Production of Bio Diesel Oil from Algae in Coastal Area of Balochistan-Pakistan

Bashir Ahmed Leghari, Syed Ali Raza Shah, Wazir Muhammad Leghari, Abdullah Mengal, Mohammad Mushtaque.

Abstract:- Transportation is the backbone of our society, powering the economies of the world every day. The Transportation network is responsible for a large amount of the hazardous emissions causing global warming and air pollution problems worldwide. Bio-diesel is one of the most important suitable oil to eliminate greenhouse gases emissions and alternative of the fossil fuels. The demand of energy is increasing on day-to-day basis, because enhancement in industrialization and population. Bio-diesel (mono-alkyl-esters) is the substitutive fuel, which obtained through the process of transesterification of monohydric alcohols with triglyceride oil. Bio-diesel oil obtained from the renewable sources of fuel having no properties of degradable and toxic. The waste cooking oil, such as sunflower, canola, soybean, coconut, corn oil, fish oil, rice bran, chicken fat, and algae can be used for preparation of Bio diesel, by adopted this process, the dependency on petroleum-based fuel decreased partially. This paper will focus on production of bio diesel oil from algae (micro algae and macro-algae) having higher efficiency of photosynthetic process by the other biomass products. The algae are best sources for the production bio-diesel, and having best yielding stock for bio-diesel. The macro algae is available in abundant in the form of seaweed at coastal area of Balochistan which extends over 750 kms. The micro algae cultivated near the beach of coastal area either in wet land (ponds) or in saline lagoons. It will provide main source of income to the people of coastal area inhabitants and consequently, it will provide good opportunity to the Govt. in order to reduce the rate of unemployment within Balochistan. The national bio-diesel project can be launched in the coastal area, taking the stakeholders in confidences. It will play an important role in alleviation the rate of poverty among the people of Balochistan. Secondly, it will save the fertile land of other provinces, which are more suitable for cultivation of food commodities instead of fuel producing species; otherwise, it will adversely affect the economy of the country, due to the shortage of food commodities. The pollution in air as well as in aquatic life of marine will reduced. It will produce the best result, by adopting of Bio-diesel fuel in Transport sector.

Index Terms— Algae, Algal oil, Bio-diesel, Transesterification, Glycerin, Coastal area, Marine species, Air pollution, Water pollution.

1 INTRODUCTION

THE area of Balochistan province is about 347,190 sq.km that is about 43.6 % of the area of Pakistan, and situated in the southwestern part of Pakistan. It has large area but having smallest population in scattered position. The coastline is about 760 Km long extended from Hub adjacent Karachi, up to the Gwadar seaport bordering to Iran-Pakistan. There is variety of marine life available in the blue seawater. The sunny beaches provided amazing environment. Coastal area of Balochistan consisting over the towns, such as Jiwani, Pasni, and Gwadar, now this area is most viable for the foreign investment and local businesspersons. All these towns connected with Karachi through air. Since there is no extensive hinter land near coastal towns, so they remain undeveloped. However, development of Gwadar port project and construction of Makran Coastal Highway, the economical activities will be flourishing in the entire area of Balochistan generally, and coastal belt particularly [1].

1. *Bashir Ahmed Leghari,(Corresponding Author)* baleghari@gmail.com
2. *Syed Ali Raza Shah,* dopazi@yahoo.com
3. *Wazir Muhammad Leghari,* niaz1111@yahoo.com
4. *Abdullah Mengal,* ahmengal@yahoo.com
5. *Mohammad Mushtaq Rajput,.*Mushtaq@buetk.edu.pk

[1,2,4,5] Assistant Professor, Mechanical Engineering Department.
[3] Lecturer Electrical Engineering Department.
Balochistan University of Engineering & Technology, Khuzdar
URL:- http://www.buetk.edu.pk.

Bio-diesel is one of the most important suitable oil to eliminate greenhouse gases emissions and produced alternative of the fossil fuels. The demand of energy is increasing on day-to-day basis, because enhancement in industrialization and population. Bio-diesel oil obtained from the renewable sources of fuel having no properties of degradable and toxic. The waste cooking oil, such as sunflower, canola, soybean, coconut, corn oil, fish oil, rice bran, chicken fat, and algae can be used for preparation of Bio diesel, by adopted this process, the dependency on petroleum-based fuel decreased partially[2].

Bio diesel from algae, though not a new phenomenon, the recent oil crises have focused some extra advantages of algae over other Biodiesel feeding stock, such as its property of high oil yield capacity. Biodiesel is equivalent to diesel oil, normally produced from the oil crops such as sunflower, corn, soybean, and rapeseed or from waste recover cooking oil. Bio-ethanol is the bio fuel equivalent to the petroleum products and normally obtained from starchy crops such as sugar beet, sugar cane or wheat. Bio-ethane is the third type of Biofuel that is equivalent of compressed natural gas.

2 ALGAE CLASSIFICATION

Algae range from a small single celled organism to multi cellular organism. Presently there as approximately 100,000 species of Algae are available throughout the world, and every year near about 400 new species found. The study began by trying to determine which species of algae would be suitable for pro-

ducing bio-diesel. For the production of bio-diesel, the selected strain of algae must have very high growth rates and a very high lipid or oil content. Approximately 300 species of algae, identified by the National Renewable Energy Laboratory (NREL) U.S.A, as varied as the diatoms (genera Amphora, Cymbella, Nitzschia) and green algae (genera Chlorella in particular), and having best source of bio-diesel oil from algae. Diatoms, or Bacillariophytes, are unicellular, microscopic algae. These organisms are widespread in salt water where they constitute the largest portion of phytoplankton biomass [3]

TABLE-1

OIL CONTENT OF FEW MICRO ALGAL SPECIES

Micro algal species	Oil content(% dw)
Ankistrodesmus TR-87	28-40
Botryococcus braunii	29-75
Chlorella sp.	29
Chlorella protothecoides(autotrophic/ heterothrophic)	15-55
Cyclotella DI- 35	42
Dunaliella tertiolecta	36-42
Hantzschia DI-160	66
Nannochloris	31(6-63)
Nannochloropsis	46(31-68)
Nitzschia TR-114	28-50
Phaeodactylum tricornutum	31
Scenedesmus TR-84	45
Stichococcus	33(9-59)
Tetraselmis suecica	15-32
Thalassiosira pseudonana	(21-31)
Crpthecodinium cohnii	20
Neochloris oleoabundans	35-54
Schizochytrium	50-77

3 ALGAE PRODUCTION SYSTEMSSECTIONS

Algae species have the ability to produce their food by photosynthesis, a bio-chemical process in which plants and algae in the presence of chlorophyll convert the sunlight energy into chemical energy. Regardless of the type, each algae consist over carbohydrates, fats, proteins, and nucleic acids. The content in every type of algae is very percentages wise as per its family type. The fatty acid (oil) extracted and converted into Biodiesel by any process of extracting of oil. The algae growth normally depends upon sunlight, carbon dioxide and presence of water. The growth of algae achieved everywhere in any kind of environments, such like in fresh water, salty water, at sea, saline lakes, in the wastewater ponds, salt lakes, etc. Algae grew even in closed vessels. Given abundant carbon dioxide, their growth rate can be faster in closed vessel like photo bioreactors. Algae also grew in minimum space as compared to all other bio-fuel feedstock. Being on microorganism alga also requires limited nutrients for growth. Besides all these, algae are most suitable for producing more capacity of oil then other bio-fuel feedstocks. The algae feedstocks have more yields for their oil production, so it considered for the said purpose. In report of DOE (Department of Energy, Govt. of USA) has mentioned, that the energy yield per acre of land for other oily crops such soybeans and corn has less than 30 times, and some cases the estimate of yield pertaining to the algae is even higher up to 15000 gallons per acre [4]. Considering the cleaning of earth and keep it free from pollution, these algal biodieel fuels will vital role and providing helping hand in mitigation of pollution from the world. These resources are available huge quantity for utilization and for harnessing and exploration. [5]. Potential of algae oil yield in gallons per acre per year with other feedstock of oily crops for bio-fuel given in the Table-2.

TABLE-2

POTENTIAL OF ALGAE OIL YIELD IN GALLONS PER ACRE PER YEAR

Potential of oil yields in gallons per acre per year	
Fatty acid composition of algal oils used for Bio-fuel feed stocks.	Oil Yield Gallons/acre
Corn	18
Cotton	35
Soybeans	48
Mustard seed	61
Sunflower	102
Rapeseed/Canola	127
Jatropha	202
Oil palm	635
Micro Algae (10g/m2/day at15%TAG) triacylglycerols	1200
Micro algae (50 g/m2/day at 50% TAG)	10,000

The table-2 shows that the algae have more producing Biodiesel capacity than all other oily bio-fuel feedstock crops. There is different system available worldwide for the growth of algae, but some are the most commonly in use, for example, the Japanese government has developed optical fiber based reactor systems that could minimized the surface area required for algae production [6]. However, costs considering main factor while breakthroughs in these types of systems, especially for the production of fuels. The department of energy office of United States for fuel provided funds for the development of Aquatic Species Program (ASP) from 1978 to

1996. They focused on open pond raceway systems because of their relative low cost (Benemann, 1996), while the other system for production on large scale such as Algae Pond Model, which was programmed and developed in Mat-Lab to predict the energy use and emissions that result from growing algae in various regions. It was based on the results obtain during the operation of the Micro algae Outdoor Test Facility (OTF) in Roswell, New Mexico [7].

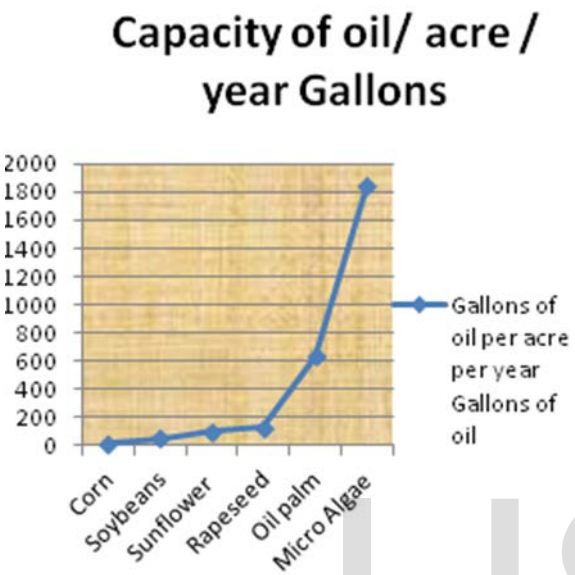

FIGURE-1 SHOWS CAPACITY OF OIL IN FALLONS/ACRE/YEAR

The Figure shows that the algae have more producing Biodiesel capacity than all other oily bio-fuel feedstock crops. There are various methods in use for extracting oil out of the seeds like hexane solvent oil extraction process, supercritical fluid extraction refining method, oil expeller method etc. Therefore, by using similar methods algae brought under process for oil production. Oil produced from the algae is equivalent to Biodiesel that is close to the petroleum diesel and that does not different from the Biodiesel refined from the vegetable/plant oils [8][9]. The Pure Biodiesel oil is less flammable than petroleum diesel oil, that start igniting at 50 0C. Due to high viscosity and flash point of Biodiesel are often use by mixing with petroleum diesel. There will be no change in engine's structure by using the mixture of petroleum diesel and Biodiesel [10]. Similarly, a US aeroplane company carried out a recent experiment by using algae oil in aeroplane during January 2009. US airline (Continental Being 737-800) completed its first test flight of 90 minutes partly powered by bio-fuel derived from algae. The chief executive described the bio-fuel as a drop in fuel "which meant that no modification to the aircraft or its engines was needed [11].

3.1. A Detailed Process of Biodiesel from Algae

The Procedure to produce the Bio diesel depending upon type of Micro Algae species that have the vital role in the production process as its details given in Figure-2.

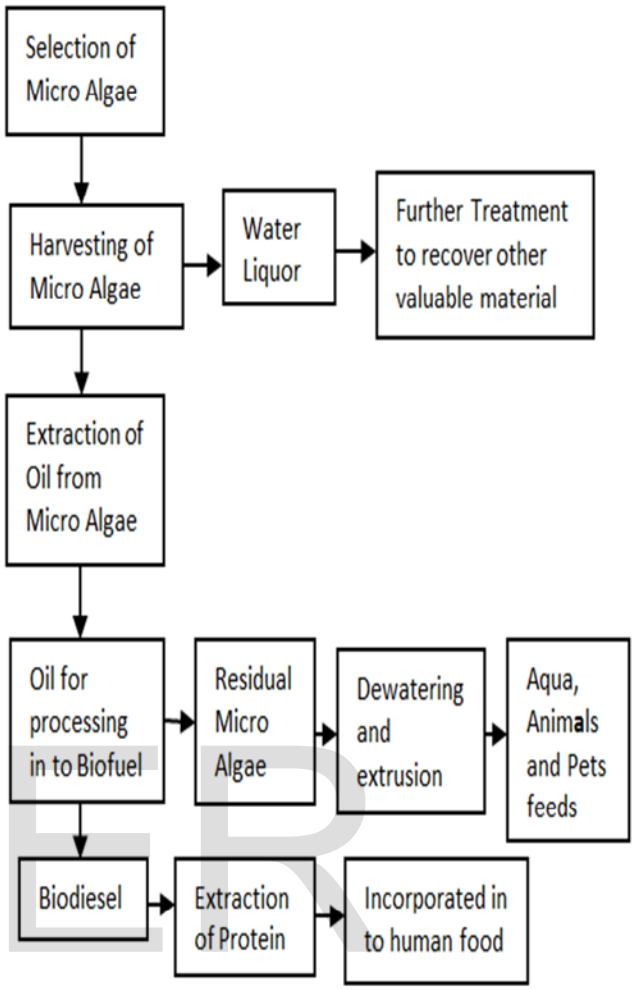

FIGURE-2, DETAILED PROCESS OF BIODIESEL FROM ALGAE

3.2. Transesterification Process.

After growing and harvesting the algae, there are a various methods to extract the oil. Any methods used for extraction, the product will a vegetable oil that known as 'green crude', which similar to the crude oil. Finally a process of 'transesterification' is used to transform the crude oil in to the biodiesel. That was not a new process, because the Scientists E. Duy and J. Patrick had already used that process as early as 1853. The first transesterified vegetable oil used for powering the heavy-duty vehicles before World War II, in South Africa [12].

Transesterification process refers a chemical reaction between ester and alcohol, and finally reaction between methyl acetate and ethyl alcohol to form ethyl acetate. The extracted liquid then mixed with vegetable oil, and entire mixture settles down after that process.In this process the Glycerin will depressed down in to the bottom while methyl esters, or biodiesel oil, will float over the top of mixture. The glycerin is normally used for making the soap (or any other by products) ,while the remaining methyl esters wash out and used after filteration process.

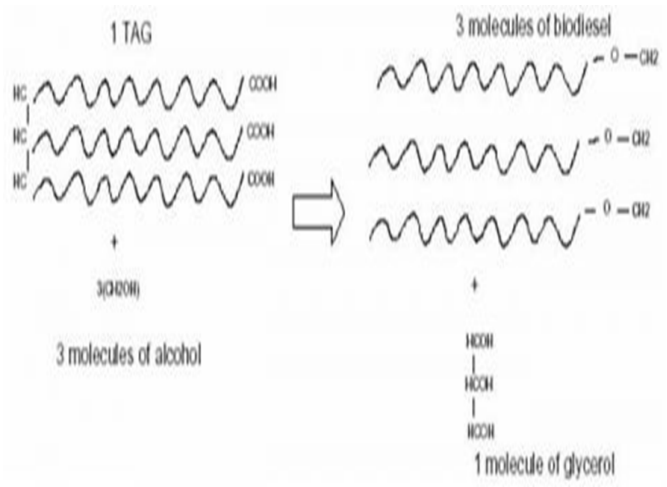

FIGURE-3 PROCESS OF TRANSESTERIFICATION PROCESS

4. CHARACTERISTICS OF BIODIESEL

1. Algae biodiesel is free from the sulfur content.
2. It increases the life of injunction fuel, and reduces wears & tears in fuel system due to the super lubricating properties of fuel.
3. It dissolves all leftover varnish residues, because it is better solvent than other petroleum products.
4. In order to avoid clogging in the Fuel system, the fuel filters changed frequently on periodical basis, after introducing Biodiesel fuel into systems formerly running on petro-diesel.
5. The density of bio-diesel has approximately 5-8 % less energy than petroleum products.
6. The combustion efficiency is higher and having good lubrication properties, so it compensated partially.
7. The use of Biodiesel fuel will affect only 2 % Overall fuel efficiency.
8. The pure (B100) Biodiesel starts to gel/solidify, at about 32 0F, due to its cloud point.
9. A blend of B20 generally does not gel in cold weather, if it has containing 20% biodiesel, 80% petro-diesel. The gel point of B100 lowered with help of different additives used in bio-diesel.
10. However, Biodiesel has 266-0F flash point that is higher than other fuels such as Petro-diesel has 147 0F, while gasoline is 52 0F only.
11. The quantity of particulate matter reduces up to the 47% against the petroleum diesel.
12. Biodiesel increasing the amount of oxygen and decreasing the solid carbon fraction, so by the virtue of this property, it will be less dangerous for particulate matter.

5. MERITS AND DEMERITS OF BIODIESEL

1. Algae has less cost and having higher yield of oil up to the Ten Thousand gallons of oil over an acre.
2. The cultivation of algae is easy and only requires sufficient amount of sunshine, so it produced in every place.
3. In order to mitigate air pollution constitutes emitted from the power plants such as NOx and carbon particulates. The biodiesel production from algae is the beneficial, if exhaust gases from the power plants are used for growth of the algae.
4. The stability of biodiesel decreased to due to the reasons that Algae has higher levels of polyunsaturated fatty acids.
5. Algal biodiesel having low melting points than other saturated or un-saturated carbons, so it is more suitable for cold weather, comparing with other bio-feedstock.
6. Poly un-saturates also have much lower melting points than mono un-saturates or saturates, thus
7. The demerit of biodiesel oil is its poor performance during the cold weather.

6. RECOMMENDATION.

1. Algae are a diverse group of simple plant like organisms, growing in fresh water and seawater, and it has capacity of producing 30 time extra oil comparing with other oily crops. The basic requirement for growth of Algae is sunlight, salts and carbon dioxide for the production of oil. Algae can be cultivated in saline land for reducing the salinity of the used land and it will also reduce quantity of the salts from saline lands. Some countries had already started projects on saline algae farming to utilize their barren lands for abundant biofuel production. Usually Algae contains about 40 percent of oil and 60 percent residual bio-matter. Hence, after extracting 40 percent of oil, which can be used for biodiesel production, while the remaining left over 60 percent bio-matter can be used for animal feed.

2. The research oriented in the area of biofuel, in order to avoid the air pollution problem related with fossil fuels coming in future. There were different procedures in practice for the production of biodiesel, bio-ethanol and biogas from various feedstocks, but there was a problem to maintain the international standard and the cost of production were the main barriers in the area of research and development of biofuel. International research organizations were in the search of producing the biofuel from the other sources such as cultivation of Jatropha and Caster oil crops etc and finally they selected algae for achieving their targets.

3. Since the saline land in Pakistan is available in abundance having very meager output, therefore it will be more suitable for the production of biofuel. Cultivation of algae would also be helpful for mitigation of carbon dioxide from air and salts from saline lands, cleaning environment along with a package of enough carbon credits to Pakistan.

4. All developed and some developing countries have established a lot of biofuel institutes and research centers to study about the possibilities regarding the use to produce biofuel in a more productive and highly sustainable manner.
5. Since Pakistan is energy deficient country and mostly depending on import of fossil fuel, so it is need of time to try for establishing a research center for Bioful, and pay attention to develop biofuel industry within the country by adopting the advance technologies.

6. Oil of 6.7 million ton imported by Pakistan during the fiscal year 2010- 2011 against $ 4686 million. By cultivation of algae in Pakistan over commercial basis, and producing the huge quantity of Biodiesel, it will reduce the bill of imported oil [13].

7. Algae have capability of producing 1200 gallons (7003.012 liters) of oil per acres and if cultivated in 1.5 million acres of saline land near the coastal area of Balochistan that can produce 6.8137 million tons of Biodiesel oil that will meet the total yearly diesel demand of the country and became self sufficient in this area.

8. At present cultivation of land are millions of acres while the same is the figure for barren land. If a little part of it utilized for algae, it will be enough for diesel needs. If biofuel produced commercially from algae, then it provided to farmers at low price for suction of underground water through pumps.

9. After extraction of oil, the leftover may be used as fertilizer for crops and as well as feedstock for the animals. Thus, algae can provide both basic inputs to farmers for better crop at low cost and feed for their animals.

10. Pakistan can use its little part of saline lands to cultivate algae, which is the best alternative feedstock to biofuel production

7. CONCLUSION.

This work focuses on the present crisis of energy faced by the country. It will open the venue for other researchers, and provided help in combating with recent problem of energy. If a little part of a saline land surrounding the coastal area of Balochistan utilized for algae, then it will be enough for diesel needs of the country and will leave better impact on the economy of whole country, with following views:-

1. Production of biodiesel from Algae are an economical choice, because of its availability and friendly environmental properties.

2. Sufficient amount of biodiesel can be produced from micro/ macro algae.

3. Biomass after oil extraction may be used for animals, while ethanol production also in paper making industries.

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8. REFERENCES

1. Aisha K and M. Shameel 1995. Some **freshwater green** algae **near**. **Balochistan coast of Pakistan**. **Pakistan** Journal of Botany 27: 41-48.
2. Saifullah, S.M., K. Aisha and F. Rasool 1997. Algal epiphytes on mangroves of Balochistan, Pakistan. Pakistan Journal of Botany 29: 191-197.
3. Research on algal biodiesel fuel is available at http://www.oilgae.com/algae/oil/biod/res/res.html
4. A.B.M. Sharif Hossain, Aishah Salleh, Amru Nasrulhaq Boyce, Partha chowdhury and Mohd Naqiuddin "Biodiesel Fuel Production from Algae as Renewable Energy" Biotecnology Laboratory, Institute of Biological Sciences, Faculty of Science, University of Malaya, Kuala Lumpur, and published in American Journal of Biochemistry and Biotechnology 4 (3):250-254, 2008 ISSN 1553-3468 © 2008 Science Publications.
5. Chaudhry Kamran Naseer, "Algae a source of biofuel, fertilizer" published in Dawn Economic & Bussiness Review April 13 ~ 19, 2009. P.III.
6. Zhang, J. and B. Hu (2012). "A novel method to harvest microalgae via co-culture of filamentous fungi to form cell pellets." Bioresource Technology 114(0): 529-535.
7. X. Liu, A. F. Clarens and L. M. Colosi, Year: 2012 "Algae biodiesel has potential despite inconclusive results to date" in Journal of Bio resource TechnologyVol-104,Pages: 803-806, ISSN: 0960-8524.
8. A. Sathish and R. C. Sims, Year: 2012 "Biodiesel from mixed culture algae via a wet lipid extraction procedure", Journal: Bioresource Technology, Vol-118 Issue: 0 Pages: 643-647 ISSN: 0960-8524
9. B. D. Wahlen, R. M. Willis and L. C. Seefeldt, Year: 2011"Biodiesel production by simultaneous extraction and conversion of total lipids from microalgae, cyanobacteria, and wild mixed-cultures", Journal 'Bioresource Technology, Volume: 102 Issue: 3 Pages: 2724-2730, ISSN: 0960-8524.
10. X. Wu and D. Y. C. Leung, Year: 2011"Optimization of biodiesel production from camelina oil using orthogonal experiment" Journal: Applied Energy Volume: 88 Issue: 11 Pages: 3615-3624 ISSN: 0306-2619

11. S. A. Scott, M. P. Davey, J. S. Dennis, I. Horst, C. J. Howe, D. J. Lea-Smith and A. G. Smith, Year: 2010 "Biodiesel from algae: challenges and prospects" Journal: Current Opinion in Biotechnology, Volume: 21, Issue: 3 Pages: 277-286 ISSN: 0958-1669.
12. T. M. Mata, A. A. Martins and N. S. Caetano, Year: 2010 "Microalgae for biodiesel production and other applications" Journal of Renewable and Sustainable Energy Reviews" Vol-14, Issue:1, Pages: 217-23207.020 ISSN: 1364-0321
13. Information about Import of diesel oil and petroleum products from other countries, during 2010-2011, available information at http://www.mpnr.gov.pk.