ transesterification of biomass into fatty acid methyl esters (FAMEs) has been recently investigated to remove the extraction step but turned out to remain an expensive alternative [11].

The potential of microalgae as renewable source for sustainable biodiesel production is promising due to the capability to store more lipid amounts (20–75%wt) than other oil crops like Jatropha *curcas* and rapeseed [4,26] and can be used for carbon fixation where 1 kg algal biomass requires 1.8 kg CO_2 [9]. Algae cultivation does not compete with classical agricultural resources [18]. These can be grown on domestic wastewater and offer a triple facet solution: environmental, economic and waste control (Moustafa, S. *et al.*, 2012) where 1 l of algal biodiesel will consume 20 l of water for plantation [9].

Algal biodiesel is technically available but still of no commercial value because of the high investments costs and the high demand on auxiliary energy for biomass production, microalgae oil "Oilgae" leaching, and biofuel industrialization [15,27]. Feedstock cost is the bottleneck of biodiesel marketing on large scale as it represents about 80% of total manufacturing cost [7,29]. Utilization of algal cake after Oilgae production, for example, as soil conditioner is a key factor in biorefinery concepts in order to improve economic feasibility (Raphael S. and Ausilio B., 2012). On the other hand, the Egyptian consumption rate of fossil diesel is currently approximately 37 kt per day, of which 50–60% is imported with US$ 800–1100 per ton according U.S. Energy Information Administration statistical data (2016).

Consequently, the objective of the present study is to perform a techno-economic assessment of erecting a biodiesel factory with annual capacity of 1.0 MT from microalgae cultivated in domestic wastewater in order to reduce the dependence on fossil fuel and mandate B5 (5% algal biodiesel and 95% petro-diesel) by 2020.

2. Process design and case study

2.1. Background of the case study

Egypt is a large country with a total area of 1 million km^2 and total population of 92 million people according to the Central Agency for Public Mobilization and Statistics of Egypt (2016). While the diesel demand rose by approximately 30% from 2005 to 2015 according to EIA statistics, diesel prices have increased from October 2008 to July 2014 by 64% to record US$ 230 per ton (EGP 1.9/L). Currently, no policy has been

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implemented to use at least 1% biodiesel as a blend in fossil diesel. In this respect, the Egyptian Government is poised to encourage the marketing of biodiesel business by raising people awareness, offering tax incentives and subsidies on biofuel (e.g. project land and water) as has been done for natural gas. It is proposed to mandate B5 by 2020 as per the Egyptian strategic plan 2030. To reduce diesel shortage and save its imports by at least 5%, it is suggested erecting a biodiesel factory with annual capacity of 1.0 MT. This is the reason why this paper focuses on the techno-economic appraisal of biodiesel production from microalgae cultivated on domestic wastewater.

2.2. Algal oil extraction and biodiesel production using homogeneous catalysts

Algal lipids (polar and non-polar) can be extracted using the well-established Static Solvent Methodology [16] where the biomass is delivered to extraction vessels using methanol as solvent (10 ml/1*g* algae). The extraction mixture is then agitated at 500 rpm for 12 h. Cells' residue "algal cake" is removed by filtration then subjected to solar drying. The filtrate (methanol-algal oil mixture) is subsequently fed to a reactor and heated to a specified temperature (e.g. 65 °C). For biodiesel synthesis using an alkaline homogeneous catalyst such as KOH, the algal oil must be pretreated with sulfuric acid and methanol to esterify the free fatty acids (FFAs) to fatty acid methyl esters (FAMEs) or biodiesel, hence avoiding soap formation during biodiesel production [5,6]. After this pretreatment process, by-product water is decanted from the treated oil and then excess methanol is reacted with potassium hydroxide to produce potassium methoxide (CH_3OK) which catalyzes the transesterification process. Once the reaction has completed, the products are subjected to flash evaporation in order to recover the excess alcohol, then transferred to a decanter where biodiesel and glycerol layers are separated due to the difference in their densities (0.86 and 1.22*g*/ml, respectively). The algal biofuel layer is washed twice with hot water (55 °C) to remove catalyst and glycerol traces. The wastewater is then decanted and biofuel distilled under vacuum for purification before storing. In contrast, the crude glycerol layer (85% purity) is neutralized by phosphoric acid (H_3PO_4) to disacrd FFA (Nada, MR. *et al.,* 2014), where three layers are generated: FFA on the top; which is recycled to the esterification reactor, glycerol in the middle layer, and potassium phosphates [$K_3(PO_4)_2$] in the bottom, which can be dried and used as fertilizer. Glycerol is washed with water at 55 °C for at least three times, then decanted and dried at 110 °C. Pure glycerin (95%) is obtained from this step. (El Shimi, H. *et al.,* 2016b).

2.3. Algal biodiesel production using heterogeneous catalysis

Heterogeneous catalysts such as calcium oxide (Liu, X. *et al.,* 2015), phosphate rock, $Ca_3(PO_4)_2F$ [2] and sodium orthosilicate, Na_4SiO_4 [12] are extensively used as an alternative to homogeneous catalysts. Biodiesel manufacturing using solid catalysts involved fewer unit operations compared to KOH and H_2SO_4 catalyzed processes [22]. The obtained oil "Oilgae" is heated to a specified temperature (e.g. 65 °C) then reacted with methyl alcohol (CH_3OH) in presence of powdered catalyst (e.g. Na_4SiO_4) without any pre-esterification [12]. At the end of transesterification reaction, the catalyst is removed through settlers or hydrocyclones to be used in the next batch. The produced mixture is distilled under vacuum to recover excess methanol, then transferred to a decanter to get two distinct layers of biodiesel and glycerol due to the densities difference. The glycerol is obtained in high purity (min. 98%), while the FAMEs are treated twice with hot water (55 °C) to remove residual alcohol, catalyst and glycerol traces. A schematic diagram for algal biodiesel industrialization using Na_4SiO_4 catalyst is shown in Fig. 1.

2.4. Design basis

Nannochloropsis sp. microalgae of 44% lipids were grown on domestic wastewater obtained from Zenein Wastewater Treatment Plant (ZWWTP), Giza governorate, Egypt (Moustafa, S. *et al.,* 2012). Oilgae extraction was performed in accordance to the methodology appreciated by Smedes and Thmasen [28], as solvent (methanol)-to-biomass ratio of 10 ml/g is required to yield 73% Oilgae in 12 h at ambient conditions to avoid energy consumption [14]. Generally, algal oils contain FFA in range of 1–19% [16]. Actually, the average molecular weight of *Nannochloropsis sp.* oil is 845 and its FFA content is less than 2%. Fatty acid profile of algal methyl esters abides by the European biodiesel standards (Moustafa, S. and El-Gendy, N. *et al.,* 2013). While the feasibility analysis for producing biodiesel from algae based on a homogeneous catalyst was recently

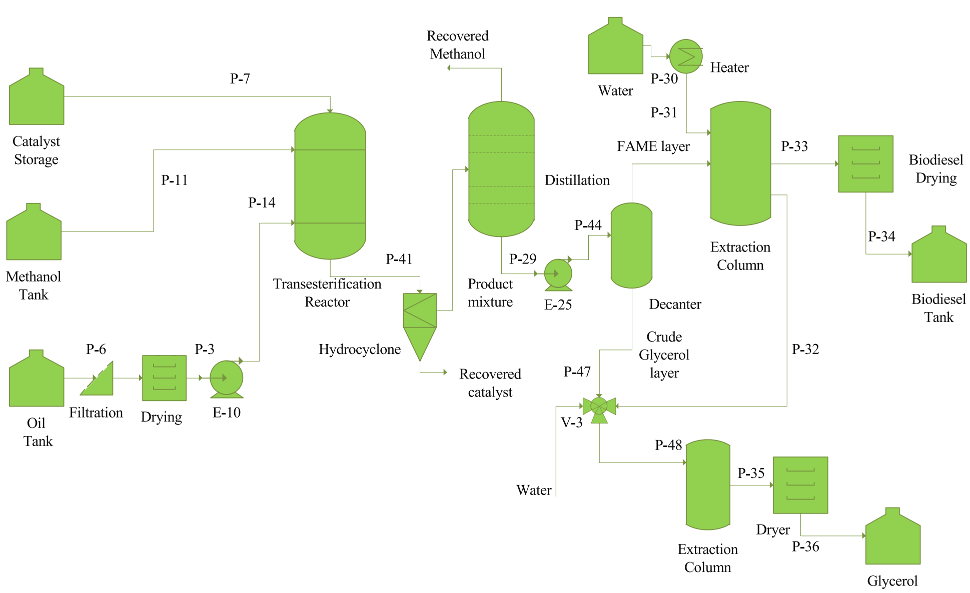

Fig. 1. Schematic diagram of algal biofuel production processes catalyzed by Na_4SiO_4.

Table 1
Evaluation of algal biodiesel and its blends to fossil diesel according to EN 14,214 standards (Moustafa, S. and El-Gendy, N. *et al.,* 2013).

Property	Unit	Egyptian Fossil diesel	Biodiesel (EN 14,214)	Algal biodiesel (B100)	5% Biodiesel (B5)	20% Biodiesel (B20)
Density at 15 °C	g/cm^3	0.8422	0.86–0.90	0.8637	0.843	0.8462
API		36.35	–	31.5	36.19	35.55
Viscosity at 40 °C	cSt	1–7	3.5–5.0	12.4	4.2	5.11
Acid number	mg KOH/g oil	0.023	< 0.5	0.75	0.05	0.102
Iodine number	mg I_2/100 mg oil	–	102	< 120	–	–
Pour point	°C	−3	–	−9	−6	−6
Cloud point	°C	+6	−4	−3	0	0
Flash point	°C	82	> 101	189	100	112
Aniline point		67		84	75	82
Water content	ppm	52	< 500	39	45.5	40.9
Total Sulfur	%wt	0.13	< 0.01	Nil	0.09	0.021
Ash	%wt	0.009	< 0.02	Nil	0.0028	0.0018
Calorific value	MJ/kg	45.35	32.9	45.63	45.58	45.62
Cetane number		50	> 51	70	62	68
Diesel index		48	–	67	59.69	65
Distillation temp.	°C	157		270	165	210

researched [1], the recent study deals with an economic analysis for producing algal biofuel using heterogeneous catalyst in an attempt to minimize production costs. Optimization of heterogeneous transesterification disclosedthat an ultimate biodiesel yield of 97% can be achieved using 6/1 alcohol-to-oil molar ratio and Na_4SiO_4 concentration of 5.87% by weight at 65 °C for 3 h (El Shimi, H., 2016c). The evaluation of algal biodiesel and its blends to fossil diesel according to EN 14,214 standards are illustrated in Table 1.

3. Results and discussion

3.1. Economic assessment

As previously mentioned, the *Nannochloropsis sp.* feedstock was grown on domestic wastewater. Cultivation was enhanced by adding few nutrients like ammonia containing fertilizer and Ferric chloridehexahydrate solution (0.25 g/l. $FeCl_3{\cdot}6H_2O$). This way, the cost of algal biomass was assumed to be US$400 per ton including the cost of all downstream processes like harvesting and drying [1]. Operating hours were based on three shifts (8 h) per day and 300 working days per year. The storage capacity is suggested to be one week for all materials. Glycerin and algalcake are co-products that help minimizing the annual production cost. Algal cake price is assumed to be US$180 per ton to be marketed as organic fertilizer. The international selling prices of biodiesel and glycerin per ton were found to be US$1000 and US$650 respectively. Also, the Na_4SiO_4 catalyst will be recovered and transferred to the next batch or marketed with a reduction in price of US$50 per ton from its purchased cost as per a deal reached with the manufacturer (Silica Egypt C°) The amount of recovered methyl alcohol was assumed to be 95% and 40% in lipids extraction and transesterification processes, respectively (Abo El-Enin, S.A. *et al.,* 2013). Materials cost accounting sheet of the recent study based on the optimum extraction and transesterification conditions (El Shimi, H. 2016c) is presented in Table 2.

The purchased cost of equipment (PCE) is calculated for the heterogeneous catalysis process of biodiesel production and illustrated in Table 3. The sizing of each piece of equipment was estimated and approximated from the continuous biodiesel production capacity per day in accordance with the feeding, reaction and discharging time intervals then the number of units and the unit cost (US$) of each specific equipment used were determined [25]. Electricity cost is assumed to be US$0.1 per kilowatt hour (kWh), and its consumption is assumed to be 70kWh per ton of algal biodiesel [21]. Working capital investment (WCI) represents 15% of fixed capital investment (FCI) because the products (biodiesel and glycerol) are

Table 2
Materials cost accounting sheet.

	Quantity (ton/yr)	Unit cost ($/ton)	Cost ($/yr)	
Process Inputs				
Algal biomass	*	400	986,533,813	
Methyl alcohol	**	500	82,605,570	
Na_4SiO_4 Catalyst	60,516	250	15,128,866	
		Raw Materials	***1,084,268,249***	
Process Outputs				
Algal biodiesel	1,000,000	1000	1,000,000,000	
Glycerin (99% purity)	110,000	650	71,500,000	
Algalcake (as organic-fertilizer)	1,435,407	180	258,373,206	
Recycled catalyst (97% recovered)	58,700	200	11,740,000	
		Revenues	***1,341,613,206***	
Algal Oil (required for reaction)	1,030,928	ton/yr	Extraction system	Cold oil extraction
Algae biomass (theoretical)	2,343,018	ton/yr	Solvent	Methanol
**Algae biomass (actually) taken into account the extraction efficiency of 95%*	*2,466,335*	*ton/yr*	Solvent/biomass (v/w)	10
Algalcake	1,435,407	ton/yr	Extraction time (h)	12
Methanol requirement (Extraction)	246,633	ton/yr	Oilgae yield (%)	95
Methanol consumption (Extraction) as 90% is recovered	24,663		Solvent recovery (%)	90
Methanol requirement (Reaction)	234,246	ton/yr		
Methanol consumption (Reaction)as 40% is recovered	140,548			
***Total alcohol consumption rate*	*165,211*	*ton/yr*		

Table 3
Purchased cost of equipment (PCE) and Total capital investment (TCI).

Equipment	Unit no.	Unit cost ($)	Total cost ($)	Category	%PCE	Cost ($)
Methanol storage tanks (200 m^3)	57	50,000	50,000	*Physical Plant Cost (PPC)*		
Belt conveyor	15	22,000	330,000	Equipment cost	100	89,083,500
Extraction vessels (300 m^3)	100	75,000	7,500,000	Equipment delivery cost	10	8,908,350
Mixers (Propeller, 10 hp)	125	10,000	50,000	Installation cost	20	17,816,700
Pumps (progressive cavity type, 30gallon/min)	300	11,000	3,300,000	Piping	20	17,816,700
Filters (Hydrocyclone, 1 m diameter, 50 m^3/h)	64	50,000	3,200,000	Buildings	10	8,908,350
Mechanical pressing machine (capacity: 3–4 t/day)	100	200,000	20,000,000	Utilities	15	13,362,525
Transesterification reactors (Jacketed & Agitated 100 m^3)	25	300,000	7,500,000	Instrumentation & Control	15	13,362,525
Flash evaporation/Distillation columns	26	400,000	400,000	Site Development	10	8,908,350
Settlers/Centrifuges (bottom driven 3 m diameter)	40	37,000	1,480,000	Auxiliary buildings	10	8,908,350
Absorption-Stripping towers (2 m Diameter, 20 m Height)	34	500,000	17,000,000		*PPC*	*187,075,350*
Algal biodiesel storage tanks (200 m^3)	117	50,000	50,000	*Indirect Plant Cost (IPC)*		
Glycerin storage tanks (100 m^3)	13	25,000	25,000		% of PPC	
				Design and Eng.	20	37,415,070
	Purchased Cost of Equipment (PCE)		*80,985,000*	Contractor' fee	20	37,415,070
110%PCE	*89,083,500*			Contingency	10	18,707,535
Scrap value	*8,908,350*			Legal expenses	10	18,707,535
Life span	15				*IPC*	*112,245,210*
Depreciation cost	*5,345,010*			*Fixed capital investment (FCI)*		*299,320,560*
				Working capital investment (WCI)		*44,898,084*
				Total capital investment (TCI)		***344,218,644***

easily marketed. The total capital investment (TCI) was estimated and shown in Table 3. In this respect, it is important to note that different categories were involved in calculating the TCI [25].

Total production cost (TPC) of algal biodiesel project was estimated as listed in Table 4. The feedstock and utilities (Electrical distribution, air instrument and steam generation systems) contribute to approximately 70–75% of total costs. Although it contributed to 71% of total costs for biodiesel produced from waste cooking oils using KOH as a catalyst [11], in the present case, it represents about 88% of TPC as shown in Fig. 2.

To evaluate the 1.0 MT algal biodiesel project, some profitability indicators must be estimated (Table 4) such as the economic potential (EP, US $/year) or net profit, return on investment (ROI, %) and pay-back period (year) according to "Eq. (1) to Eq. (3)". For a new investment, the minimum ROI in an established market is 20%, and the maximum pay-back period is 5 years (Skarlis, S. *et al.,* 2012). Although the Egyptian Government offers tax incentives for the new industries up to 10 year, 10% of gross earnings were nevertheless allocated for taxes expenses.

Table 4
Total production cost (TPC) and Process profitability indicators (PPI).

Item	Unit cost	Cost (US$/yr)
Direct Production Cost (DPC)		
Raw Materials		1,084,268,249
Miscellaneous materials	10% M & O	890,835
Utilities	US$0.1/kWh, US$0.1/m^3 H_2O	10,000,000
Shipping & Packaging	1%PCE	890,835
Maintenance and operational cost (M & O)	10% PCE	8,908,350
Operating labor	$8000/Egyptian employee/ year	2,000,000
Supervision	15% Labor	300,000
Plant overheads	50% of labor and M & O	5,454,175
Interest	2% PCE	1,781,670
Rent	2% PCE	1,781,670
Royalties	Not Found	0
	DPC	1,116,275,784
Indirect Production Cost (IPC)		
Research and Development	5% of DPC	55,813,789
General expenses	25% of labor and M & O	2,727,088
Property insurance cost	5% PCE	4,454,175
Depreciation	Straight-line depreciation over 15 years factory life	5,345,010
	IPC	68,340,062
Total Production Cost (TPC)		***1,184,615,846***
TPC/ton algal biodiesel		1185
Gross earnings (US$/yr)	*156,997,360*	
Economic Potential (US $/yr)	***141,297,624***	
ROI (%)	***41.05***	
Pay-back time (yr)	***2.04***	

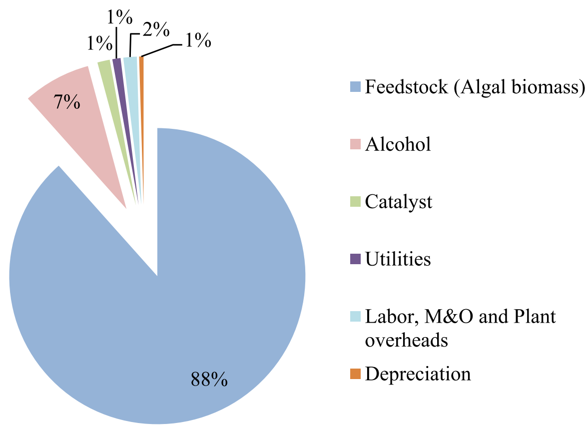

Fig. 2. Cost analysis of algal biodiesel production in Egypt 2017.

$$\text{Economical potential (EP, US\$/year)} = \textit{Total Revenues} - \text{TPC} \tag{1}$$

$$\text{ROI\%} = \frac{\text{EP}}{\text{TCI}} \times 100 \tag{2}$$

$$\text{Payback period (years)} = \frac{\text{FCI}}{\text{EP} + \text{Depreciation}} \tag{3}$$

In this research, the ROI and payback time are calculated to be 41% and 2 years, respectively, with annual net profit of US$141,297,600 inferring that biodiesel industrialization from microalgae cultivated in domestic wastewater seems to be feasible.

3.2. Break-even analysis

Break-even analysis was performed to determine the biodiesel selling price at which no profit is achieved. The break-even analysis disclosed that the minimum biodiesel selling price per ton is US$ 843 (US$135/barrel) based on *Nannochloropsis sp.* cost of US$400 per ton, and the maximum algal biomass cost per ton is US$461 for algal biodiesel spot of US$1000 per ton. Crude oil prices are continuously changed as in 2010 year, the Brent Crude Oil Spot per barrel was US$77, and rose to US$120 in 2012 then declined to US$36 in December 2015 according to EIA statistics (Jan 2016). Consequently, the standard diesel prices are changed. However, Brent Crude Oil Prices will be in range of US$40–60 per barrel up to 2020 as appreciated by the Kuwait Administrator at OPEC in January 2016.

Algal biodiesel project would be feasible in Egypt if its price became comparable to international diesel fuel prices. Based on the monthly average prices of Brent Crude Oil, break-even oil barrel chart for biodiesel industry is presented in Fig. 3. Accordingly, the break-even biodiesel cost (US $135/barrel) and petro-diesel prices are matched in four points, the corresponding Brent Crude Oil Spot at any point does not exceed US$100 per barrel. Therefore, the recent project will only be feasible if the Crude Oil Spot per barrel exceeds US$100. In any case, it is more economical to blend the algal biodiesel with jet fuel instead of blending to petro-diesel [1].

3.3. Sensitivity analysis

Feedstock cost is the limiting factor of algal biodiesel commercialization. The capital investment is assumed to be recovered within the first year where the production only reaches 50% of the full capacity, while the second year onwards rose to 100% of total production capacity. An annual increase of 10% is suggested for TPC. Concerning the break-even analysis results, the algal biodiesel spot per ton should be above US$843 and the variations in algal biomass cost must be limited to maintain its price below US$461 per ton for the recent Egyptian case study.

Lipid content is a major critical issue in selecting the sustainable algae strain. Sensitivity analysis was performed with variations in algal lipids content from 15% (e.g. *Chlorella sp.*) to 60% (e.g. *Phaeodactylum tricornutum*) (Sharma, K. *et al.,* 2012) and the financial analysis of the project was reported using Tornado Chart (Fig. 4). For a profitable algal biofuel project (EP > zero), the microalgae oil content cannot decline below 35%. To obtain ROI greater than 20% and payback time less than 5 years, the lipids content should be above 38.8%, at which the economic potential (EP) is US$68,339,200. Therefore, sensitivity analysis indicated that the algal biodiesel commercialization in Egypt can be implemented using

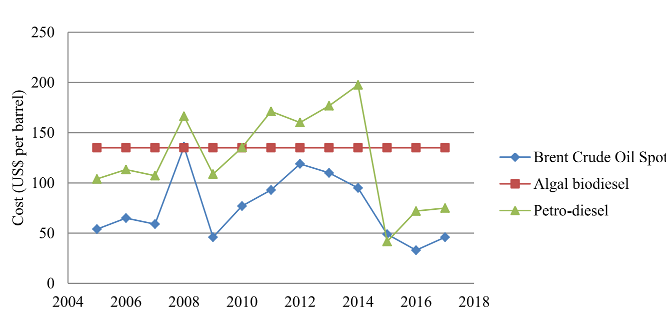

Fig. 3. Break-even oil barrel chart.

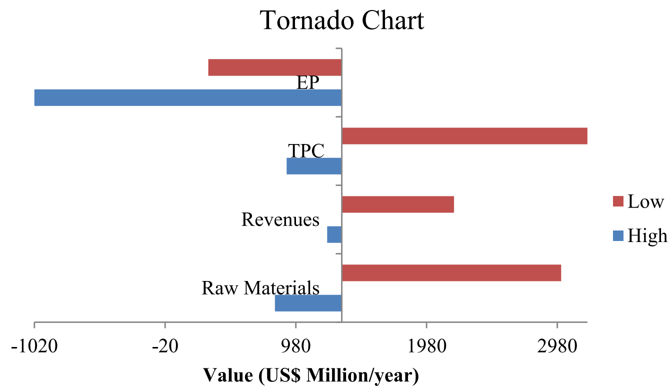

Fig. 4. Tornado Chart for variations in algal lipids%.

heterogeneous transesterification of microalgae grown on domestic wastewater provided the lipid content exceeds the above figure.

3.4. Contrast between using algal biodiesel versus Jatropha curcas biodiesel

Industrialization of Jatropha *curcas* biodiesel is considered by many researchers to be the future fuel with the recent success of 2000 acres plantation in Egyptian locations such as Aswan, Kina, Luxor, Suhag, El Wadi El Gadeed and Abu-Rawash using primary treated municipal wastewater besides its oil content of up to 40% (Tewfik S. *et al.,* 2012; [24]). Jatropha biodiesel is an integrated project including seeds harvesting, crushing, oil extraction and transesterification stages and its economics were evaluated on the basis of approximately 3.15 t seeds are produced per acre by year three, in which 2.4 t are hulls that can be utilized as a feedstock for biogas production with US$120 per ton [24]. Also, after oil extraction, the seedcake can be used as a fertilizer owing to the rich ratio of N:P:K 12:24:12, where 1 t of Jatropha seeds produces about 200 kg of fertilizer and the price was estimated to be US$42 per ton [10]. During the transesterification process, high amounts of FFA and potassium phosphate are also generated on sedimentation, and discharged into soap manufacturing [17].

For 1.0 MT Jatropha biodiesel project, a 3.8 MT of seeds are required and the cost of seeds per ton was evaluated by the Egyptian Ministry of Agriculture to be US$250 [13], hence the capital investments of Jatropha *curcas* biodiesel are still high besides many risks such as climate extremes at flowering, insufficient labor at harvest, and mishandling of seed or oil- resulting in rise in free fatty acids, and fall in value (Tewfik S. *et al.,* 2012). Accordingly, the potential use of Jatropha *cuscas* as a feedstock for biodiesel production does not seem to be, at present, a tempting alternative.

The main contrast between using algal biodiesel versus Jatropha *curcas* biodiesel is the feedstock sustainability since more than 1.25 Million acres are required for Jatropha *curcas* plantation, which is a formidable figure. Furthermore, huge amounts of irrigation water, estimated as 4000 billion cubic meters per year, are required during the plantation stage of Jatropha *curcas* for the production of 1.0 MT biodiesel which seems impossible since Egypt annual share from the Nile River does not exceed 55 billion cubic meters [19,20]. On the other hand, the required algal cultivation area depends on the cultivation system (open ponds or photobioreactors), the strain type and its lipid content; for *Nannochloropsis sp.* of 44% lipid content and biomass productivity of 135 mg per liter per day [8]. The open pond area necessitated is about 90,000 acres. Therefore, industrialization of algal biodiesel seems to be currently more realistic than Jatropha biodiesel.

4. Concluding remarks

This study presents a techno-economic assessment of 1.0 MT biodiesel production through Na_4SiO_4 transesterification of *Nannochloropsis sp.* microalgae grown on domestic wastewater obtained from Zenien treatment plants. The following results were obtained:

1. Purchased cost of equipment (PCE), total capital investment (TCI), total production cost (TPC) and net profit were estimated to be US$ 81 million, US$ 344 million, US$ 1.2 billion and US$ 141.3 million, respectively.
2. Algal biodiesel project of 1.0MT annual capacity was recommended to be an economic alternative with annual revenues, return on investment (ROI) and pay-back period of US$1.34 billion, 41% and 2 years respectively, based on the marketed biodiesel price of US$1000 per ton and appreciated algal biomass cost of US$400 per ton.
3. Break-even analysis indicated that the price of algal biodiesel that makes the project feasible is at least US$843 per ton while the cost of algal biomass should not exceed US$461 per ton.
4. Commercialization of algal biodiesel business in Egypt will be feasible when the algae lipids content exceeds 35% and the barrel cost of Brent Crude Oil Spot gets over US$ 100.
5. A comparison between using algal biofuel against Jatropha to produce biodiesel indicated that the industrialization of Jatropha biodiesel seems to be non-realistic due to the huge Jatropha plantation area and excessive irrigation water required.
6. Mandating of B5 (5% algal biodiesel and 95% fossil diesel) can be applied in Egypt by 2020.

Author contributions

Hassan I. El Shimi conducted the techno-economic assessment using the data collected from literatures, and analyzed the results and contributed to the writing of the manuscript; and Soha S. Moustafa assisted in the revision of manuscript. The final version was approved by all authors.

Conflicts of interest

The authors declare no conflict of interest.

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