# Evaluation of Biogas Production Potential from Waste Coconut Water

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## ABSTRACT

**Abstract:** Coconut oil production is the eminent agro based industries in Tamil Nadu. The matured coconut water was considered as a waste. Coconut oil industries discharge considerable amount of waste coconut water having very high values of Biochemical Oxygen Demand (BOD) to the extent of 29,000 mgl-1 (Sison. 1977) [1], the wash water about 3,000 mg. and Total Solids (TS) of 5.45 ± 0.35%. Tripetchkulet et al., (2010) [2], has also reported that the fermented coconut water is highly acidic with a pH of 4.03 ± 0.01. Coconut water contains most nutrients required for microbial growth. The pH of coconut water is 6.1. The Total Suspended Solids in coconut water is found out as 0.0028 g/ml. The Total Dissolved Solids is 0.8014 g/ml, Total Solids is 0.8042 g/ml and Volatile Soluble Solids is 99.5 %. A laboratory scale batch type anaerobic digester (Air tight 2 litre plastic bottles) was set up for the experimental purpose for a retention time of 35 days. Coconut water, water and cow dung were mixed in different proportions (5 treatments). Each treatment was replicated 3 times. Biogas volume and biogas composition were measured at 5:30 pm every day. Remarkable volume of biogas production was noticed between 12th and 16th days. Maximum biogas volume of 976. 67 ml was noticed for the combination of 1:1 (Cow dung: Coconut water) with methane content of 53 %. For the combination of 2:1:1 (Cow dung: Coconut water: Water) the maximum volume of biogas production is 833.3ml with methane content of 31 %. For the combination of 1:1 (water: Cow Dung) the maximum volume of biogas produced is 133.3 ml with methane content of 48 %. The biogas produced from different ratios was tested for its flammability. It was seen that blue flame is produced and the flame is last for few seconds for all ratios but the maximum amount of flame was produced from the sample which contains maximum amount of Coconut water than other samples.

**Conclusion:** Non-invasive independent predictors for screening esophageal varices may decrease medical as well as financial burden, hence improving the management of cirrhotic patients. These predictors, however, need further work to validate reliability.

*Keywords: Coconut oil production, Waste coconut water, Biochemical Oxygen Demand (BOD), Anaerobic digestion, Biogas production, Methane content, Feed ratios, Volatile Soluble Solids (VSS).*

## 1. INTRODUCTION

The coconut (cocosnucifera) is an important crop in the tropical regions. India is the third largest coconut producing country in the world after Indonesia and Philippines. In India, during the year of 2017-2018, the total cultivable area for coconut is 2079 hectares, its production is 16228 metric tonnes and its yield is 7804 kg/ha. Tamil Nadu is the third largest producer of coconut in India.

The total cultivable area for coconut is 448.49 ha, its production is 4213.414 metric tonnes, and its yield is 9394 kg/ha in Tamil Nadu (Department of Economics and Statistics, 2018). Coconut cultivation is adaptable to various conditions. Nearly two million people in India are employed by the processing and related activities of coconut. Coconut oil contributes 6% to the national edible oil pool. In addition the crop contributes Rs.7000 crores annually to the gross domestic production (Pankaj Ket al.,(2014) [3]. Coconut oil production is the eminent agro based industries in Tamil Nadu. They discharge considerable amount of waste coconut water having very high values of Biochemical Oxygen Demand (BOD) to the extent of 29,000 mg Sison. (1977) [1] and Total Solids (TS) of 5.45 ± 0.35% Tripetchkul et al.,(2010) [2].

Coconut water contains most nutrients required for microbial growth. Coconut water constitutes a serious pollution hazard since it is usually allowed to run off from nut processing compounds into waterways and onto agricultural land. The biochemical oxygen demand of waste coconut water is commonly of the order of 40000 mg-1 and may be more than double this value M. E. Smith et al., (1976) [4].

Wastewater originated from virgin coconut oil production by fermentation contains a number of nutrients of which could potentially be used for cultivation of microorganisms; therefore, these wastewaters could also be employed to produce bio-extract which could reduce amount of wastewater disposed into natural water resource, hence, reduce impact on environment as a whole Tripetchkulet et al.,2010) [2]. It is highly relevant to save these coconut water by providing affordable technology which is capable of producing energy.

Anaerobic digestion of organic wastes is a known technology. Anaerobic digestion is the degradation of complex organic matters in an oxygen free environment. The biological conversion of the organic matters occurs in the mixture of primary settled and biological sludge under anaerobic condition followed by hydrolysis, acidogenesis and methanogenesis to convert the complex compounds into simpler end products as methane $CH_4$ and carbon dioxide $CO_2$ Gerardi. (2003) [5]. This technology offers simultaneous production of energy in the form of biogas.

Werner et.al.,1989[6] reported that cow dung generated from 3–5 cattle/day can run a simple 8–10 m³ biogas plant which is able to produce 1.5–2 m³ biogas per day which is sufficient for the family 6–8 persons, can cook meal for 2 or 3 times or may light two lamps for 3 hr or run a refrigerator for all day and can also operate a 3-kW motor generator for 1 hr.

Manimuthu, et al., (2015) [7] reported that the digester performance mainly depends upon the type and number of microbial populations in digests. In their study various amounts (50ml, 100ml, and 150ml) of coconut water supplemented in batch anaerobic (bio-gas) digester revealed that the digester added to 100 ml of coconut water showed better performance than the other two digests. Analysis of microbial population indicates that the microbial number sharply increased with the amount of the coconut water addition. It is concluded that the optimum amount of coconut water can be supplemented in biogas digested in order to achieve better digester performance.

Onwuliri FC, OnyimbaIA, Nwaukwu IA(2013) [8] studied the laboratory-scale biogas production from cow dung under four different treatments(using water and lime water at ambient conditions, exposed to sunlight and kept at 40°C). Equal volumes of slurry (3 g dung: 10 cm³ water) in the digesters were subjected to anaerobic digestion over a four-week retention period, with weekly measurements of gas yields. Gas was collected by the water displacement method. He concluded that the gas collected from the lime water has the higher gas yield than other samples and also he concluded that the gas production increased by increase in retention period.

Samuel Tewelde et al., (2012) [9] analysed biogas production from the anaerobic single stage co-digestion of brewery wastes (BW) and cattle dung (CD) in batch mode at mesophilic conditions. For a retention period of 40 days, the average gas yield was 0.290m³/kg VS added. To make favourable fermentation conditions, the content of the initial Total Solids [TS] was changed from 16% to 8% by diluting with water. Maximal overall methane productivity was attained when the ratio CD/BW was 70:30 and maximum organic loading rate was 3.3kgVS/m³d found from semi-continuous digestion on 70:30 without clogging of the digester. They found that the biogas production was increased to 0.610dm³/dm³day after BW addition with 70:30 ratio. The average biogas composition was 69% and 25.7%. (Hills and Nakano)[10] has highlighted the importance of the particle size on the methane production and they had shown that the highest gas production was occurred with smallest particle size. Koumanova.B., M.Saev(2008) [11] worked in anaerobic co-digestion of wasted tomatoes and cattle dung for biogas production in semi-continuous mode. They had shown that a conversion of 72.5% of the organic solids fed into the digester at 20 days hydraulic retention days was obtained. The average gas yield was 220dm³per kg VS added. They used 7%total initial solids and later diluted to 3.5% to avoid clogging.

Smith and Bull (1976) [12] reported that waste coconut water represents a serious pollution risk since it is usually disposed to run off from coconut processing compounds into waterways and agricultural lands. The waste coconut water had a BOD value about 40000 mg. Sison (1977) [1] reported on the environmental problems due to desiccated coconut factories. The matured coconut water was considered as a waste having a BOD value of 29,000 mg. and the wash water about 3,000 mg.

Prachuabkerikhan province is the number one coconut producer of Thailand. In 2008, 434,719 tons or 29.3% of the total coconut production in Prachuabkerikhan. (Office of Agricultural Economics, 2008). Approximately 2% of coconut produced in Prachuabkerikhan province was employed annually to produce virgin coconut oil by natural fermentation. Typically, fermentation starts by mixing coconut milk with boiled water at 1:1 (w/w) ratio and left to stand at room temperature for 24 hrs leading to more or less yield of 20% virgin coconut oil while the rest consisting of coconut whey and wastewater, i.e., 80%, was considered wastes. Annually, total amount of wastewater originated from virgin coconut oil production of 560 cubic meters was approximated (Fuangworawongetet al., (2008) [13].

Tripetchkulet et al., (2010) [2] studied the utilization of wastewater originated from naturally fermented virgin coconut oil manufacturing process. They found that the wastewater had a pH 4.03 ± 0.01, TS (%) 5.45 ± 0.35, oil and grease (%) 4.04 ± 0.01, and a COD of 3540 ± 0.10 mg.

Abubakaret et al., (1990) [14] reported the characteristics of cow dung in his study as total solids 156 mg/l, volatile solids 32.5 mg/l, COD 2200 mg/l, - N 680 mg/l, 7.1 to 7.4, moisture content 41.2 %. He concluded that the cow dung digestion reaches 47% VS reduction and approximately 48.5% COD reduction with biogas yield of 0.15 litre of biogas per kg VSadded.

Garg and Mudgal (2007) [15]; Randhawa et al., (2011) [16] stated that cow dung is a mixture of faeces and urine in the ratio of 3:1, it mainly consists of lignin, cellulose and hemicelluloses. It also contains 24 different minerals like nitrogen, potassium, along with trace amount of sulphur, iron, magnesium, copper, cobalt and manganese. The indigenous Indian cow also contain higher amount of calcium, phosphorus, zinc and copper than the cross-breed cow.

Bodius Salamet al., (2014) [17] conducted a research work to investigate the production ability of biogas from mesophilic anaerobic digestions of cow dung (CD) using silica gel as catalyst.Two laboratory scale digesters were constructed to digest cow dung. The digesters were operated at ambient temperatures of 27 – 31°C. The total gas yield was obtained about 27.3 l/kg CD for digestion without catalyst and about 30.5 l/kg of CD for digestion with catalyst. The retention time was about 76 days for both the digestions.

## 2. MATERIAL AND METHODS

A laboratory scale batch type anaerobic digester was set up for the experimental purpose. Anaerobic digestion was carried out in 2 litre plastic bottles. The experiment was conducted using 15 plastic containers for a retention time of 35 days. A hole was drilled in the centre of the cork for insertion of glass tube. Araldite was pasted in the joints between cork, glass tube and wall of the container to make the container leak proof. Coconut water, water and cowdung were mixed in different proportions. Each proportion was replicated 3 times. The mixture was then filled in the plastic container and cork was fitted over the mouth of the container. The gas tube was folded at the end by using a metal holding clip. Biogas volume and biogas composition was measured at 5:30 pm everyday.

**Table 1 Feed ratios for coconut water : water : cow dung**

| S.No | Treatments | Feed ratio | | |
|---|---|---|---|---|
| | | Water, ml | Coconut water, ml | Cow dung, g |
| 1 | A | 500 | 0 | 500 |
| 2 | B | 375 | 125 | 500 |
| 3 | C | 125 | 375 | 500 |
| 4 | D | 250 | 250 | 500 |
| 5 | E | 0 | 500 | 500 |

**Image 1 : Sample of cow dung**

## 2.1 Characteristics of Coconut Water

Coconut water was collected from the girls and boys hostels of AEC&RI, Kumulur and analyzed for pH, Total dissolved solids (TDS), Total Solids (TS), and Volatile Soluble Solids(VSS).

**2.1.1 pH:**

The term pH is used to indicate the degree of basicity or acidity of a solution ranked on a scale 0 to 14, with pH 7 being neutral .A glass electrode in contact with hydrogen ions of the water sample acquires on electric potential which depends upon the concentration of hydrogen ions.This measures potentiometrically against reference electrode which is usually a calomel electrode and it expressed in pH units.
1.The pH electrode was standardized using distilled water (pH value 7) before using it for pH measurement.
2.Take 100 ml of coconut water sample.
3.Add 50ml of distilled water, stir the contents and to stand for half an hour.

4.Wash the electrode with distilled water and wipe it dry.
5.Immerse the electrode in the beaker containing coconut water and record the meter reading.

**2.1.2 Total suspended solids (TSS):**
The term TSS can be referred to materials which are not dissolved in water and non-filterable in nature. It is defined as residue upon evaporation of non-filterable sample on a filter paper.
Initial weight of a filter paper was taken and denoted as $W_1$. Filter paper (Whatman no.3, pore size=6µm) was placed in a funnel and kept in a stand. Well mixed sample volume (V) of 100 ml was filtered using weighed filter paper. After filtration, filter paper was kept in an evaporating dish along with its residue and was placed in a hot air oven around 103°C-105°C for one hour. After cooling it was cooled and denoted as $W_2$.

$$TSS = \frac{(W2 - W1)X1000}{V}$$

**2.1.3 Total dissolved solids (TDS):**
The term TDS refer to materials that are completely dissolved in water. These solids are filterable in nature. It is defined as the residue upon evaporation of filterable sample.
An empty silica crucible was taken and heated in a hot air oven at 108°C for 1 hour. After heating, it was cooled and weighed; it was denoted as $W_1$. Sample was mixed well and poured into a filter paper (Whatman no.3, pore size = 6 µm) which was placed in a funnel. 100 ml sample was filtered. Using pipette 50 ml of filtrate (V) was transferred to silica crucible. After transformation of filtrate, crucible was placed in a hot air oven at 105°C - 108°C for 1 hour. After cooling final weight of a crucible was taken and denoted as $W_{2.}$

$$TDS = \frac{(W2 - W1)X1000}{V}$$

**2.1.4 Total Solids (TS):**
Addition of TDS and TSS will give total amount of solids present in a sample.

TS (mg/ l) = TDS + TSS

**2.1.5 Volatile Soluble Solids (VSS):**
VSS represents the amount of volatile matter present in the solid fraction of the measured sample. The ignition generally takes place in a muffle furnace at a temperature of 550°C - 600°C for 1 hour. Weight of an empty silica crucible is W. A dried residue with silica crucible weight was taken and denoted as $W_1$ which was used in a estimation of TDS. Residue in a crucible was ignited in a muffle furnace at a temperature of 550°C for 1 hour. After ignition and cooling weight of a crucible was taken and denoted as $W_{2.}$

$$VSS = \frac{(W2 - W1)X1000}{W_1 - W}$$

## 2.2 Measurement of volume of biogas by water displacement method:

The biogas produced from each sample was measured daily at 5:30 pm by water displacement method. The biogas produced was collected in a graduated inverted measuring jar, which was immersed in a tub of water. When the metal holding clip was released, the produced biogas got filled in the measuring jar displacing the equal volume of water in the tub. The water displaced by the biogas in the measuring jar indicates the volume of biogas generated.

Water displacement method - Biogas volume measurement

**Image 2 :**

## 2.3 Biogas composition:

Saccharometer was used to measure the amount of methane and carbon dioxide present in the gas produced from different treatments.
By dissolving granules of 30g NaOH in 100 ml of distilled water 30% of dilute sodium hydroxide solution was prepared which absorbs $CO_2$but does not absorbs methane in the biogas sample. NaOH solution was filled in a saccharometer upto its bulb level. A 5ml syringe fitted with flexible tube of 4mm diameter was used take 5ml sample of biogas and put the end of the tube into saccharometer mouth containing 30% NaOH solution, then pushed the gas sample into it. The volume of liquid displaced indicates the percentage of $CO_2$ absorbed.

Image 3

**Measuring Biogas Methane content using Saccharometer**

## 3. RESULTS AND DISCUSSION

### 3.1 Analysis of coconut water

Coconut water was collected from the farm and the girls and boys hostels of AEC&RI, Kumulur and analyzed for its characteristics and presented in Table 2.

**Table 2. Analysis of Coconut Water**

| Properties | Values |
|---|---|
| pH | 6.1 |
| TSS | 0.0028 g/ml |
| TDS | 0.8014 g/ml |
| TS | 0.8042 g/m |
| VSS | 99.5% |

## 3.2. Evaluation of biogas production and methane content in various treatments

The biogas produced from all the treatments were measured for 20 days. It was observed that there was no gas production after$18^{th}$ day in all the treatments.

The Volume of biogas produced from the sample A containing 500 g water, 500 g Cow Dung ranges from 20ml to 40 and the maximum volume of 133.3 ml biogas is produced on $156^{th}$ day. The $CH_4$ percentage in the biogas gradually increased from 5% to and the highest methane content of 48% was obtained on $14^{th}$ day of retention period.

The Volume of biogas produced from the sample B containing Cow dung: 500 g, Coconut water: 125 ml, Water: 375 ml is less than 80 ml during observation and the methane content of 40-50 % is observed during $12^{th}$ to $15^{th}$ day of HRT.

The Volume of biogas produced from the sample C containing Cow Dung: 500 g, Coconut water: 375 ml, Water:125 ml ranges from 180ml to 30ml and the methane content varies from 5 to 25%.

The Volume of biogas production from the sample D containing Cowdung: 500 g, Coconut water: 250 ml, Water: 250 ml is gradually decreased from 850ml to 100 m during observation. But the methane content of the biogas is gradually increased from 5% to 30%.

The Volume of biogas produced from the sample E containing Cow dung: 500 g, Coconut water: 500 ml ranges from 150ml to 1000ml and the content varies from 10% to 55 %. Highest methane content is observed on $14^{th}$ day of HRT.

It is observed that for all the treatments the volume of biogas production is gradually increased with less methane content. The volume of biogas production and its methane content on $14^{th}$ and $15^{th}$ day is presented in the Table 3

**Table 3:Volume of Biogas production and methane content**

| Sample | $14^{th}$ day | | $15^{th}$ day | |
|---|---|---|---|---|
| | Volume of Biogas, ml | $CH_4$ Content, % | Volume of Biogas, ml | $CH_4$ Content, % |

| | | | | |
|---|---|---|---|---|
| **A** | **25** | **45** | **140** | **30** |
| **B** | **25** | **48** | **50** | **50** |
| **C** | **20** | **15** | **70** | **25** |
| **D** | **40** | **30** | **80** | **28** |
| **E** | **75** | **50** | **100** | **55** |

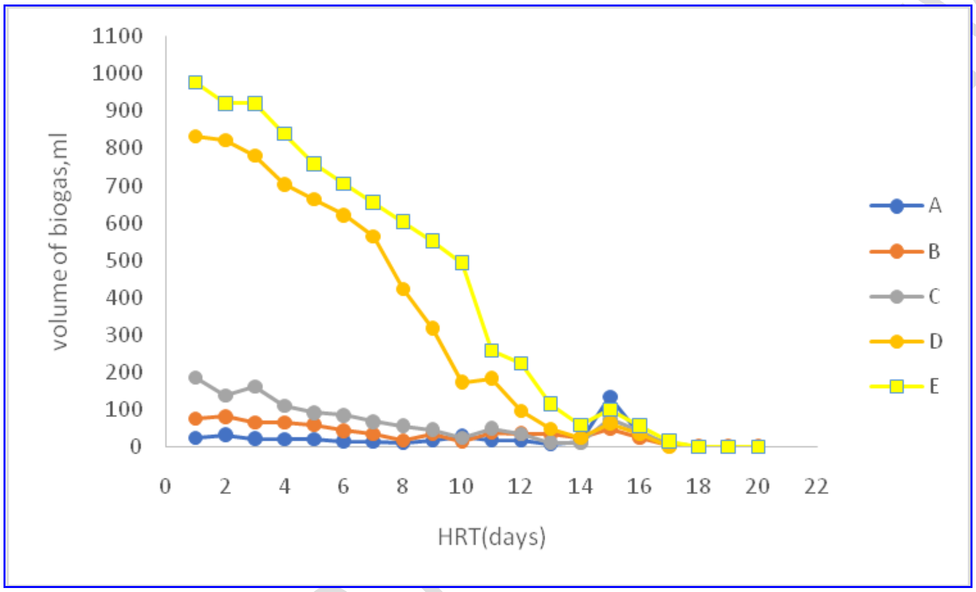


**Figure 1. Volume of biogas produced from different samples**

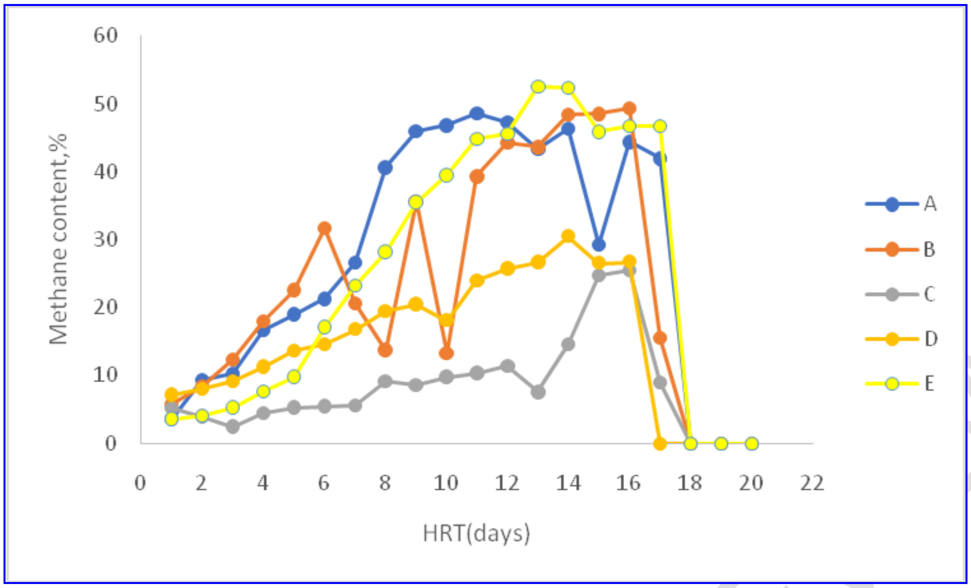


**Figure 2.** Methane content of biogas produced from different samples

### 3.3. Flame test:

The biogas produced from different ratios was tested for its flammability. It was seen that flame last for few seconds from all ratios but the maximum amount of flame was produced from the sample E which contains maximum amount of Coconut water than other samples. The flame produced from biogas by burning the sample ratio illustrated in the Fig.3

**Flame of Biogas burning**

*Fig .3*

## 4. CONCLUSION

The waste coconut water obtained from various sources can be mixed at 1 : 1 ratio which will yield biogas volume in the range of 150 ml to 300 ml with methane content in the range of 40-50% within 15 days of HRT period. The results of the present study is confirmed with research findings of Manimuthu, et al.,(2015)[7], stated that the coconut water can be supplemented in biogas production which will increase the anaerobic microbial population for to achieve better digester performance.

## REFERENCES


1. BC Sison Jr**.**Disposal of coconut processing waste.Philippine Journal of Coconut Studies, 1977
2. Sudarut Tripetchkul, Sasithorn Kusuwanwichid, Songpon Koonsrisuk, Saengchai Akeprathumchai.2010.
3. Pankaj K Kanaujia, YK Sharma, MO Garg, Deependra Tripathi, Raghuvir Singh.2014.Review of analytical strategies in the production and upgrading of bio-oils derived from lignocellulosic biomass. Journal of Analytical and Applied Pyrolysis 105, 55-74.
4. Smith.M.E. and A.T. Bull.1976. Studies of the Utilization of Coconut Water Waste for the production of the food yeast Saccharomyces fragilis.Journal of applied bacteriology, vol.41. pp.81-95.
5. Gerardi, M.H. (2003) The Microbiology of Anaerobic Digesters.Journal of Water Resource and Protection, vol. 7
6. Werner, U., U. Stohr and N. Hoes. 1989. Biogas Plants in Animal Husbandries. A Practical Guide. Vieweg and Sohn, Germany.
7. Manimuthu. M.,A.Saranya., N.SathiyaPandi and S.Rajendran. 2015. Role of Coconut water on Microbial Population of Anaerobic Digester. International journal of current microbiology and applied sciences, vol.4. No.10.pp.945-950.
8. Onwuliri FC,Onyimba IA,Nwaukwu IA (2013) Generation of Biogas from Cow Dung. J Bioremed Biodeg S18:002. doi:10.4172/2155-6199.S18-002
9. Samuel Tewelde., K.Eyalarasan, R.Radhamani and KaliyaperumalKarthikeyan. 2012. Biogas production from Co-Digestion of Brewery Waste and Cattle dung.International journal of latest trends in agriculture and food sciences,Vol 2. No.2. pp.90-93.
10. Hills, D.J. and Nakamo, K. (1984) Effect of Particle Size on Anaerobic Digestion of Tomato Solid Wastes. Agricultural Wastes, 10, 285-295.
11. Koumanova.B.,M.Saev. 2008. Anaerobic digestion of wasted fruits and vegetables. Ecological Engineering and Environmental Protection. pp.20-29.
12. Smith.M.E. and A.T. Bull.1976. Studies of the Utilization of Coconut Water Waste for the production of the food yeast Saccharomyces fragilis.Journal of applied bacteriology, vol.41. pp.81-95.
13. Fuangworawong,P.&Tripetchkul,Sudarut&Koonsrisuk,Songpon&Akeprathumchai,S.. 2008. Study on availability and utilization of wastes from coconut processing in prachuapkirikam province. SUSTJ.28.13-31.
14. Abubakar M.M. 1990. Biogas generation from Animal wastes. Nigerian Journal of Renewable Energy,vol.5. pp.69-79
15. Garg, A. K. and Mudgal V. (2007) Organic and mineral composition of gomeya (cow dung) from desi and crossbred cows – A comparative study. International journal of Cow Science, 3 (1 & 2): 17-19
16. Randhawa, Gurpreet & Kullar, Dr Jagdev. (2011). Bioremediation of Pharmaceuticals, Pesticides, and Petrochemicals with Gomeya/Cow Dung. ISRN pharmacology.

17. Bodius Salam., Sumana Biswas and MdSanaul Rabbi. 2014. Biogas from Mesophilic Anaerobic Digestion of Cow Dung using Silica Gel as Catalyst.Procedia Engineering, vol.105. pp.652-657.