BIOMASS ASSESSMENT REPORT

SCIENTIFIC RESEARCH ORGANISATION OF SAMOA

ENVIRONMENT AND RENEWABLE ENERGY DIVISION

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Introduction & Background

The demand for energy is steadily rising due to rapid industrialisation and improvement of living standards of society. As such, there has been immense damage to the environment leading the climate change and global warming. To mitigate the impact on the environment, there has been a strong push for clean and green energy for sustainable development. Renewable energy alternatives such as solar, biomass, wind and others are being applied to different sectors around the world to minimize greenhouse gas emissions and the use of fossil fuels.

Biomass was the main source of heating and cooking application prior to the introduction of fossil fuels such as petroleum products, coal and natural gas. Today, however, about 80% of the energy demand is met by fossil fuels leading to severe environmental issues globally. In rural areas though, biomass is the primary energy feedstock source in developing countries. Biomass is classified as potential fuels which store chemical energy in the form of carbohydrates produced from photosynthesis and solar energy. This applies to a variety of materials such as agricultural residues, biological material by-products and wood.

As part of the "**Energy Bill and Development and Implementation of Sustainable Bioenergy in Samoa Project**", SROS is required to complete a Biomass Assessment on the forest and coconut inventory found on STEC plantation in Faleolo. This includes the identification of various species and testing of energy content to determine the feasibility of a biomass gasification plant to be able to meet the objective of the project which is to "*Enhance energy security in Samoa through development of a biomass supply chain for biomass gasification for electricity production*."

METHODOLOGY

Sampling

From the survey, invasive species of trees was opted for potential feedstock as they were abundant and dense in the STEC lands at Faleolo. The selected plants for analysis are puluvao, pulumamoe, pafiki, tufaso, tavai, aoa, niu, tamaligi

and mosooi. Stems were elected as the testing component. A team from SROS and STEC are responsible for sampling from different areas of the forest.

The sampling periods are every three months in the months of August 2016, November 2016 and February 2017. Three batches were run to provide a conclusive average of values from analysis.

Samoa Name	English Name	Scientific Name
Puluvao	African Rubber tree	*Funtumia elastica*
Pulumamoe	Mexican Rubber Tree	*Castill elastica*
Niu	Coconut tree	*Cocos nucifera*
Aoa	Polynesian Banyan	*Ficus obliqua*
Mosooi	Ylang-ylang	*Cananga odorata*
Pafiki	Jatropha	*Jatropha curcas*
Tavai		*Rhus taitensis*
Tamaligi		*Albizia falcataria*
Tufaso		*Dysoxlum Samoense*

Table 1. Dominant species of plants on STEC land

Sampling Preparation

A small section of the trunk, about 2kg, is cut from each tree using a chainsaw then axed down to firewood before being put through a wood chipper. This brings the pieces to approximately 3-4cm in length with some finer particles which are sieved for conducting analysis. This is all completed on the same day as fresh samples are taken for examination to obtain baseline values before drying. The drying method used in the study is to spread out the wood chips in the backhouse for air drying at approximately 31^{0}C for different periods. Day 0 is the fresh sample with another sample taken every four days after for up to two weeks (Day 14).

Figure 2. Moisture analysis

Sample Analysis

Moisture Assessment

Apparatus

- Moisture dish, 4 decimal place analytical balance, Dehydrating oven, Desiccator

Method

The moisture content of the selected plant samples was tested by using the method published by the Official Method Analysis of AOAC International (18th Edition, 2005), Official Method 92.5.04(3.1.03).

The dishes were dried in the oven at 105^{0}C for two hours, and then cooled in a desiccator for 45 minutes. Initial weights of the dish are taken then 2g of the plants sample is weighed. First run is to dry the samples in the dishes for two hours at 135^{0}C, afterwards it is removed and cooled in the desiccator for 45 minutes before a first reading is taken by weighing the dish with the sample. The second and consecutive runs are drying dish with sample for one hour then cooled for 45 minutes before weighing again until the reading becomes constant or with miniscule difference in readings.

<u>Formula for finding moisture content:</u>

$$Moisture\ \% = \frac{(Wi - Wf)}{sample\ wt}\ x\ 100$$

Energy Content Assessment

Determining the Energy Content of the different plant samples was done using an Oxygen Bomb Calorimeter (model: 1341)

Figure 3. Energy content analysis using oxygen bomb

Apparatus

- Oxygen Bomb Calorimeter, 45C10 Fuse Wire, Pellet Press,

Reagent

- Sodium Carbonate and Phenolphthalein

Weigh 1 gram of the sample on the combustion capsule then use the Pellet Presser to press the sample together. Next, measure 10cm of the 45C10 fuse wire to use with the A38A head support and stand holding the bomb head while attaching the fuse wire. Then add a small amount of distilled water to the bottom of the bomb chamber because most combustion procedure use a small amount of liquid to be placed at bottom of the bomb as a sequestering agent and absorbent. Close the bomb tightly then fill it with Oxygen before placing it in the vessel with the 2901EB Ignition Unit to ignite the bomb. After firing the bomb, temperature is recorded by interval of one minute until the temperature is at its highest degree Celsius. Measure the fuse wire left and the distilled water used for an absorbent is then titrated by Sodium Carbonate and phenolphthalein as an indicator.

<u>Formula for finding Energy Content:</u>

Energy/^{0}C = 2345 calories/^{0}C

1mL Sodium Carbonate = 1 calories

Energy/ cm fuse wire = 2.3 calories

$$Energy = \frac{\left[\left(temp\ dif * Energy\ per\ ℃\right) - \left(BFW * Energy\ per\ cm\right) + \left(titre\ vol\ Energ\right.\right.}{sample\ weight}$$

RESULTS

An average reading was taken from all three batches tested to present a more concise result for the nine species. The moisture values as well as the calorific value of the trunks of the dominant species found in the STEC forest are given below.

Note: The highlighted values in RED are the peak energy values for each plant species within the two week drying period.

PAFIKI					
ANALYSIS	DRYING PERIOD (DAYS)				
	0	4	7	10	14
Moisture (g/100g)	67.63	29.11	18.33	19.18	15.6
Energy (kJ/g)	4.79	12.85	15.11	11.36	12.62

PULUVAO					
ANALYSIS	DRYING PERIOD (DAYS)				
	0	4	7	10	14
Moisture (g/100g)	47	20.7	7.11	11.02	12.5
Energy (kJ/g)	11.1	15	15.13	14.17	13.82

PULUMAMOE					
ANALYSIS	DRYING PERIOD (DAYS)				
	0	4	7	10	14
Moisture (g/100g)	66.2	39.5	7.38	11.72	12.7
Energy (kJ/g)	8.14	11.13	14.97	12.61	13.82

TUFASO					
ANALYSIS	DRYING PERIOD (DAYS)				
	0	4	7	10	14
Moisture (g/100g)	49.78	25.14	15.19	14.21	16.15
Energy (kJ/g)	8.79	11.98	14.43	16.22	14.35

TAVAI					
ANALYSIS	DRYING PERIOD (DAYS)				
	0	4	7	10	14
Moisture (g/100g)	41.5	24.15	15.06	12.99	13.7
Energy (kJ/g)	9.06	13	13.13	13.61	14.23

AOA					
ANALYSIS	DRYING PERIOD (DAYS)				
	0	4	7	10	14
Moisture (g/100g)	60.37	41.35	26.33	21.39	18.05
Energy (kJ/g)	6.83	9.51	11.71	11.08	11.96

MOSOOI					
ANALYSIS	DRYING PERIOD (DAYS)				
	0	4	7	10	14
Moisture (g/100g)	58.4	31.02	18.81	13.92	14.7
Energy (kJ/g)	6.28	8.83	13.49	11.36	11.52

TAMALIGI					
ANALYSIS	DRYING PERIOD (DAYS)				
	0	4	7	10	14
Moisture (g/100g)	46.5	25.06	12.28	15.71	12.25
Energy (kJ/g)	8.68	12.48	14.77	12.91	11.76

COCONUT TREE					
ANALYSIS	DRYING PERIOD (DAYS)				
	0	4	7	10	14
Moisture (g/100g)	53.85	33.64	26.21	15.3	18.5
Energy (kJ/g)	5.76	10.51	12.89	15.26	14.3

Table 2. Moisture and Calorific Values of plants tested

Summary of results:

Nine plant species selected for testing, four are categorised as invasive species (pulumamoe, puluvao, pafiki and tamaligi) and five are either native or indigenous species. For energy content Tufaso has the highest of 16.22kJ/g followed by coconut tree of 15.26kJ/g, Puluvao at 15.13kJ/g, Pulumamoe 14.97kJ/g, Tamaligi 14.77kJ/g then Tavai 14.23kJ/g, Mosooi 13.49kJ/g and lastly Aoa with a 11.96kJ/g. Tufaso and coconut tree were dried for 10 days before reaching highest energy value with moisture contents between 14 to 15%. Pulumamoe, Puluvao, Pafiki and Tamaligi reached highest energy value within 7 days of drying, with Pulumamoe and Puluvao moisture content at below 8%. Clearly from the data/ results there is a correlation between the moisture content and energy content being that they are inversely proportional to one another.

RECOMMENDATION/ JUSTIFICATION

	Recommendation	Justification
1.	The uses of Pulumamoe, Pafiki and Puluvao as the primary focus for the biomass gasification	All these plants are considered invasive species.
2.	Priority to Pulumamoe and Pafiki	Pulumamoe and Pafiki are fast growing plants with high rate of growth succession. Pulumamoe has very high fecundity rate which gives a very good candidate for feedstock. Pafiki on the other hand is similar and has other valuable uses as well.
3.	Control planting and replanting of feedstock	Due to the invasiveness nature of the trees recommended for biomass gasification, it is also recommended that replanting is to be restricted within STEC boundaries.
4.	Alternative or backup site for feedstock supply	STEC has another 6000 acres of land on the big island of Savaii, it is recommended that a similar study is to be conducted for the species found in Lata Savaii.