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Data Analysis on Biomass Pyrolysis

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Abstract: *Biomass is a promising sustainable and renewable energy source due to its high diversity of sources, and as it is profusely obtainable everywhere in the world. 50% of the global population uses biomass as a source to generate energy and heat. Recent advances in biomass availability and technology allow its use as a renewable energy source with low emissions and environmental impact. Biogas, bio-liquid, and bio-solid fuels replaces fossil fuels in power and transportation. The report examines pyrolysis products, their yields, and biomass product characteristics, as well as the current pyrolysis technique and potential concerns. This study found that the properties of pyrolysis products depend on the proximity and ultimate analysis parameters. We have predicted yield of bio-oil and H2 content in yield from proximate and ultimate analysis parameters. We have used machine learning algorithms like Multiple Linear Regression, Multivariate Polynomial Regression and Random Forest regression to predict the yield and H2 content in yield.*

Keywords: Renewable energy; biofuel; environment; technology development.

I. INTRODUCTION

Energy consumption nowadays is enormous, a vital determinant in a country's development, and energy scarcity has turned into a threat to the economic growth of countries throughout the world. "Energy is a key component of our existence," it is said. We cannot possibly imagine economic expansion in the absence of energy. However, not everyone has access to contemporary energy services despite their importance. Due to global population increase, continued economic development, and technological improvement, today's energy needs are on the rise. Due to their high calorific values, effective knock-resistance, and high heating values, fossil fuels are currently the primary source of energy; yet, their supplies are finite. Therefore, by lowering their usage, the development of alternative energy sources can slow the depletion of fossil fuels. On the other hand, global warming is getting worse every day. The dangerous CO2 threshold that was expected to be crossed in next 10 years has now been reached in the atmosphere. The search for alternative energies and renewable energy sources that can supply the world's energy demand, reduce greenhouse gas emissions, curb pollution, and maintain the planet's temperature at a stable level has also been sparked by the depletion of fossil fuels and drastic climate change. Due to its high availability and diversity among alternative energy sources, biomass can emerge as a promising sustainable energy source. All organic material that is biodegradable and comes from plants, animals, or microorganisms is referred to as biomass. This term also covers agricultural products, waste from agricultural processes, byproducts, and non-fossil organic waste generated by municipal and industrial waste. The third most significant source for thermal and electrical uses is biomass. Banana peels, rice and coffee husks, sugarcane bagasse, byproducts of the manufacturing of palm oil, and animal waste are the most typical biomass feedstocks. In addition to modest amounts of minerals and organic materials, biomass also contains carbon, oxygen, hydrogen, nitrogen, Sulphur, and chlorine. Through the thermal conversion of biomass, various forms of energy can be created, including combustion, pyrolysis, gasification, fermentation, and anaerobic decomposition. When a fuel is burned, it undergoes a chemical reaction known as oxidation, which releases a significant quantity of energy in the form of heat. This process is known as combustion (exothermic reaction). In the absence of oxygen, a thermal degradation process known as pyrolysis occurs. Pyrolysis is the first phase in the combustion and gasification processes, and then the principal products are completely or partially oxidized. The process of gasification involves heating organic material while reducing 2 the oxygen content to produce power. Yeast is used in the fermentation process to make alcohol from organic sources, which is then utilized to power automobiles.

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Biogas is created by anaerobic decomposition, which also produces electricity.

II. OBJECTIVE

The utilization of machine learning algorithms in order to make predictions regarding the yield of bio-oil as well as the H2 Content based on biomass compositions of feedstock and pyrolysis settings is the purpose of the work that is being done for this project. Multiple linear regression (MLR), multivariate polynomial regression (MPR), and the random forest (RF) method were all effectively employed and contrasted in this context. The findings demonstrated that MPR is more accurate than MLR and RF in estimating the amount of bio-oil that will be produced. In addition to this, the profound information that underpinned the model was uncovered. Aside from that, the information obtained by proximate analysis and ultimate analysis was preferred to determine yield, which was the same for H-bio-oil. Because of this effort, we now have a reference for improving the bio-oil, and our knowledge of the biomass pyrolysis process has been expanded.

III. LITERATURE SURVEY

Different parameters of proximity and ultimate analysis of Bio mass Pyrolysis have been gathered and combined into a single data-frame for prediction of our models. This dataset can also be used for further predictions.

Name	Ash	FC	V	C	H	N	O	HTT	HR	FR	YIELD	Ref.
Palm shell	9.024	13.85	77.125	52.05	5.37	0.49	42.1	500	10	2000	47.73	8
EFB	3.115	11.6	85.285	43.06	5.98	0.55	50.42	500	10	2000	45.75	8
Mesocarp fiber	6.346	8.315	85.334	45.03	6.15	0.94	47.89	500	10	2000	43.87	8
Trunk	5.27	4.97	82.6	42.72	5.61	0.44	51.24	500	10	2000	40.87	9
Frond	0.24	3.22	82.7	42.76	5.99	0.39	50.88	500	10	2000	43.5	9
Palm leaf	12.32	11.92	66.76	42.76	5.99	0.39	50.88	500	10	2000	16.58	9
Palm leaf rib	4.26	11.79	75.94	43.76	6.3	0.38	49.57	500	10	2000	29.02	9
rapeseed oil cake	7.02	-	-	45.92	6.23	6.74	33.17	500	20	100	32.2	10
rapeseed oil cake	7.02	-	-	45.92	6.23	6.74	33.17	500	20	100	34.6	10
Moso bamboo	1.12	12.65	86.23	47.2	5.77	0.27	44.23	300	10	500	26.5	11
Moso bamboo	1.12	12.65	86.23	47.2	5.77	0.27	44.23	400	10	500	35.2	11
Euphorbia rigida	6.701	14.742	78.56	53.6	8.3	2.2	35.9	400	7	400	24.0351	12
Euphorbia rigida	6.701	14.742	78.56	53.6	8.3	2.2	35.9	500	7	400	31.0526	12
Sunflower pressed bagasse	6.164	15.41	78.427	49.6	7.4	4.4	38.5	400	7	200	36.1364	12
Sunflower pressed bagasse	6.164	15.41	78.427	49.6	7.4	4.4	38.5	500	7	200	44.0909	12
Hazelnut shells	0.753	18.602	80.645	51.3	5	0.5	43.2	400	7	100	20.0897	12
Hazelnut shells	0.753	18.602	80.645	51.3	5	0.5	43.2	500	7	100	23.0045	12
S. dimorphus microalgae	17.33	31.13	51.45	52.6	6.21	8.75	31.92	300	10	100	29.7973	13
S. dimorphus microalgae	17.33	31.13	51.45	52.6	6.21	8.75	31.92	400	10	100	33.2432	13
grape bagasse	5.01	22.05	72.94	46.59	6.25	1.67	45.49	550	50	50	25.58	14
grape bagasse	5.01	22.05	72.94	46.59	6.25	1.67	45.49	550	50	100	27.6	14
Babool seed	8.352	12.586	79.062	54.1	6.12	5.23	34.53	600	25	100	34	15
Babool seed	8.352	12.586	79.062	54.1	6.12	5.23	34.53	700	25	100	29.9342	15

safflower seed	2.33	11.98	85.68	60.46	9.08	3.1	27.36	500	5	0	39.0663	16
safflower seed	2.33	11.98	85.68	60.46	9.08	3.1	27.36	550	5	0	38.9759	16
Hornbeam shell	9.742	9.589	80.669	41.78	5.36	0.6	52.26	500	7	0	21.8817	17
Hornbeam shell	9.742	9.589	80.669	41.78	5.36	0.6	52.26	550	7	0	22.04	17
Olive residue	4.139	17.114	78.747	44.82	5.08	0.92	49.18	700	7	0	30.2	18
Olive residue	4.139	17.114	78.747	44.82	5.08	0.92	49.18	500	7	50	37.043	18
soybean cak	6.145	15.706	78.149	55.89	6.57	9.29	28.25	500	5	0	27.4	19
soybean cak	6.145	15.706	78.149	55.89	6.57	9.29	28.25	550	5	0	30	19
Lemon grass	8.643	26.706	64.651	39.34	5.81	1.54	53.3	400	30	0	32.4742	20
Lemon grass	8.643	26.706	64.651	39.34	5.81	1.54	53.3	450	30	0	36.0309	20
hazelnut cupula	6.02	13.96	70.16	51.15	5.89	2.12	40.84	500	200	200	48.9043	21
hazelnut cupula	6.02	13.96	70.16	51.15	5.89	2.12	40.84	600	200	200	52.3478	21
hazelnut bagasse	6.56	15.25	68.22	43.8	6.29	7.92	41.99	500	50	0	30.1691	22
hazelnut bagasse	6.56	15.25	68.22	43.8	6.29	7.92	41.99	550	50	0	28.43	22
pine chips	0.35	12.61	87.04	46.08	5.29	0.22	48.41	550	40	0	26.2081	23
pine chips	0.35	12.61	87.04	46.08	5.29	0.22	48.41	500	40	50	30.8194	23
sunflowerextracted bagasse	6.421	11.053	82.526	53.2	7.1	8	31.7	550	7	200	21.9809	24
Sunflower extracted bagasse	6.421	11.053	82.526	53.2	7.1	8	31.7	550	7	500	20.3732	24
oilseed	4.2	14.7	72.6	53.1	6.2	0.8	39.9	400	300	100	30.2	18
oilseed	4.2	14.7	72.6	53.1	6.2	0.8	39.9	400	300	200	30	18
Soybean cake	5.63	14.39	71.6	55.89	6.57	9.29	28.25	700	300	100	35.8503	25
Soybean cake	5.63	14.39	71.6	55.89	6.57	9.29	28.25	550	5	200	34.7586	25
sesame stalk	6.63	9.87	74.8	52.43	6.09	0.62	40.86	550	300	0	35.5396	26

TABLE 1: Dataset for Bio-oil

IV. EXISTING SYSTEM

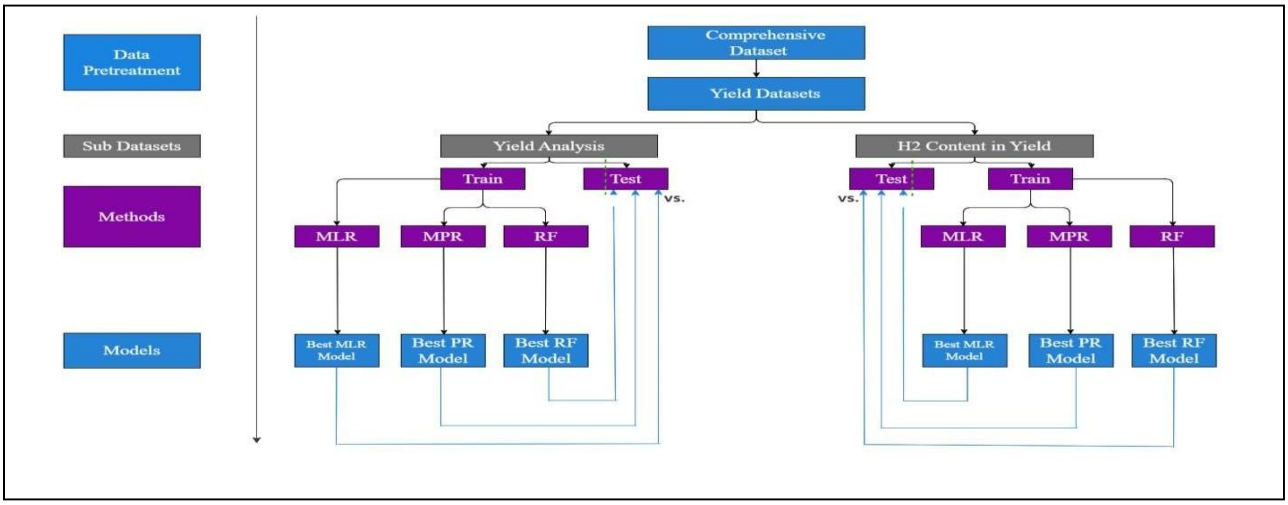
The Present existing system is based on the petroleum resources that are non- renewable and the data which is having the data about the petrol and other petroleum products. There is no existing system about the particular biomass pyrolysis. As the current system will release more amount of carbon di oxide as this harms the environment and damages the health of the living people and it also increases the greenhouse gases in the atmosphere.

V. PROPOSED SYSTEM

In the proposed system it will use the biomass which means bio is life and mass means things, which means the living things that are present in the environment. The petroleum products like petrol, diesel etc will give high pollutants when compared to biofuel as it gives the less pollutants. In this system we will use a dataset and gives the amount of yield that a given biomass is used for the production of the biofuel. In this the main advantage is used for mainly for the industries as they use the energies in huge amount for the production and it will take high loss for the customers and producers as they spend more amount of energy in the production. So, by using the energy which is produced by using the biomass it will take less cost margin when compared to the petroleum products and gives high profits to both the customer and producer.

VI. IMPLEMENTATION

The decomposition of heated organic matter in the absence of oxygen from the atmosphere is known as pyrolysis technology. Heating is regulated by temperature ranges, which supplies the energy required to disassemble the macromolecules found in biomass. In the pyrolysis process, biomass is degraded through heating, resulting in the generation of three products: coal, oil, and pyrolytic gas, one of which can be maximized depending on the circumstances in the reactor. Slow pyrolysis, fast pyrolysis, and ultrafast pyrolysis are the three main types of pyrolysis that are being practiced worldwide. The reactor feed system, which is typically an endless screw, receives biomass initially. The biomass then enters the reactor where it is thermally degraded. Gases that do not condense and have no energy ends are recycled back into the process and used as entrainment gas in the reactor. The utilization of machine learning algorithms in order to make predictions regarding the yield of bio-oil as well as the H2 Content based on biomass compositions of feedstock and pyrolysis settings is the purpose of the work that is being done for this project. Multiple linear regression (MLR), multivariate polynomial regression (MPR), and the random forest (RF) method were all effectively employed and contrasted in this context. The findings demonstrated that MPR is more accurate than MLR and RF in estimating the amount of bio-oil that will be produced. In addition to this, the profound information that underpinned the model was uncovered. Aside from that, the information obtained by proximate analysis and ultimate analysis was preferred to determine yield, which was the same for H-bio-oil. Because of this effort, we now have a reference for improving the bio-oil, and our knowledge of the biomass pyrolysis process has been expanded.



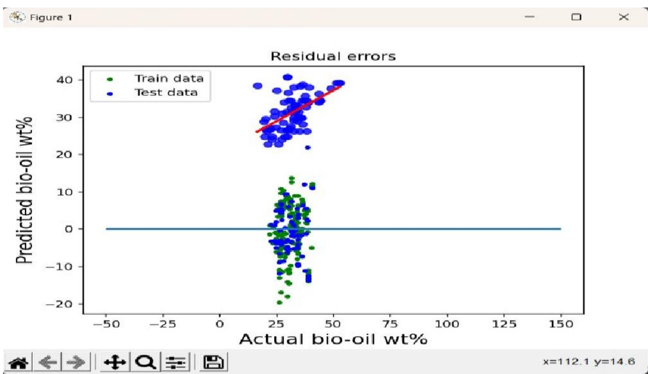
FLOW CHART

VII. RESULTS AND DISCUSSION

The detailed results of the data analysis of the biomass pyrolysis is given in the table and we observed the following results of the taken data set.

Output of MLR Bio-oil Graph:

```
PS D:\asthra\python codes> python .\MLR-Biooil.py
Coefficients of Bio-oil model:  [-0.56997016 -0.68256659 -0.95768166 -0.46927977  1.4544161  -1.44312097
 -0.68332684  0.01373505]
r2_score :  0.3090334674489654
```



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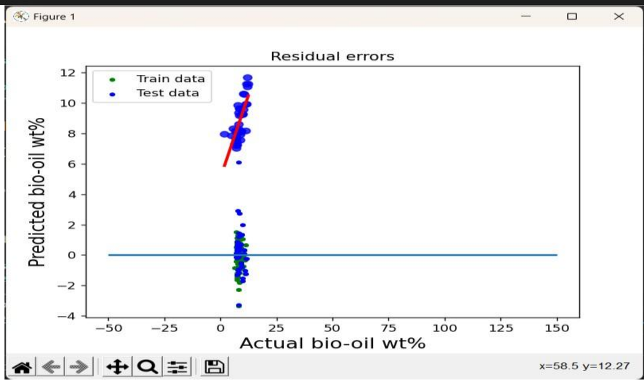
Output of MLR - H Bio-oil Graph:

```
PS D:\asthra\python codes> python .\MLR-H-Biooil.py
Coefficients of H-Biooil model:  [ 0.12848014  0.04747069  0.06014164  0.03305896  0.64999284  0.01971243
 -0.02894999  0.00104735]
r2_score :  0.49875290655919446
```

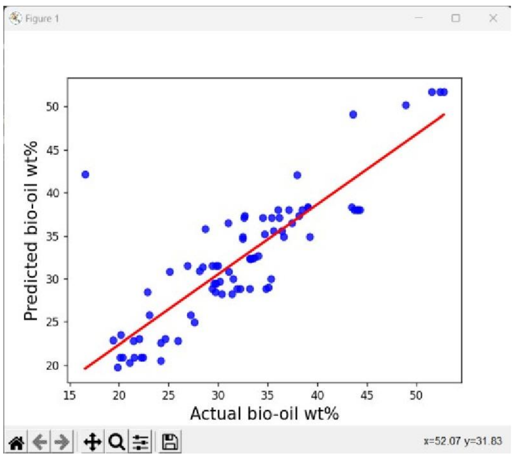


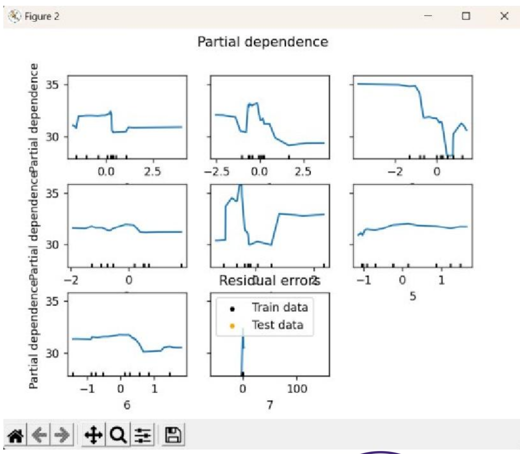
Output of MPR H-Biooil Graph:

```
PS D:\asthra\python codes> python .\MPR-H-Biooil.py
Coefficients of Bio-oil model:  [ 4.66689043e+08  9.20871776e+00 -4.79592815e-01  6.94753357e+00
  7.30083043e+00 -2.69880678e+01  3.16972107e+00  4.28276211e+00
 -5.39571252e-01 -2.22515877e-03 -1.20030138e-04  5.86349314e-03
 -1.08241005e-01  1.21969314e-03 -1.01003027e-01 -9.64457165e-02
  3.36949540e-04  1.06790203e-02  8.06815454e-03 -2.32523810e-02
  6.34328939e-02 -1.72354213e-02 -8.25532996e-03  1.50232997e-03
  4.33928265e-03 -8.02626469e-02 -1.67169783e-04 -9.62132188e-02
 -6.69916690e-02 -1.22646063e-03 -3.19075884e-02  1.99588671e-01
 -1.70241126e-02 -4.39695761e-02  6.07965384e-03  2.06633382e-01
  2.15971582e-01  1.96523510e-01  9.83682718e-03  7.03033866e-03
  2.68838191e-02  5.90046846e-03 -1.15570438e-02  5.59660877e-03
 -1.19613846e-06]
r2_score 0.5960207928603725
PS D:\asthra\python codes>
```

RF output and graph:

```
PS D:\asthra\python codes> python .\RF-Biooil.py
Mean Absolute Error: 2.72 degrees
Mean Squared Error: 17.73829926832936
Root Mean Squared Error: 4.2116860362958395
Accuracy: 90.98 %
C:\Users\hp\AppData\Local\Programs\Python\Python37-32
```





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VIII. CONCLUSION

Pyrolysis has been used since ancient times to turn wood into charcoal. Today pyrolysis is being developed as a waste energy technology to convert biomass and plastic waste into liquid fuels. Liquid fuels are projected to increase in demand and remain the most consumed fuel type for the next 30 years. The transportation sector relies heavily on petroleum based liquid fuels, which emit a significant amount of greenhouse gases. Pyrolysis presents an opportunity to manufacture low-carbon liquid fuels and decrease the emissions of the industry. In fact, Pyrolysis can be carbon negative if the bio-char produced is buried into the soil and used for crop enhancement instead of combustion. The fuels produced are considered second generation fuels since the feed stocks are from renewable sources, like waste and biomass. As a result, they are less carbon-intensive than fossil fuels.

IX. ACKNOWLEDGMENT

On this great occasion of accomplishment of our project on Data Analysis and Modelling on Biomass Pyrolysis. We would like to take this opportunity to extend our heartfelt appreciation to N. Seetayya sir, Assistant Professor in the Department of Computer Science and Engineering at Raghu Institute of Technology-Visakhapatnam, for all the support he has provided throughout the completion of this project. At several points along the process of finishing this job, your insightful direction and recommendations were a great assistance to me. In this sense, I will be grateful to you for the rest of my life. To conclude, as a member of the team, I would like to express my gratitude to the other members of the group for their assistance and coordination, and I express the hope that we will be successful in our ongoing endeavors.

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