GUJARAT TECHNOLOGICAL UNIVERSITY

Chandkheda ahmedabad

Gujarat Technical University

LUKHDHIRJI ENGINEERING COLLEGE
MORBI

A
Project Report
On

PRODUCTION OF BIOFUEL FROM ALGAE

Under subject of
Project 1
B.E. Semester –VII
(Chemical Engineering Department)
Submitted by
Group ID: 61751

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Academic year
2015-16

CERTIFICATE

<u>CERTIFICATE</u>

Date: _______

This is to certify that **Karan Gupta, Mehul Patel, Devarshi Tadvi, Savaniya Arjun** of B.E. Semester VII (Chemical Engineering) has completed their work titled "<u>PRODUCTION OF BIOFUEL FROM ALGAE</u>" satisfactorily in partial fulfillment for requirement of course, Gujarat Technical University, Ahmedabad, in the academic year 2016-2017.

_____________ _____________

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ACKNOWLEDGEMENT

As a part of our study for B.E. in Chemical engineering, final year at Lukhdhirji Engineering College, Morbi, we have undertaken a project on “Production of Bio-fuel from Algae”.

It gives me immense pleasure in submitting this project report at the end of 7th semester. To show me deep sense of gratitude towards them, the word thanks is not satisfactorily, but I would like to thank them to express my gratitude in words.

I would like to present my heartiest thanks to the Prof. A.D. Kalariya, the Head of Department and the faculty guide in our project. I would also like to thank all other faculty members of Chemical department who have helped and guided us to give us broader understanding on the subject.

ABSTRACT

Now-a-days many researchers are performing various experiments on ways to substitute petrochemicals such as petrol and diesel. Till now, there is not even a single acceptable substitute for it. Researchers have come up with a partial substitute, i.e.: mixing alcohol (specifically ethanol) with petrochemicals up to a certain percentage. In this project, we aim to classify and find out a perfect, cheaper and easier way to produce ethanol from biodegradable wastes that is available plentiful in nature, like algae.

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CHAPTER 1: INTRODUCTION

Biofuel is the name given to fuel for Diesel engines created by the chemical conversion of animal fats or vegetable oils. Pure vegetable oil works well as a fuel for Diesel engines itself, as Rudolf Diesel demonstrated in his engine at the 1900 world's fair with peanut oil as the fuel. The United State Fuelling stations make biodiesel readily available to consumers across Europe and increasingly in the USA and Canada. This is an indication that biodiesel can operates in compression ignition engines like petroleum diesel without requiring no essential engine modifications. Moreover it can maintain the payload capacity and range of conventional diesel unlike fossil diesel, pure biodiesel is bio-degradable, nontoxic and essentially free of sulphur and aromatics. This work involves the study of biofuel production from green micro algae [1].

In 1942 Harder and Von Witsch were the first to propose that microalgae be grown as a source of lipids for food or fuel. Following research began in the US, Germany, Japan, England, and France on culturing techniques and engineering systems for growing microalgae on larger scales, particularly species in the genus Chlorella. Meanwhile, H. G. Aach showed that Chlorella pyrenoidosa could be induced via nitrogen starvation to accumulate as much as 70% of its dry weight as lipids [2].

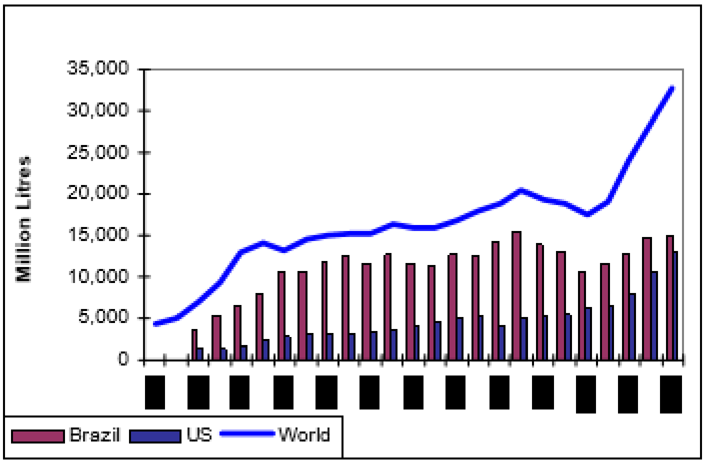

Fig. 1: Global biofuel production [2]

Biofuel is by far the most widely used biofuel for transportation worldwide. Global production reached 33 million litres in 2013 [2].

1.1: Aim of the Project

- To replace the conventional petrochemical fuels with biodiesel as an alternate fuel.

1.2: Objectives of the Project

- To make a cost effective fuel used in vehicles.
- To make some type of fuel which cannot be extinguished.
- To derive energy for a fuel from renewable resources whose frequency of availability is not fluctuating in nature due to natural or weather conditions.
- To increase the efficiency of fuel used for automobile.
- To reduce the carbon emission due to burning of fuel.
- To reduce the presence of toxic substances in fuel and thereby causing a reduction a pollution level.

CHAPTER 2:

2.1: Definition and types of bio-fuel

Biofuels can be defined as liquid fuels produced from biomass for either transport or burning purposes. They can be produced from agricultural and forest products, the biodegradable portion of industrial, residue, algae [3].

Bioethanol is a distilled liquid produced by fermenting algae and other biodegradable waste whose manufacturing process is presented in Figure 1. A second generation of bioethanol – lignocellulose - also includes a range of forestry products such as short rotation coppices and energy grasses [3]. Bioethanol can be used in pure form in specially adapted vehicles or blended with gasoline. Bioethanol can be blended with gasoline in any proportion up to 10% without the need for engine modification. Blends of 5% or 10% of bioethanol in gasoline are denominated B5 and B10, respectively [5].

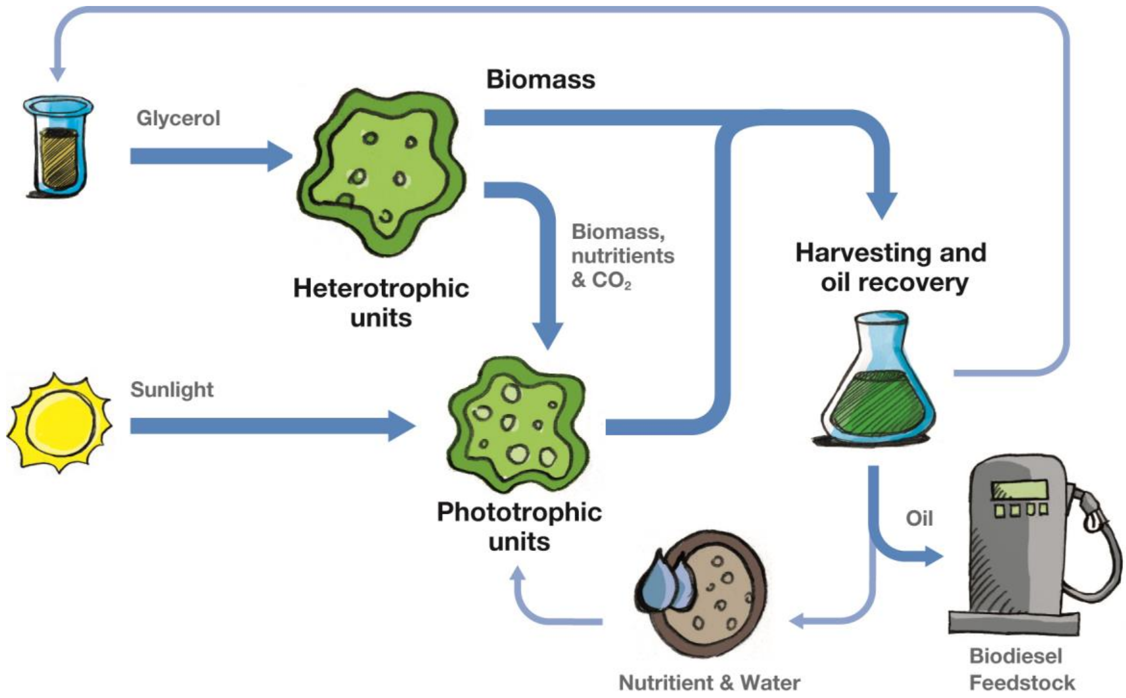

Fig. 2: Production of biofuel from algae [5].

Biodiesel is produced from the algae. With the help of sun light the photosynthesis reaction takes place with the auto tropic crop such as algae. Algae can be cultivated from the method like open pond, photo bioreactor. From the harvested algae biofuel can be extracted by extraction followed by distillation to get product of higher purity. Now the biofuel that is produced can be used as a transportation fuel by blending with the 5% to 10% with petrol and diesel. Now the waste can be used for the fertilizer.

Table 1: Characteristics of Biodiesel [1]

Sr. No.	Property	Values of algae Biodiesel
1	pH	7
2	Specific gravity	0.86
3	Density kg/ m^3	7.3
4	Cetane number	44
5	Calorific value KJ/Kg	44152
6	Moisture content %	0.001
7	Flash point ºC	52
8	Fire point ^oC	81
9	Pour point ºC	-10
10	Viscosity centi poise	9.1
11	Ash content	Nil
12	Saponification value	192
13	Cloud point ºC	-30 to -60
14	Free fatty acid value	0.9
15	Carbon residue %	0.008

2.2 Materials and Methods [1]

2.2.1 Algal Samples and Oil Extraction:

The algal samples (chlorella) collected and analysed are identified as green algae-chlorella vulgaris, dried algal biomass (5g) is to be taken in solvent mixture (100 ml) of acetone and the content were refluxed for 4 hrs. After the extraction, the contents are to be cooled and filtered (or centrifuged) to separate the biomass and washed the biomass with 25 ml of acetone twice to extract the residual lipids present in the biomass. The extracts are pooled and taken in a separating funnel and washed with 1% aqueous sodium chloride solution (50 ml) twice. The solvent removed by using rota-evaporator under vacuum to get the algal oil. The weight of algal oil is taken to determine the oil content in biomass. If the biomass is available in smaller quantities, the content may be reduced accordingly.

2.2.2 Washing and Drying:

Biofuel must be washed to remove any remaining methanol, glycerine, catalyst, soaps and other impurities. Water used is warmed to about 45 C and is passed through the esters to allow soluble material, excess catalyst and other impurities to stick to the water and be settled to the bottom of the vessel. The water is removed from the vessel periodically until the wash water drained out is clear or the pH of the biofuel becomes relatively neutral.

The biofuel washing sometimes leaves the biofuel looking a bit cloudy. This means there's still a little water in it. It is heated slowly to 100^oC and held there until all moisture present was evaporated.

2.2.3 Determination of Acid Value/Free Fatty Acid (FFA):

2g of the oil is to be measured and poured in a beaker. A neutral solvent a mixture of petroleum ether and ethanol was prepared and 50ml of it was taken and poured into the beaker containing the oil sample. The mixture is stirred vigorously for 30minutes. 0.56g of potassium hydroxide (KOH) pellet is measured and placed in a separate beaker and 0.1M KOH is prepared, 3drops of phenolphthalein indicator is added to the sample and titrated against 0.1M KOH till the colour change observed turned pink and persisted for 15minutes.

AV = 56.1*N*A/W of oil

Where; V= volume of standard alkali used;

N= normality of standard alkali used;

W = weight of oil used

FFA= AV/2

2.2.4 Determination of Saponification Value:

The alcoholic KOH is freshly prepared by dissolving KOH pellet in ethanol. 2g of oil is measured and poured into a conical flask. 25ml of the alcoholic KOH is added to it, a blank is used. The sample to be well covered and placed in a steam water bath for 30minutes shaking it periodically, 1ml of phenolphthalein is added to the mixture and titrated against 0.5MHCl to get the end point.

SV= 56.1*B – A*N/W of oil

Where; B = Volume of standard ethanol potassium hydroxide used in blank titration;
A=Volume of standard ethanol potassium hydroxide used in titration with the oil;
N=Normality of standard acid;
W= Weight of oil used.

2.2.5 Determination of Moisture Content:

In other to determine the moisture content in the oil (%), 50g of oil is weighed in a moisture pan, the weight of the pan and oil is taken and put inside an oven for 3hours at a temperature of 450^{o}C. After every 1hour, the sample is cooled and weighed until the weight before and after approximately equal.

2.2.6 Determination of Specific Gravity/Density by Hydrometer Method:

This procedure is used to measure of specific gravity of the biodiesels. A clean dry empty 50ml density bottle is to be weighed and the mass recorded as M, it is then filled up with distilled water and subsequently with the samples. The mass of the bottle and water is taken and recorded as M1 and that of biodiesel as M2 respectively hence, the specific gravity is evaluated. This procedure is used to determine the specific gravity of the sample.

2.2.7 Determination of Flash Point:

A sample of the biodiesel is heated in a close vessel and ignited. When the sample burns, the temperature is recorded; the pen sky-martens cup tester measures the lowest temperature at which application of the test flame causes the vapour above the sample to ignite. The biodiesel is placed in a cup in such quantity as to just touch the prescribed mark on the interior of the cup. The cover is then fitted onto the position on the cup and Bunsen burner is used to supply heat to the apparatus at a rate of about 5^{o}C per minute. During heating, the oil is constantly stirred. As the oil approaches its flashing, the injector burner is lighted and injected into the oil container after every 12 second intervals until a distinct flash is observed within the container. The temperature at which the flash occurred is then recorded, it is repeated three times and the average taken.

2.2.8 Determination of Cloud Point and Pour Point:

A sample of the biodiesel is placed in a test jar to a mark and then placed inside a cooling bath. The temperature at the bottom of the test jar that is the temperature at which the biodiesel starts to form cloud is taken as the cloud point. A sample of the biofuel is kept in the freezer to about 500^{o}C then placed in a heating mantle to melt. The temperature at the bottom of the test jar that is the temperature at which the biodiesel starts to pour is taken as the pour point.

2.2.9 Determination of Kinematic Viscosity:

A viscometer is inserted into a water bath with a set temperature and left for 30minutes. The sample is added to the viscometer and allowed to remain in the bath as long as it reaches the test thermometer. The sample is allowed to flow freely and the time required for the meniscus to pass from the first to the second timing mark is taken using a stop watch. The procedure is repeated a number of times and the average value are taken which is then multiplied with the viscometer calibration to give the kinematic viscosity.

2.2.10 Cetane Number:

Cetane Number is a measure of the fuel's ignition delay. Higher Cetane numbers indicate shorter times between the injection of the fuel and its ignition. Higher numbers have been associated with reduced engine roughness and with lower starting temperatures for engines.

2.3: Current scenario of biofuel in India

India’s biofuel production accounted for only 1% of global production in 2012. Bio-ethanol and bio-diesel are the two commercially produced biofuels [6]. Currently, feedstock’s such as sugarcane, maize, sugar beet and cassava are commonly exploited for bio-ethanol along with palm oil, Jatropha oil and other edible oils from various oilseed crops for the production of bio-diesel. But as the production of these fuels compete with food crops, questions regarding food security and sustainability issues arise. Hence, there is tremendous potential for second generation biofuels in India, especially for cellulosic crop such as algae [7].

Depending on the feedstock choice and the cultivation technique, second generation biofuel production such as algae has the potential to provide many benefits such as reducing competition with food consumption by making use of abandoned lands and consuming waste residues. However, current estimates indicate that the production of biofuel from algae will not be sufficient to meet India's mandated requirement of 5 per cent blending with fuels as India produces only 2% of biofuel [7].

Second-generation biofuels derived from lingo-cellulosic feedstock's can overcome the problem of feedstock availability. In India, although second-generation biofuels are still under technological investigation regarding conversion technologies and process operation, they are expected to meet the requirements for lower land use and much better CO_2 emission reduction potential after commercialisation [8].

CHAPTER 3: BRIEF LIETRATURE REVIEW

3.1: Existing potential

It is believed that the market transition from first to second-generation biofuels will be slow but steady based on this compatible infrastructure. Second-generation biofuels are compatible with today's fuels, and the necessary infrastructure may come, to some extent, from the existing infrastructure of the petroleum in India [9].

In the year 2010 to 2011, about 20 billion litres ethanol is being produce from algae and biofuel production is estimated to reach about 65 billion litres annually by 2020 to 2030 [9].

The recent World Energy Outlook (WEO) report of the International Energy Agency (IEA) projects that India's primary energy demand will increase from 750 Mt to 1200-1600 Mt (the range is defined by WEO 450 Scenario and Current Policies Scenarios) between 2010-2035 (IEA, 2013), it will likely double over these years [10].

Biofuels are considered among the most promising and economically viable alternative option, as they can be produced locally, within the country, and can be substituted for diesel and petrol to meet the transportation sector's requirements. Then there wouldn't be dependency on foreign oils, helping boost the country's overall economy [10].

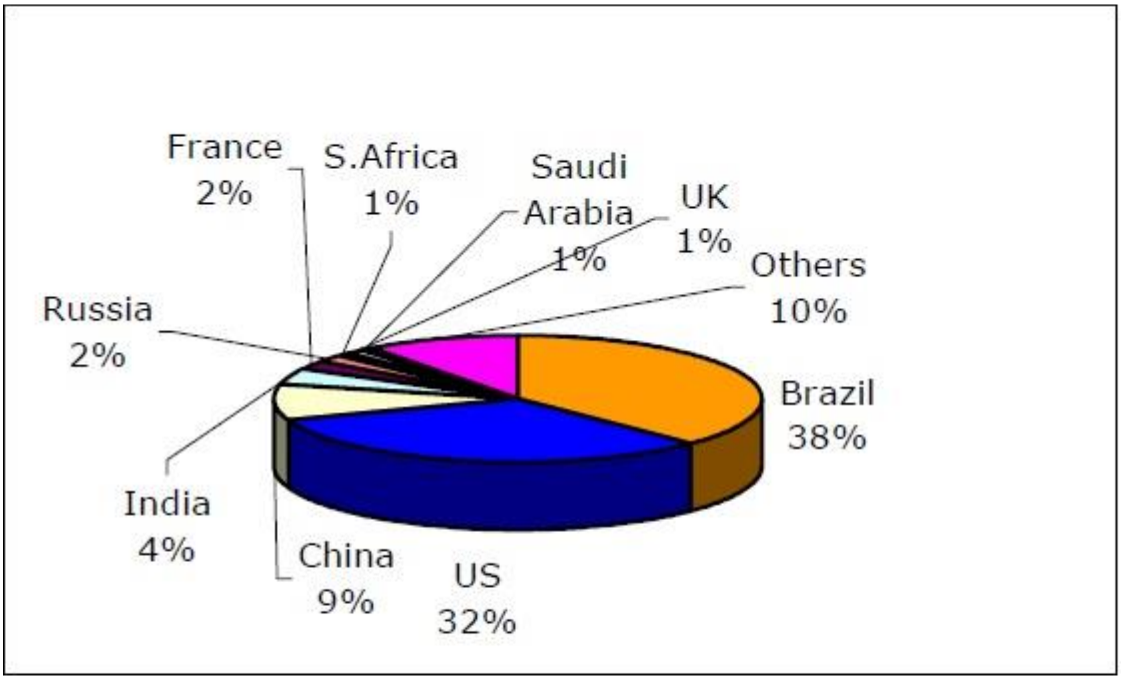

Fig.3: Top 10 countries as bioethanol producers, in 2010 [10].

3.2: The Indian Bio-fuel Policy [11]

The Indian economy is growing at the rate of approximately 7% since 2000.

The biofuel policy of India has an indicative target of 20% blending of bioethanol by 2017. India has 330 distilleries, which can produce more than 4 billion litres of rectified spirit (alcohol) per year in addition to 1.5 billion litres of fuel ethanol which could and should meet the requirement of 5% blending.

3.3: Cost Issues [12]

There are considerable challenges to making biofuels capable of competing with petroleum. Certainly, a premium price is warranted for clean fuels (fuels that have a 50% lower CO_2 cradle-to-grave footprint than petroleum); however, estimated costs of a barrel of algae-based fuel using current technology is US$10.87 gallon^{-1} to 13.26 gallon^{-1} , compared with $40–80 (2009) for petroleum. Although some estimates for a barrel of algae oil in specific regions reach as low as $84. The higher dollar estimates are more common and similar to our own estimates, and exclude algal oil from the current liquid fuel market.

An alternative co-product strategy is to genetically engineer algae to produce higher value proteins, specifically industrial enzymes and animal feed supplements. These co-products would enhance the value of the protein residual from biofuel production strains. The current market values for recombinant proteins range between US$5 and $10,000 per kg. Although the higher value end of this spectrum consists of small niche markets, there are many industrial enzymes that can be produced, with values ranging between $25 and $50 per kg, and for which large markets currently exist. With sufficient expression and economic purification of these protein co-products, the price gap between fossil fuels and algae-based biofuels can be minimized.

Table: 2 costs of algae fuel production of different leading companies [13].

Source	Scenario	Cultivation	Cost (USD gal/$)	Lipid yield (wt.% of dry mass	Areal Dry Algae Mass Yield (gm m day)
Benemann	Baseline	Open pond	1.7	50	30
Benemann	Maximum growth	Open pond	1.2	50	60
NREL	CURRENT	Open pond	10.6	25	20
NREL	AGGRESSIVE	Open pond	3.5	50	50
NREL	MAXIMUM GROWTH	Open pond	2.4	60	60
NMSU	Current, 1 acre	Open pond	38.7	35	35
NMSU	Highest yield, 1 acre	Open pond	13.9	60	58
NMSU	Current, 2000	Open pond	25.2	35	35

	hectare				
NMSU	Highest yield, 2000 hectare	Open pond	9.7	60	58
SOLIX	Current	Hybrid	31.8	16 to 47	25
SOLIX	PHASE 1	Hybrid	2.6	16 to 47	30 to 40
SOLIX	PHASE 2	Hybrid	0.9	16 to 47	30 to 40
Seambiotic/IEC, Israel	Best yield	Open pond	24.9	35	20
Sandia	CURRENT	Open	15.7	35	30
Sandia	CURRENT	PBR	33.2	35	30
Bayer Tech Services	Optimistic	PBR	14.3	33	52
General Atomic	LOW	Open/hybrid	20	Unknown	Unknown
General Atomic	HIGH	Open/hybrid	32.8	Unknown	Unknown
California Polytech, Pomona	Optimistic	Open pond	16.8	25	20
Tapie & Bernard	Tubes on ground	PBR	40.6	35	20
Tapie & Bernard	Double tubular bioreactor	PBR	33.1	35	20

3.4: Patent Search and Analysis [14].

- **Method for producing biodiesel:**

Inventors: Christoph Benning, East Lansing, MI (US); J. Michael Younger, Holt, MI (US)

The present invention relates to the production of biodiesel. In particular, the present invention provides systems and methods for fermenting biomass materials with transgenic plant materials expressing the transcription factor. Accordingly, the present invention provides methods comprising first plant material from a plant comprising an exogenous lignocellulose plant material from a second plant. Contacting the first plant material with the lignocellulose plant material under conditions such that triacylglycerol's are produced by the first plant material. In some process, the first plant material is selected from the group consisting of canola, corn, soybean, and sunflower and safflower plant material. In further process, the first plant material is selected from the group consisting of seeds, leaves, germinated seeds, seedlings and combinations thereof. In some process, the lignocellulos plant material is selected from the group consisting of perennial grass, annual grass, perennial woody plants, and crop residue. Then lignocellulose plant material is treated to hydrolyse cellulose and hemi cellulose contained in the material. In some process, the lignocellulose material is treated by a method selected from the group consisting of chemical and enzymatic treatment. The WRI1 gene is at least 70% identical to SEQID NO: 1. The WRI1 gene is operably linked to a promoter selected from the group consisting of 35S CMV promoter, Universal Seed Promoter, 2S Seed Storage Protein Promoter, Crucifer in promoter, and vicilin promoter. The methods further comprise the step of extracting the triacylglycerol's from the first plant material. The methods further comprise the step of refining the triacylglycerol's. In some method lignocellulose material is pre-treated prior to the chemical or enzymatic treatment.

CHAPTER 4: PLAN OF WORK

4.1: Possible ways to produce bio-fuel:

Most of the world's ethanol is produced by fermentation of crops (93%) with synthetic ethanol (7%) being produced by direct hydration of ethane.

The fermentation of plant material (for example, barley and rice) is the route by which alcoholic drinks (e.g. beer, whiskey, gin and vodka) are produced. It is also how bioethanol for biofuels is produced. Of the uses of bioethanol, easily the most important is as a fuel for cars but an increasing one is in the manufacture of ethane. The main uses of ethanol produced from ethane are as the chemical intermediate for:

- glycol ethers
- ethanolamine's/ethylamine's
- ethyl propionate

It is also used as a solvent in the manufacture of cosmetics, pharmaceuticals, detergents, inks and coatings.

Recently, bioethanol has become an important, used to make many polymers.

Table 3: Comparison of some sources of biodiesel [15]

Crop	Oil yield (L/ha)
Corn	172
Soya bean	446
Canola	190
Jatropha	1892
Coconut	2689
Oil palm	5950
Microalgae[(a)]	136900
Microalgae[(b)]	58700

(a) 70% oil (by wt) in biomass.
(b) 30% oil (by wt) in biomass.

4.2: Advantages of Algae over crop based Biofuels:

- Algae produces up to 300 times more oil per acre than conventional food crops, such as palms, grape seed, soybeans, or Jatropha.
- Algae has a harvesting cycle of 1–10 days, it allows several harvests in a very short time-frame, a differing strategy to yearly crops. Algae can grow 20 to 30 times faster than food crops.
- Algae can be grown on land that is not suitable for other established crops, for example arid land, land with excessively saline soil or drought-stricken land.

Table 4: Oil content of some microalgae [15]

Microalgae	Oil content(%)
Botryococcus braunii	25–75
Chlorella sp.	28–32
Crypthecodinium cohnii	20
Scenedesmus	16–37
Dunaliella primolecta	23
Isochrysis sp.	25–33
Monallanthus salina	20
Nannochloris sp.	20–35
Nannochloropsis sp.	31–68
Neochloris oleoabundans	35–54
Nitzschia sp.	45–47
Phaeodactylum tricornutum	20–30
Schizochytrium sp.	50–77
Tetraselmis sueica	15–23

From the above mentioned algae we prefer to use the Chlorella spices because of following reason

- The oil content of Chlorella algae is between 28% -32 % which is moderate. The oil content of Nitzschia species is higher compared to chlorella species but the problem is the cultivation period require for Nitzschia species is higher compared to Chlorella Sp.
- The gas liquid ratio of Chlorella algae is 1.7 % while that of the Nitzschia species is lower 0.4.
- It is easily cultivable compared to other types of algae’s.
- The land area required for cultivating Chlorella algae is less compared to other crops.
- Schizochytrium sp is having the higher oil content but it is rare species and is not available easily while that of the chlorella species is easily available can also be cultivated.

Chlorella Algae [18]

Chlorella is a genus of single-cell green algae belonging to the phylum Chlorophyta. It is spherical in shape, about 2 to 10 μm in diameter, and is without flagella. Chlorella contains the green photosynthetic pigments chlorophyll-a and -b in its chloroplast. Through photosynthesis, it multiplies rapidly, requiring only carbon dioxide, water, sunlight, and a small amount of minerals to reproduce.

The name Chlorella is taken from the Greek chloros, meaning green, and the Latin diminutive suffix ella, meaning small. German biochemist and cell physiologist Otto Heinrich Warburg, awarded with the Nobel Prize in Physiology or Medicine in 1931 for his research on cell respiration, also studied photosynthesis in Chlorella. In 1961, Melvin Calvin of the University of California received the Nobel Prize in Chemistry for his research on the pathways of carbon dioxide assimilation in plants using Chlorella.

Many people believe Chlorella can serve as a potential source of food and energy because its photosynthetic efficiency can, in theory, reach 8%, which exceeds that of other highly efficient crops such as sugar cane.

Table 5: Criteria considered for selection of chlorella algae [14]

Waste water	Algae	Cultivation period (day)	Biofuel content G/L (%)	Reactor type
Artificial wastewater	Scenedesmus	15	0.22 to 0.33	Batch
Digested effluent	Chlorella	21	1.7	Batch
Artificial wastewater	Chlorella	14	1.7	Batch
Artificial wastewater	Nitzschia	25	0.4	Semi-continuous

4.3: Possible methods for cultivation of algae [19].

4.3.1: Closed-loop system

The lack of equipment and structures needed to begin growing algae in large quantities has inhibited widespread mass-production of algae for biofuel production. Maximum use of existing agriculture processes and hardware is the goal.

Closed systems (not exposed to open air) avoid the problem of contamination by other organisms blown in by the air. The problem for a closed system is finding a cheap source of sterile CO_2. Several experimenters have found the CO_2 from a smokestack works well for growing algae. For reasons of economy, algae farming for biofuels will have to be done as part of cogeneration, where it can make use of waste heat and help soak up pollution.

4.3.2: Photo-bio-reactors

Most companies pursuing algae as a source of biofuels pump nutrient-rich water through plastic or borosilicate glass tubes called "bioreactors" that are exposed to sunlight and so-called photo-bio-reactors or PBR.

Running a PBR is more difficult than using an open pond, and costlier, but may provide a higher level of control and productivity. In addition, a photo-bio-reactor can be integrated into a closed loop cogeneration system much more easily than ponds or other methods.

Fig: 4 photo bio reactor

4.3.3: Open pond

Fig.5: Raceway pond used for the cultivation of microalgae

Open-pond systems for the most part have been given up for the cultivation of algae with especially high oil content. The entire effort is dependent upon the hardiness of the strain chosen, requiring it to be unnecessarily resilient in order to withstand wide swings in temperature and pH, and competition from invasive algae and bacteria. Open systems using a monoculture are also vulnerable to viral infection. The energy that a high-oil species invests into the production of oil is energy that is not invested into the production of proteins or carbohydrates, usually resulting in the species being less hardy, or having a slower growth rate. Algal species with lower oil content, not having to divert their energies away from growth, can be grown more effectively in the harsher conditions of an open system.

Some open sewage-ponds trial production has taken place in Marlborough, New Zealand.

4.3.4: Algal turf scrubber

Fig.6: 2.5 acre ATS system, installed by Hydromantic on a farm creek in Florida

The algal turf scrubber (ATS) is a system designed primarily for cleaning nutrients and pollutants out of water using algal turfs. ATS mimics the algal turfs of a natural coral reef by taking in nutrient rich water from waste streams or natural water sources, and pulsing it over a sloped surface. This surface is coated with a rough plastic membrane or a screen, which allows naturally occurring algal spores to settle and colonize the surface. Once the algae have been established, it can be harvested every 5–15 days, and can produce 18 metric tons of algal biomass per hectare per year. In contrast to other methods, which focus primarily on a single high yielding species of algae, this method focuses on naturally occurring polycultures of algae. As such, the lipid content of the algae in an ATS system is usually lower, which makes it more suitable for a fermented fuel product, such as ethanol, methane, or butanol.Conversely, the harvested algae could be treated with a hydrothermal liquefaction process, which would make possible biodiesel, gasoline, and jet fuel production.

There are three major advantages of ATS over other systems. The first advantage is documented higher productivity over open pond systems. The second is lower operating and fuel production costs. The third is the elimination of contamination issues due to the reliance on naturally occurring algae species. The projected costs for energy production in an ATS system are $0.75/kg, compared to a photo bioreactor which would cost $3.50/kg.Furthermore, due to the fact that the primary purpose of ATS is removing nutrients and pollutants out of water, and these costs have been shown to be lower than other methods of nutrient removal, this may incentivize the use of this technology for nutrient removal as the primary function, with biofuel production as an added benefit.

4.4: Factors for selection of suitable type of algae for maximum biofuel production

1.) High oil content.
2.) Easier growth of algae.

Hence, as per the selection factors, we have selected Chlorella type of algae for our project because of its special features and higher side of oil content which will be eventually useful to produce more amount of bio-fuel. It is a freshwater algae which is easily available in freshwater resources like rivers. It is rich with phytonutrients, including amino acids, chlorophyll, beta-carotene, potassium, phosphorous, biotin, magnesium and the B-complex vitamins.

Fig. 7: Chlorella algae in a freshwater body [17].

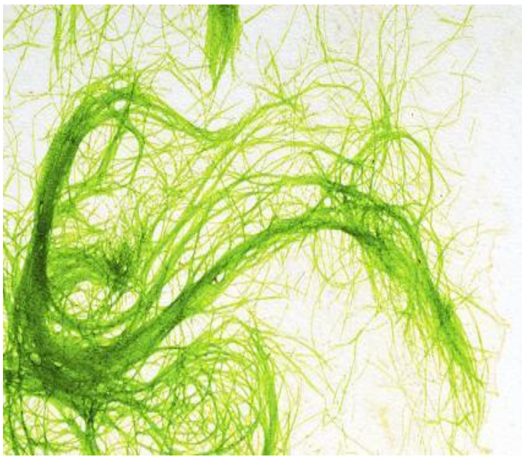

Fig. 8: Chlorella algae extract [17].

CHAPTER 5: CANVAS

5.1: Observation Matrix

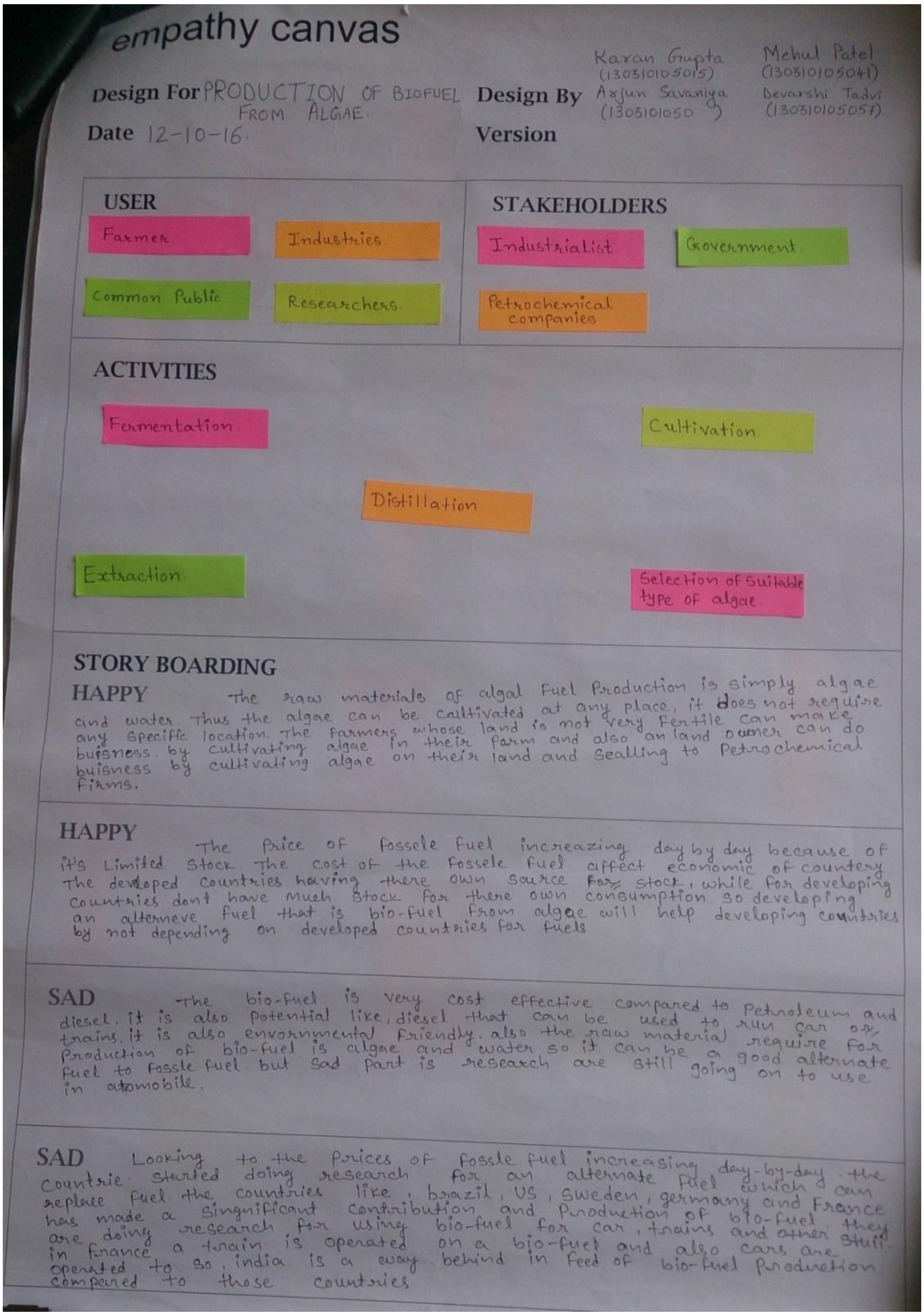

Fig.9: Empathy Canvas

User:

- Farmer
- Common public
- Industries
- Researcher

Stakeholders:

- Industrialist
- Petrochemical companies
- Government

Activities:

- Fermentation
- Extraction
- Distillation
- Cultivation
- Selection of suitable type of algae

Happy:

The raw material of algae fuel production is simply alage and water. Thus the algae can be cultivated at any place, it does not require any specific location. The farmer whose land is not very fertile can make business by cultivating algae in their farm and also land owner can do business by cultivating algae and sell it to the petrochemical firms.

Happy:

The prices of fossil fuel are increasing day by day because of its limited stock. The cost of the fossil fuel effect the economy of countries. The developed countries having their own source or stock. While for the developing countries don’t have much stock for their own consumption. So developing an alternate fuel i.e. biofuel from algae will help the developing countries by not depending on the developed countries for fuel.

Sad:

The biofuel is very cost effective compared to petrol and diesel. It is also potential like that of diesel that can be used to run a car or train. It is also environmental friendly. Also the raw, material required for the production of biofuel is algae and water. So it can be a good alternate fuel to fossil fuel. But sad part is that research is still going on to be used in automobile.

Sad:

Looking to the price of fossils fuel increasing day by day. The countries started doing research for an alternate fuel which can replace fuel. The countries like Brazil, US, Sweden, Germany and France has made a significant contribution in production of biofuel. They are doing research for using biofuel for cars, train and other stuff. In France a train is operated on a biofuel and also car are also run on biofuel. India is a way behind in field of biofuel production compared to those countries.

5.2: IDEATION CANVAS

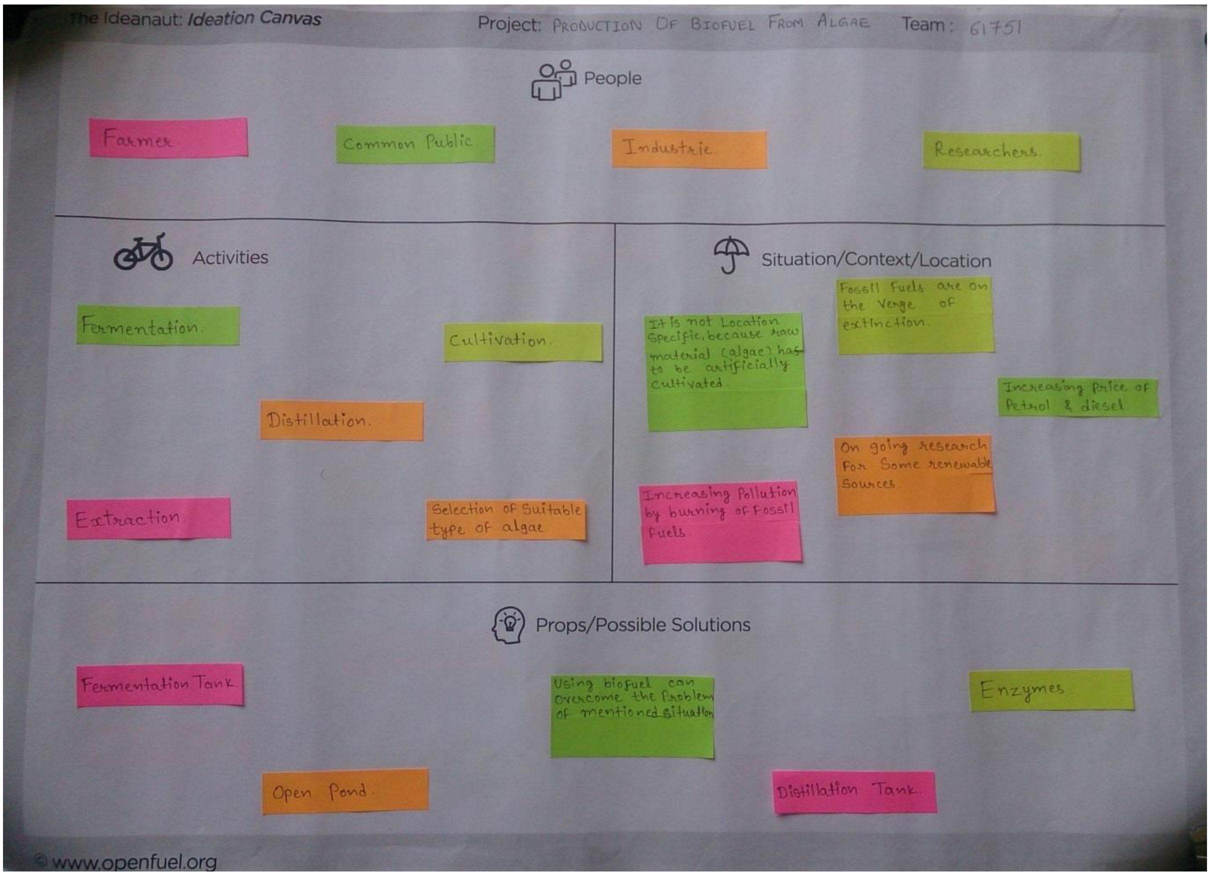

Fig.10: Ideation Canvas

Situation

- It is not location specific as raw material has to be artificially cultivated.
- Fossil fuels are on verge of extinction.
- Increasing pollution by burning of fossil fuel.
- Increasing price of fossil fuel day by day.
- On-going research for some renewable sources.

Props/Possible Solutions

- Using biofuel can overcome the mentioned problem.
- Open Pond
- Fermentation tank
- Distillation tank
- Enzymes

5.3: PRODUCT DEVELOPMENT CANVAS

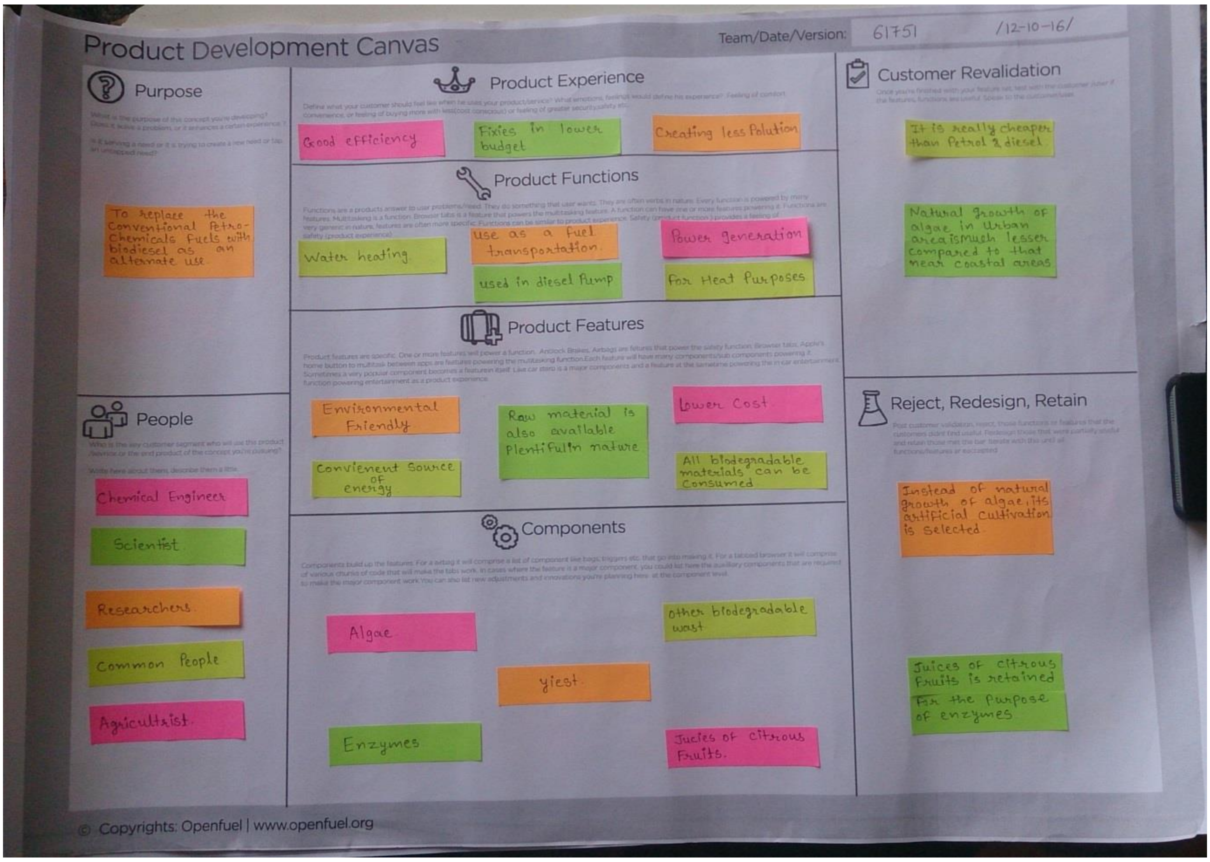

Fig.11: Product Development Canvas

Purpose

To replace the convectional petrochemicals fuels with biodiesel as an alternate use.

Product Experiences

- Good efficiency
- Fixes in lower budget
- Creates less pollution

Product functions

- Use for heating purpose
- Use for power generation
- Use in automobile
- Diesel pump
- Water heating

Product features

- Environment friendly
- Lower cost
- Less pollution
- Convenient source of energy
- Raw material are available easily

Components

- Algae
- Enzymes
- Yeast
- Other citreous food material
- Other biodegradable waste

Customer Revalidation

- It is cheaper than other petrol and diesel
- Natural growth of algae in urban areas is much less compared to that at coastal areas.

Reject, Redesign and Retain

- Juices of citrus fruit are retained for the purpose of enzymes.
- Instead of natural growth of algae its artificial growth is selected.

5.4: AEIOU SUMMARY

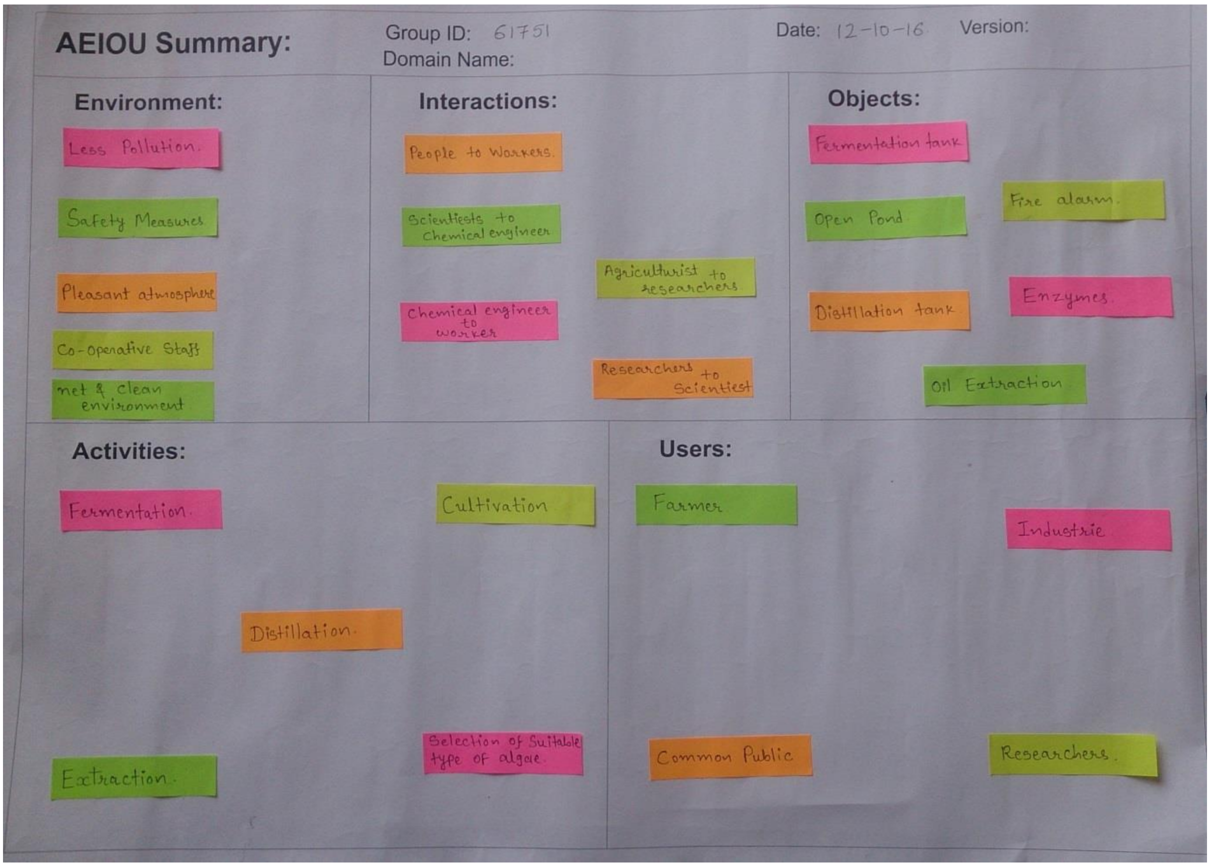

Fig.12: AEIOU Summary

Environment

- Less pollution
- Safety measures
- Pleasant atmosphere
- Co-operative shaft
- Neat and clean environment

Activities

- Fermentation
- Extraction
- Distillation
- Cultivation
- Selection of suitable type of algae

Interaction

- People to worker
- Scientist to chemical engineer
- Chemical engineer to worker
- Agriculturist to researcher
- Researcher to scientist

Objects

- Open Pond
- Fermentation tank
- Distillation tank
- Enzymes
- Fire Alarm
- Oil extraction

User

- Farmer
- Common public
- Industries
- Researchers

Chapter 6: FUTURE SCOPE:

In future we are going to carry the experiment of producing biofuel from the algae that we have selected in this semester. In current semester we have selected the algae and processes that we are going to use in future for production of biofuel. First of all we will carry out the fermentation of algae and collect algae oil. Then from algal oil, oil can be extracted using oil press and extraction followed by distillation.

In future the biofuel can be used as transportation for vehicle or train by blending 15% to 20% with petrol and diesel. From the recent fact Indian railway use diesel with blending 5% biofuel in shatabdi train now the results they found that about 300 to 400 core rupees can be saved annually using biofuel. So research can be done in this filled for using more of biofuel.

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