INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 21, No. 6, p. 112-122, 2022

RESEARCH PAPER OPEN ACCESS

Development Waste Biomass Agriculture as Bioenergy and Sustainable Agriculture in Tapin District, South Kalimantan, Indonesia

Nuryati[1], Meldayanoor[*2], Nina Hairiyah[3], Raden Rizki Amalia[4]

[1]*Department of Agroindustry, Tanah Laut State Polytechnic, Pelaihari, South Kalimantan 70815, Indonesia*

[2]*Department of Agroindustry, Tanah Laut State Polytechnic, Pelaihari, South Kalimantan 70815, Indonesia*

[3]*Department of Agroindustry, Tanah Laut State Polytechnic, Pelaihari, South Kalimantan 70815, Indonesia*

[4]*Department of Agroindustry, Tanah Laut State Polytechnic, Pelaihari, South Kalimantan 70815, Indonesia*

Key words: Biomass, Bioenergy, Biogas, Sustainable agriculture

http://dx.doi.org/10.12692/ijb/21.6.112-122 Article published on December 05, 2022

Abstract

Biomass is the originating material from organisms encompassing life plants, animals, and products beside him like the rubbish garden, yield harvest and so on. Study this aim to identify available biomass, analyze location strategy and potential biomass, design, and apply tool bioenergy and integrate with the concept of sustainable agriculture. Data used is production data agriculture, plantation and animal husbandry with studies literature, survey/observation direct, interview, study comparison in a manner descriptive, design tool using Autocad tools, and calculations efficiency of the biogas produced. Research results show available biomass, including straw rice, husk rice, dirt cows, leaves, stems, and empty bunches of the coconut palm. The strategic location for the development of bioenergy is the district area of Tapin Tengah because it has potency big for the production of rice, cow, coconut oil palm and plants chili cayenne. Study results comparison show that biomass straw rice and manure cow potentially for developed. Tool design was conducted with the used reactor made of fiberglass, which has part form inlet hole, outlet hole, hole disposal, and tub overflow. After the fermentation process began for 21 days, the resulting pressure of 12.43 atm and gas volume of 0.2826 m3 for every shelter. The results of the flame test performed for boiling water as much as 600 ml is for 6 minutes, so the level efficiency is tall enough that in 1 minute time could heat up 100 ml of water. Waste results fermentation of dirt cows and straw paddy that has fermented could be applied as fertilizer compost for fertilizing the plant so which could support implementing sustainable agriculture.

* **Corresponding Author:** Meldayanoor ✉ meldayanoor@politala.ac.id

Introduction

Biomass is the originating material from organisms encompassing life plants, animals, and products beside him like the rubbish garden, yield harvest and so on. Biomass alone is grouped into various type groups; among others is bioethanol (plants), biodiesel (oil palm and soybeans), biogas, bio briquettes and biokerosene (oil vegetable). It is because the source ingredients and the raw materials are different, and the processing is done. Potency source power biomass in Indonesia is one of the largest compared to other countries; according to the Ministry of Energy and Mineral Resources page, its potential, if developed, is 50 Giga Watts (GW). Besides it, data from (ZREU, 2000) mentions that Indonesia produces 146.7 million tonnes or equivalent to 470 Giga Joule (GJ) of biomass per year which is the source mainly originated from residue agriculture that, is of 150 GJ per year and rubber lumber 120 GJ per year.

Potency biomass in Indonesia that can be used as a source of energy the amount is very abundant. Originating waste from animals or plants, everything has the potential for development. Plant food and plantations produce enough waste big, which can be used for other needs such as ingredient burn vegetables. Utilization of waste as ingredient burn vegetable give three profit direct. First, upgrade efficiency energy in a manner whole because the content energy contained in the waste is big enough and will be wasted uselessly if not utilized. Second, savings cost because often throwing away waste can be more expensive than using it. Third, reducing necessity will the place hoarding rubbish because the provision of the place hoarding will become more difficult and expensive, especially in the urban regions.

At the moment, an estimated about 145 M tonnes of biomass agriculture is produced in Indonesia every year. Potency biomass for electricity or ingredient burn could be sourced, among others, from coconut palm oil, sugarcane, rubber, coconut, husk rice, corn, cassava, wood, waste cattle, and trash cities/markets, with a total potential in all regions of Indonesia of 31,654 Mwe.

Regency Tapin is one of the areas in South Kalimantan that has various potential biomass for developed and put to use from sector agriculture, plantation, or farm. This could be seen based on data; District Tapin is one area buffer plant food (esp paddy). In 2020 it can produce paddy rice as much as 417,448 tons and field rice as 13,494 tons. Besides that, in the district Tapin, there is also a potency plant plantation with 2020 data on coconut palm 463,735.48 tons, 419 tons of coconut, and 9,105.46 tons of rubber. As for the potential for cattle cows in 2020, cow males have as many as 3,668 heads, cows 3,818 females, and buffaloes as many as 395 tails (BPS Tapin, 2021).

Based on the description background and existing potential, then on the study will conduct the assessment for developing waste biomass agriculture in the district Tapin as bioenergy and integrate it as a concept of sustainable agriculture.

Materials and methods

Study this carried out in the District Tapin, South Kalimantan Province. The study location is one producer of various product results agriculture in South Kalimantan. Tools used in research this is equipment writing, a camera, and a laptop. Materials used in research this is 1200 liter water reservoir, 4x4 elbow, 5cm fin, 1-inch strip, 10 washers, 10x2 bolt , ¼ stop tap, glue bottle, LPG gas regulator, bolt 12×3, ring, socket, stop faucet 2", stop faucet ½, DL 2", DD 2", pipe glue, keni 4", plain carpet, plastic, hose, funnel, bolts, BB faucets, keni pretentious, ALM pipe, bucket, and one gas stove furnace.

Results and discussion

Identification biomass

Biomass is the originating material from organisms encompassing life plants, animals, and products beside him like the rubbish garden, and waste results harvest, waste industry house stairs, or remainder dirt cattle. Identification of biomass available in the District Tapin could be seen from potential data

production agriculture, plantation, and animal husbandry. The identification process was conducted by collecting data from the Department of Agriculture, Plants Food and Horticulture, Animal Husbandry and Plantation Service, Forestry and Plantation Service and Regency Central Bureau of Statistics. Identification results show that results agriculture, plantation, fishery, and animal husbandry, the largest in the district Tapin is plant paddy with amount production of 417,448 tonnes for paddy rice and 13,494 tonnes for paddy fields, cows with amount production of 7,486 heads and 4,850 goats, and plants coconut palm 57,066.55 tonnes (Department of Agriculture, 2020).

Table 1. Matrix relationship between objectives, types of data, analysis techniques and outputs.

No	Destination	Data type	Data source	Technique analysis	Output
1	Identify available biomass developed become bioenergy and sustainable agriculture in the District Tapin	Production data agriculture, gardening, animal husbandry	Department of Agriculture and Plants Food, BPS, Department Animal Husbandry, Department of Agriculture	Secondary data study, surveys/ observations live, interview	Types Biomass
2	Identify a location strategic for the development of bioenergy and sustainable agriculture in the District Tapin.	Production data agriculture per region	BPS	Descriptive	Strategic location
3	Analyze potential biomass for the development of bioenergy and support sustainable agriculture in the District Tapin	Amount data availability biomass	Primary data	Studies Literature	Type bioenergy that will develop along the location
4	Design and design tools for processing bioenergy and support sustainable agriculture in the District Tapin	Material data raw available biomass	Primary data	Autocad	Processing design and tools bioenergy and integration sustainable agriculture
5	Apply produced bioenergy for the public around the location, processing biomass and integrating with the concept of sustainable agriculture in the District Tapin	Results data calculation capacity	Analysis results and data results interview	Efficiency study	Bioenergy that can utilize and integrated with draft sustainable agriculture

Based on the data that has been obtained at the stage identification determination location strategies, then could conduct calculation data processing percentage potential of each district to source potency biomass and applications sustainable agriculture as presented in Table 2.

Biomass that can be utilized from plant paddy is straw and chaff. Rice straw, as shown in Fig. 1 is one waste agriculture in Indonesia whose utilization is not yet maximum. Straw is a plant paddy that has taken the fruit (grain), so stay stems and leaves, which are waste agriculture biggest as well as not yet fully utilized because exists factor technical and economical. In part farmers, straw was often used as closing land at the time plant palawija. Based on the habit of the farmer in the field, hay from the remainder of harvest paddy part big burned directly on the ground with destination speed up preparation land for planting next. Burning straw in a manner constantly on the ground agriculture could cause increasing temperature air on the surface soil as well as cause pollution air that could annihilate useful microorganisms in biological processes ground, like pirate ingredient organic soil so that impact the decline rate ingredient organic in the ground. So, from that, a possible solution conducted is to utilize straw paddy for processing. It becomes an ingredient bioenergy maker in the form of biogas.

In the milling process, paddy becomes rice, and their products side in the form of waste; when left or managed in a manner that is not wise enough, it will affect harmfully man because happening pollution environment ecosystem, as well as pollution air consequence, burning waste. Waste in the milling process, the biggest paddy is husk rice, usually obtained husk of about 20 ± 30 % of weight grain, yielding other bran between 8 ± 12%. Husks with high percentages could cause environmental problems. Order source power natural could be beneficial for a

long time, so needed wisdom in the utilization of source power nature exists to get sustainable and sustainable with embed attitude compatible with the environment. Husk paddy, as shown in Fig. 2, has great potential for made-ingredient raw biogas production because it has a water content of as much as 9% and make it consists of a hollow network, has high energy, and is composed of material that can be fermented and potentially very large in produce gas production (Malik, 2006).

Table 1 Calculation percentage potency source biomass and applications sustainable agriculture.

No	Source potency biomass and applications sustainable agriculture	District location	Percentage
1.	Paddy field	District Bungur	35.64%
		District South Tapin	32.18%
		District Central Tap	32.17%
2.	Cow	District Hatungun	37.83%
		District Central Tapin	31.45%
		District Binuang	30,71
3.	Coconut palm	District Candi Laras Utara	58.98%
		District Central Tapin	25.58%
		District Binuang	15.43%
4.	Chilli cayenne	District Central Tapin	62.50%
		District Piani	21.51%
		District Candi Laras Selatan	15.98%

Source: Department of Agriculture Regency Butin (2020).

Source biomass the next potential in the District Tapin is derived biomass from a cow that is dirt cow. Cow weighing ± 300-500 kg produces 30-40 kg of feces per day (Setiyo, 2012). Amount this is a lot if not utilized optimally because dirt cows have the content chemicals in the form of nitrogen 0.4 - 1%, phosphorus 0.2 - 0.5%, potassium 0.1 - 1.5%, water content 85 - 92%, and some other elements (Ca, Mg, Mn, Fe, Cu, Zn) (Dewi *et al*., 2017).

Biomass next in the District Tapin is derived biomass from plant palm (Fig. 3) like fruit bunches empty, fiber fruit, shell, stem tree, frond as well as Palm Oil Mill Effluent (POME) or waste liquid coconut palm. Of all biomass existing palm oil, as much as 70% is midrib tree palm oil, while fruit bunches empty reach 10% and stem palm reaches 5%.

Based on the description of the results above, it can be taken conclusion that existing biomass in the district Tapin originates from rice (straw and husk), cattle (manure cow), coconut palm (frond palm, fruit bunches blank, and stem palm).

Strategic Location Identification

Identification location strategic for development biomass agriculture becomes bioenergy and support sustainable agriculture conducted with analysis based on secondary data regarding the largest area producer plant rice, cow, coconut oil palm and plants agriculture others in the District Tapin.

Identification of location/region that has productivity tall for plant paddy rice is districts retarded namely 61.74 ton/hectare, districts South Tapin 55.73 ton/ha, and sub-districts Central Tapin 55.72 ton/ha (Department of Agriculture Regency Tapin, 2020).

Producer cow, most in the district Tapin, is Subdistrict Hatungun off that is of 1,792 tails, District Central Tapin of 1,490 heads and District Binuang of 1,455 tails.

Producing location/region of coconut palm biggest is Candi Laras Utara District at 218,056.81 tons/year, District Central Tapin at 94,585.95 tons/year, and the District Binuang at 57,066.55 tons/year.

Table 2 Analysis pros and con types biomass.

No	Type biomass	Content	Pros and Cons	Source
1	Rice straw	84.22% ingredients dry (BK), 4.60% crude protein (PK), 28.86% fiber crude (SK), 1.52% crude fat (LK), and 50.80% ingredients extract without nitrogen.	Pros: huge potential not yet utilized. Cons: necessary conducted treatment beginning from fermentation to produce bioenergy in the form of biogas or bioethanol.	Setiarto (2013)
2	Husk paddy	Content chemical husk paddy consists of over 50% cellulose, 25-30% lignin, and 15-20% silica.	Pros: huge potential not yet utilized. Weaknesses: have content silica so that more potential if developed as fertilizer or ingredient composite.	Bakrie (2008)
3	Dirt cow	Methane gas 65.7 %	Pros: huge potential not yet use it, yes direct use, have high methane content.	Dharma and Riduan (2014)
4	Midrib palm	Ingredient dry 48.78%, crude protein 5.3%, hemicellulose 21.1%, cellulose 27.9%, fiber 31.09% crude, 4.48% ash, 51.87% BETN, 16.9% lignin and 0.6% silica (Imsya, 2007).	Pros: huge potential not yet utilized Disadvantages: for optimal results are needed conducted treatment fermentation is, especially formerly, quite time-consuming and necessary big place.	Imsya (2007)
5	Fruit bunches empty	Cellulose is about 45.95%; hemicellulose is around 16.49% and lignin is around 22.84%.	Pros: huge potential not yet utilized Disadvantages: for optimal results are needed conducted treatment fermentation is, especially formerly, quite time-consuming and necessary big place.	Imsya (2007)
6	Stem palm	Water 10.65 (%), Protein (%wb), 0.96 0.75 1.21 Fat (%wb), 0.37 0.23 0.33 Ash (%wb), 0.68 0.1 0.18 Carbohydrate by difference (%bk), Fiber (%bk), Starch (%bk), Amylose (% total starch), Amylopectin (% total starch)	Pros: huge potential not yet utilized Disadvantages: for optimal results are needed conducted treatment fermentation is, especially formerly, quite time-consuming and necessary quite place big.	Imsya (2007)

As for the producing region plant chili cayenne biggest results plant vegetables and fruits annuals according to type plants in 2020; the largest in the Regency Tapin is the district area Central Tapin namely of 187.25 tons/year, districts piano 64.44 tons/year, and Candi Laras Selatan District of 47.89 ton/year (Department of Agriculture Regency Tapin, 2020).

Based on the data in Table 2 can see that district that has all potency biggest for utilization of biomass from various resources and support sustainable agriculture is Subdistrict Central Tapin which produces paddy rice at 32.17%, Cattle at 31.45%, coconut palm at 25.58% and chili cayenne of 62.50% of all areas in the District Tapin, so for location strategic for development waste biomass becomes bioenergy and support sustainable agriculture is Subdistrict Central Tapin.Based on the results, the next with to review several villages in the District Central Tapin to choose your love village strategy for developing biomass agriculture Becomes bioenergy and sustainable agriculture.

Results of identification carried out through discussion with party Officer Extension Agriculture Field District Central Tapin shows that Sungai Bahalang Village, District Central Tapin is location strategic for the development of biomass agriculture becomes bioenergy and supports sustainable agriculture because in the village this produces whole source biomass like plant rice, cow, coconut oil palm and plants chili cayenne that can become object from sustainable application agriculture.

Fig. 1. Rice straw.

Analysis Potency Biomass

Based on the results, identification is beginning to see types of possible biomass developed become bioenergy and sustainable agriculture in the District Tapin, got it the source biomass can from plant rice (straw and husk), cattle (manure beef), and coconut palm (frond palm, fruit bunches blank, and stem palm).

Based on the results analysis, advantages and disadvantages potency possible biomass utilized as bioenergy and sustainable agriculture, as presented in Table 3, can be seen that the most potential biomass for development is biomass dirt cow and straw rice.

Design and Tool Design of Bioenergy and Sustainable Agriculture Tools

The stages carried out in the design and design tool bioenergy and sustainable agriculture are carried out based on step research conducted by Putra *et al.* (2014), namely started from studies characterization and design of biogas reactor later analysis design (plan functional, design structural, and drawings design tool).

Structural design analysis

a. Digester Volume Calculation

V = pi r^2 t

= 3.14 x 0.52^2 x 1.4

= 1.1886784 m^3

= 1188,6784 lt ≈ 1200 lt

b. The amount required Biomass and Water

Comparison ingredient waste with water added in tube reactor is 1:2. Charging tube reactor only ¾ of the mixture ingredient of the tube volume. This gives room for the gas produced by the gas formation process. Because that's the volume of the water and ingredients mixture waste maximum possible filled in tube reactor they are:

Vtabung = ¾ x 1188.6784

= 891,5088 lt ≈900 lt

c. Manometer

A manometer is a tool measuring for measures pressure. Manometer made with u pipe principle with given water fluid substance color for knowing the pressure of the generated biogas during the process in atm unit. When the manometer is given gas pressure in one column, then the water in the other column will rise to reach a certain pressure. The difference in height this in the second column, stated with value (h).

d. Pressure

Pressure is counted by using Boyle's Law like the formula below (Royami, 2012):

$P = \frac{p \cdot g \cdot h}{A}$ + pressure atmosphere

Description

P = Pressure absolute (N/m2)

p = density substance liquid (kg/m3) = 1000 kg/m3

g = Acceleration gravity (9.81 m/s2)

h = Difference height column substance liquid used (m)

A = area cross-section (m2)

1 atm = 101.325 N/m2

1 N/m2 = 9.869 x 10-6 atm

Design analysis

The type of reactor used in the study is a reactor made from fiberglass. Profit from the reactor is very efficient because it is very impermeable, light, and strong. If it happens, leakage is easily repaired, or forms return like back, and more efficient is reactor could move anytime if not used time.

Fig. 2. Husk paddy.

Tube reactor/digester is the place biogas material digester and as the house for bacteria, fine bacteria shaper sour or bacteria methane gas generator. Draft design reactor this drum shaped/water tank with a diameter of 104 cm with a height of 140 cm.

Biodigester temperature

High temperatures generally will give good biogas production. However, the temperature should not exceed the temperature room. Bacteria only could develop when the temperature surrounding is at the temperature room. A good temperature for the biogas formation process is between 20-40°C and an optimum temperature is between 28-30°C. The temperature during the process is very important because this is related to the ability of the live bacteria biogas processor, which ranges from 27°C-28°C. With a temperature that, the process of making biogas will walk in accordance with time. But different, when the temperature is too low (cold), the time to form biogas will be longer (Paimin, 2000). The results study obtained temperature in the inclined biodigester stable with an average temperature of 31.15°C with a temperature of a maximum of 32.11°C and a minimum temperature of 29.49°C. Temperature environment obtained around 30.59°C with the temperature a maximum of 32°C and a minimum temperature of 26°C.

Application Bioenergy and Sustainable Agriculture

Biogas pressure

Biogas pressure during fermentation tends to experience changes that are experienced in an increase and decrease.

Fig. 3. 1 Biomass plant coconut palm.

$$P = \frac{1000\frac{kg}{m^3} \times 9{,}81\frac{m}{s^2} \times 0{,}5\ m}{0{,}784\ m2} + 101.325\ N/m^2$$

= 12.43 atm

Description

P = Pressure absolute (N/m ^{2})

p = density substance liquid (kg/m ^{3}) = 1000 kg/m ^{3}

g = Acceleration gravity (9.81 m/s ^{2})

h = Difference height column substance liquid used (m)

1 atm = 101.325 N/m ^{2}

1 N/m2 = 9.869 x 10^{-3} atm

Increasing biogas pressure big indicates that the biogas produced is also increasing many (Insani, 2013). This is in accordance with the statement Hadi (1981) stated that enhancement addition time fermentation from 10 days up to 30 days increases biogas production by 50%. Research results from this show pressure generated by this biogas are already capable of being used for turning on a fire in a gas stove.

pH

The optimal pH range for the production of methane was 7.0 to 7.2, but still in the 6.8 to 8.0 range allowed (Sitorus, 2011). pH value in the study averages 6.98, so the inner pH value biogas reactor can say enough good for methane gas production.

In a bioreactor, two available bacteria play the role of bacteria acids and bacteria methane. The second type of bacteria must exist in a balanced amount. Failure of the biogas production process can be due to a balance population of bacteria methane to bacteria acid that causes the environment to be very acidic (pH less than 7). The next hinders the continuity of life is bacteria methane. The acidity recommended substrate is in the pH range of 6.5 to 8 (Sitorus, 2011).

Volume biogas

The volume of biogas produced in one-time storage of the fermentation process moment beginning test could be counted of the volume of the balloon plastic used with details calculation as follows:

Diameter = 60cm = 0,6 m

Tinggi = 100 cm = 1 m

Volume = $\beta.r^2.t$

= 3,14 x 0,3kuadrat x 1

= 0,2826 m^3

In one day, it could conduct shelter until with 3 balloons, so the volume of biogas that can be generated per day is 3 x 0.2826 m^3 = 0.8478 m^3.

Old flame

A long flame was obtained from the testing fire on the

biogas stove. Testing is done when the gas volume reaches a maximum that is 0.2826m³. Flame in the study this tested; try using a flame big. On the flame, the big obtained result was to heat up 600 ml of water to gas in a holding drum exhausted, which needed time 6 minutes, with the remainder of the mass of water being 593 ml at a temperature of 92°C. From the test results of the flame big, it turns out the time required for heating the water was very brief; besides that flame color big still mixture color blue and yellow, this caused at the start burning still many other gas content methane.

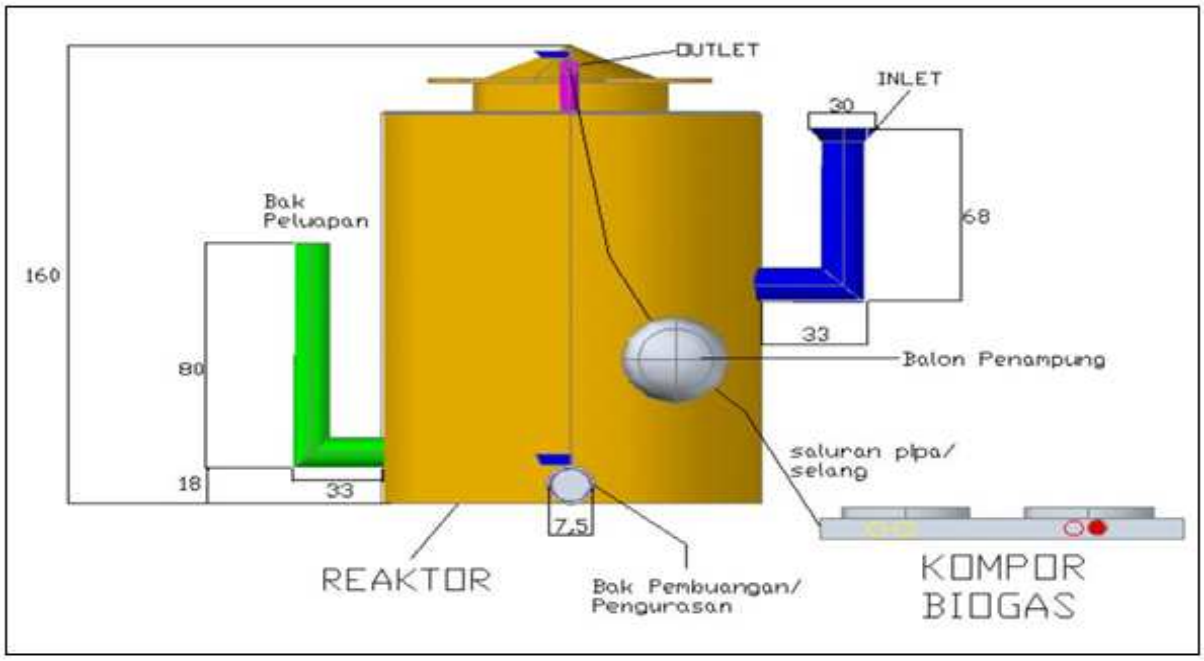

Fig. 4. 2 Biogas equipment design.

Application use of biogas equipment

Biogas apparatus is used with entering feed (waste biomass) and water with a ratio of 1:2 in parts inlet holes with less volume over 900 liters. After the bait entered, continued with the fermentation process was anaerobic for 21 days to reach optimal results. Then after 21 days, exhaust gas is through an outlet hole with an open faucet on the appliance and connected through a hose to a pocket plastic gas holder. After the plastic container is full, gas is produced and can be directly used by connecting the gas stove that has been modified especially for biogas. Arrangement big, small size fire conducted with an open-closed tap on the connection hose from plastic container to gas stove.

The outlet hole is the place that requires the release of methane gas to turn on the stove. On this outlet hole, there is a functioning faucet for expelling and closing the gas produced from the tube reactor. Then the gas that comes out from the outlet hole will be channeled to a balloon container that functions to accommodate methane gas from the tube reactor. The balloon will grow in accordance with the amount of gas released from the tube reactor. This gas will stream to the biogas stove for utilized public as a substitute for LPG gas.

After the biodigester no produces gas, fill from the biodigester can be issued or drained through a hole disposal/drain, which works as a disposal mixture of existing waste in a tube reactor because the ingredient already no produce methane gas. Ingredient outcasts could be made as organic fertilizer. Waste is a very good solid for fertilizer because processing fertilizer is perfect from fertilizer cages stacked in a place open.

Fertilizer produced from this digester can also function repair structure soil so that it becomes loose and have power high water binding. Waste liquid can

also be used for water plants because it contains the required nutrients for the plant, which could exist in sustainable agriculture on-site the place biogas processing. The other side from the inlet hole is working overflow for knowing amount content included material in tube reactor already filling ¾ of the tube reactor. Suppose the filling ingredient is more than ¾ tube reactor, so the content ingredient will go out through tub/pit overflow so that in the tube reactor always, there is room air for the formation of methane gas. Before conducting the charging ingredient back, the material is there in the tube reactor must conduct disposed of, especially first, to fill existing materials in the tube reactor with no overflow through tub/pit overflow.

Conclusion

Sources of biomass in Tapin Regency are rice straw and husk waste, cow dung, and stems, leaves, empty oil palm bunches. The strategic location for bioenergy development is in Sungai Bahalang Village, Central Tapin District. Biomass that has the potential to be developed into bioenergy is cow dung and rice straw waste. The design of a bioenergy processing tool using drums made of glass fiber produces a pressure of 12.43 atm, and a volume of 0.8478m3 per day and can be used to become fuel (biogas) and solid waste from biogas fermentation can be used for fertilizer.

Recommendations

Utilization of straw, rice husk and cow dung waste can control soil, water and environmental pollution. Waste is not only used as biogas and organic fertilizer, it can also support agricultural development with the concept of sustainable agriculture. Create a land fire disaster management program by not burning agricultural waste such as rice straw, rice husk and other agricultural waste so that it is better utilized as biomass in the development of bioenergy into biogas.

Acknowledgments

This research was carried out in collaboration between the Tanah Laut State Polytechnic and the Tapin Regency Development Planning, Research and Development Agency. Thank you to the Director and Head of the Center for Research and Community Service of the Tanah Laut State Polytechnic for their support and participation in this research. This research is part of the collaborative accountability that has been carried out and published in 2022.

References

Asian Development Bank (ADB). 2009. Energy outlook for Asia and the Pacific. ADB, Manila.

Agency for the Assessment and Application of Technology. 2016. Indonesia's energy outlook 2016: energy development to support the green industry. Center for Energy Resources Technology and Chemical Industry, Agency for the Assessment and Application of Technology. Jakarta.

Agustian A, Friyatno S, Hardono GS, Askin A, Gunawan E. 2015. Bioenergy Development Policy Studies in the Agricultural Sector (Continued). Final Report for FY 2015. Center for Socio-Economy and Agricultural Policy. Agricultural Research and Development Agency. Ministry of Agriculture.

Al Seadi T, Ruiz D, Prassl H, Kottner M, Finsterwaldes T, Volke S, Janssers R. 2008. Biogas Handbook. Denmark: University of Southern Denmark Esbjerg.

Araujo K. 2014. The emerging field of energy transitions: progress, challenges, and opportunities. Energy Research & Social Science. http://dx.doi.org/10.1016/j.erss.2014.03.002.

Bakri. 2008. Chemical and Physical Components of Rice Husk Ash as SCM for Making Cement Composites. Perennial Journal **5(1),** 9-14.

BPS Tapin Regency. 2021. Tapin Regency in Figures.

Brklacich M, Bryant CR, Smith B. 1991. Review and Appraisal of the Concept of Sustainable Food Production System. Environment Management **15(1),** 1-14.

Conway GR. 1985. Agroecosystem Analysis for Research and Development. Winrock International, Bangkok, Thailand.

Dharma US, Ridhuan Kms. 2014. Study of Potential Energy Sources of Biogas from Livestock Manure for Alternative Fuels in Kalirejo District, Central Lampung Regency. Turbo **3(2),** 34-41.

Dutu R. 2016. Challenges and policies in Indonesia's energy sector. Energy Policy 513-519.

Ghosh P, Shah G, Chandra R, Sahota S, Kumar H, Vijay VK, Thakur IS. 2019. Assessment of methane emissions and energy recovery potential from the municipal solid waste landfills of Delhi, India. Bioresource Technology 611–615. http://dx.doi.org/10.1016/j.biortech.2018.10.069.

Ghosh P, Kumar M, Kapoor R, Kumar SS, Singh L, Vijay V, Vijay VK, Kumar V, Thakur IS. 2020. Enhanced biogas production from municipal solid waste via co-digestion with sewage sludge and metabolic pathway analysis. Bioresource Technology **296,** 122275. http://dx.doi.org/10.1016/j.biortech.2019.122275.

Hamblin A. 1992. How do we Know When Agriculture Systems are Sustainable? In Environmental Indicators for Sustainable Agriculture. Report of a National workshop, 28-28 November 1991. Grains Research Corporation, Canbera, Australia. 90 p.

Hansen JW. 1996. Is Agriculture Sustainability a Useful Concept? Agriculture System. Elsevier Applied Science. Ed. Dent J.B and J.W. Jones.

Ma Y, Shen Y, Liu Y. 2020. Food Waste to Biofertilizer: A Potential Game Changer of Global Circular Agricultural Economy. J. Agric. Food Chem **68,** 5021–5023, http://dx.doi.org/10.1021/acs.jafc.0c02210

Ma Y, Yin Y, Liu Y. 2017. A holistic approach for food waste management towards zero solid disposal and energy/resource recovery. Bioresource Technology **228,** 56–61. http://dx.doi.org/10.1016/j.biortech.2016.12.090.

McBride AC, Dale VH, Baskaran LM, Downing ME, Eaton LM, Efroymson RA, Garten Jr CT, Kline KL, Jager HI, Mulholland PJ, Parish ES, Schweizer PE, Storey JM. 2011. Indicators to support environmental sustainability of bioenergy systems. Ecological Indicators **11,** 1277-1289.

Paimin. 2000. Tools for making biogas from bricks. Jakarta: Independent Spreader, 3rd Printing.

Putra GMD, Abdullah SH, Proyati A, Setiawati DA, Muttalib SA. 2017. Design of a Portable Type Biogas Reactor From Cattle Manure Waste. Scientific Journal of Agricultural and Biosystem Engineering **5(1),** 369-374.

Rohyami. 2012. Ideal Gas Law, accessed 1 Dec 2022 http://rohyami.staff.uii.ac.id/2012/05/07/gas/

Sitorus. 2011. Utilization of Sewer Mud as Raw Material for Biogas with the Batch Feeding Method. Thesis. Department of Agricultural Engineering, Faculty of Agricultural Technology, University of North Sumatra, Medan.

Sedjo RA. 2011. Carbon Neutrality and Bioenergy: A Zero Sum Game? Discussion Papers. Resources for The Future. Washington DC.

Setiarto RHB. 2013. Prospects and Potential Utilization of Lignocellulosic Rice Straw Into Compost, Silage, and Biogas Through Microbial Fermentation. Journal of Cellulose **3(2),** 51-66.

Sundari E, Ellyta S, Riko R. 2012. Making Liquid Organic Fertilizer Using bioactivator biosca and EM4. Proceedings of SNTK HATS.