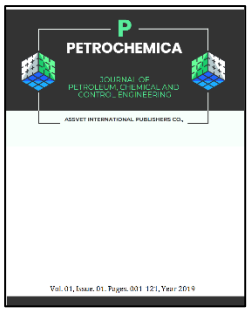

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Bio-methane production in each waste generation area – An alternative proposal for Cauvery delta Coal Bed Methane extraction

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Abstract:

In this context, an alternate to Cauvery delta Coal Bed Methane (CBM) extraction project is proposed i.e. extracting bio-methane using pilot scale bio gas plants. During anaerobic digestion of biodegradable waste, biogas is evolved which contains 75% of methane. This is the key concept of this project. The major raw material for this project is biodegradable waste which is available over 1.3 billion tons per day in India. Sweden produces biogas in large scale. But, countries with large area like India are not able to produce biogas in large scale. So, wastes can be collected and processed in its generation area itself. The initial step of the project is to collect all the bio degradable waste generated in each wards per day through furnace baked earthen pipelines and to reduce size of them using giant shredders. Then digestion is completed with the help of acid producing and methane producing bacteria which is present in the cow dunk. Spherical digesters are used for digestion process. The digestion process takes place in the absence of oxygen and sunlight. It takes 13 days for the completion of this process. So, digestion is carried out in batches. The bio gas and nutritious slurry fertilizer are the end products produced by digestion process. Bio methane is finally scrubbed from biogas for bottling. All these processes are completed within each waste generation area itself i.e. wards. The budget for this project is 112,000 USD. But, CBM project costs up to 168,000 USD. The bottled bio methane can be used as fuel for automobiles, electricity generation and cooking purposes.

Keywords: Biogas, digestion, scrubbing, bottling, application of bio methane

1. Introduction

1.1. Overview of Bio Methane project

The major composition of biogas is methane which is to be extracted in Cauvery delta. Methane has high economic value. In home scale, biogas extracted from digester is directly used for cooking purpose. While implementing in large scale methane from the mixture of other gases is separated by scrubbing [6]. This is then compressed and stored or bottled in cylinder for cooking purpose. Hence biological process is used for extraction; the gas is named as bio methane. It can also be used as fuel for vehicles. Electricity can be generated from this gas (gas portable generators are used in home scale [6]).

Thus this project is an alternative for Cauvery delta hydrocarbon extraction, cooking gas and vehicle fuel. The budget and natural resource degradation is less when compared with Cauvery delta hydrocarbon extraction. Also the production quantity is high. But the time taken for extraction is high in our project.

1.2. Origin of this project

The origin of this project is Green technology. Biogas is a hidden gem in green technology. Green technology is a system that uses innovative method to create environmental products. The heart of green technology is environmental sustainability. It focuses mainly on conserving natural resource and renewable energy generation technology (hence the source they use can be replenished).

The goals of green technology are

1. To reduce natural resource degradation.
2. To recycle or to convert waste to new material.
3. To renew energy or to generate energy from restorable source.

Most of the popular green technology achieves maximum of two of the above goals. E.g. Solar achieves first and last goals; non-biodegradable waste recycling technique achieves first two goals. But biogas extraction achieves all the three goals. So, biogas is a hidden gem in green technology.

1.3. Reason for this project

The rationale behalf of this project is to stop the Cauvery delta hydrocarbon extraction. Bio methane scrubbing from biogas method is more preferable to hydrocarbon extraction because this technique falls under Green technology. Also if the present processing of Municipal solid waste continues, then in the year 2030 India needs the landfill area which is equivalent to the area of Bangalore [2]. Thus by this method landfill area is reduced and farming lands in delta regions are saved.

2. Description

2.1 About biogas

Fossil fuels are fuels which are formed by the decomposition of organic matter with the application of heat and pressure of the earth's crust. Hundred Million years are taken for the completion of this process. Meanwhile bio gas is evolved from the anaerobic digestion of biodegradable wastes within a short span of time. The gas is evolved from anaerobic digestion which is a biological process, so it is named as biogas. Chemical processes stands next to the biological process. Digestion occurs on wastes which have humidity greater than 70% [1]. The digestion process should be carried out with the absence of sunlight. If sunlight is present, then it leads to the development of algae in the digester. This algae intakes carbon dioxide and releases oxygen. Thus anaerobic process becomes aerobic and it further leads to explosion due to the contact of air and biogas. The pH of Biogas is 7.

2.2. Composition of biogas

Methane-50 - 75%; Carbon dioxide-20-50%; Nitrogen-1-10%; Hydrogen-0-1%; Hydrogen sulphide-0-3%; oxygen-0%. The composition of the gas is dependent on pH, temperature and concentration [1]. This biogas is directly used as cooking fuels in homes. But burning hydrogen sulphide leads to corrosion in the burner walls, nitrogen causes pollution, etc. So methane is scrubbed and further used [5].

2.3. To improve production

The catalyst for this process is under research stage. However to increase production (but not rate of production) a traditional method has been found. After experimental analysis by Karnataka farmers [3] it has been concluded that production of biogas is influenced by cashew apple. The technical reason behind this is that the cashew apple is a nutritious food for the bacteria which digests waste. Adding iron oxide nanoparticles in the

digester triples the production. Silica gel also improves production. These agents increase the composition of methane by decreasing the composition of other gases. Citric acid containing waste materials reduces production, hence it disturbs the pH of the environment in which bacteria grows.

2.4 Types of Biogas plant

Out of which, fixed dome is the most commonly used plant because of its long life time. Thus fixed dome plant is considered in this project. They are cheap, built with concrete and have long life.

2.5 Components involved in our project

The following are the components

i. Trash trolleys-To collect the wastes produced in each area manually (by waste pickers) with a wheeled trash boxes/trolleys which can hold 1ton waste.
ii. Shredder-Size reduction of the feed is necessary to promote digestion by bacteria. In small scale size reduction (to improve yield) is done manually. Hence our aim is on large scale giant shredders are used for size reduction. Giant waste shredder is made up of corrosion coated steel, with feed opening – 15mm, HP-3.5, blade size of 6.75 mm and capacity of one ton per hour.
iii. Mixing tank- Homogeneous slurry (equal ratio of water and dung) and wastes are to be mixed before digestion. Mixing is done with hands in small plants. In our project mixing is done by shredder itself. The floor of the shredder is made like slope to separate unwanted settable solid particles in sludge.
iv. Inlet pipe-It is an asbestos pipe from where the substrate is discharged into digester. For large scale, asbestos is not economical. So furnace baked earthen pipelines are used. The diameter of the pipe is 6 inches, thickness is ¾ inch and the maximum length of the pipe is 155m. The pipes are joined with concrete or solvent cement. The slope of the pipe is 1/8inch per foot. The diagrammatic representation is in Fig.1 [7].

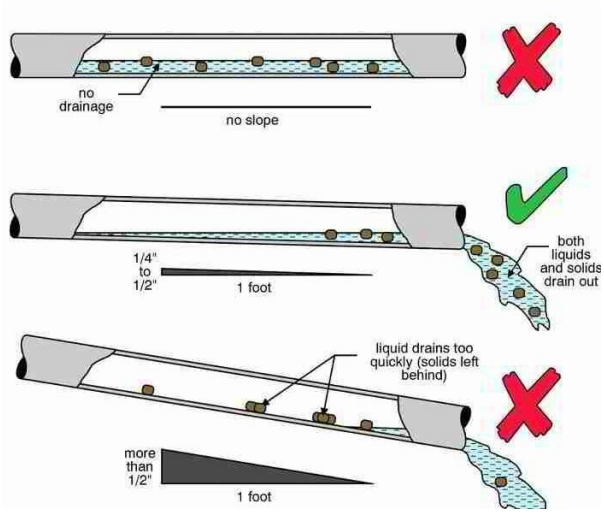

Fig. 1: Inlet pipe

Digester-Digestion process is carried out here. Some changes are made in normal digester to adopt large scale digestion process. The digester contains Up flow Anaerobic Sludge Blanket (UASB) to separate high inorganic content. The digesters are built in underground. Here the earth's pressure creates a compression force in masonry and internal gas pressure also creates compression force internally. Due to these forces tensile stress is developed in digester. If the digester has edges and corners then the stress leads to cracks. Thus digesters are built spherical instead of cylindrical shape. The structure of our digester distributes dynamic loads. The gas leakage or water leakage in the digester are ensured properly and periodically by using automated systems. The surface area, cost for construction and heat loss is low in our digester.

The material used for the construction should be acid resistant (pH-2), consistent of hydrostatic pressure in the underground (1, 2 to 1, 8 Bar), 15 m bar tight. Concrete have all the above said properties, it have better life and it is also economical. So, concrete is used for construction. To ensure gas tight concrete is lined with steel strips. Water thinnable paint coating over concrete gives inflammable property to the digester. Our single or dual component synthetic resin coating improves stability. Bacteria-The bacteria is obligate aerobe (withstand at absence of air), psychrophills (withstand at 25-45oC), nuetrophills (sustain at the pH between 5 and 8), autotrophs (have co2), osmotolerant (withstand at high concentrations), barotolerant (withstand hydrostatic pressure), and sustain the radiations such as infrared, ionising and sun rays. Generally methanogenic bacteria present in cow dung satisfies the above strategies. So, cow dung is used as the bacteria source.

- Gas holder-evolved gas is stored here.
- Scrubber-pure methane from biogas is scrubbed before combustion with it (Scrubber does not exist in existing plants).
- Compressor- The methane is compressed for various uses using this unit.
- Outlet pipe-slurry is collected from here.

3. Various Sections

3.1 Mechanical processing section (Collection-Grinding - mixing-transportation)

Wastes are collected manually in each ward by waste pickers with trolleys. In each ward we collect, shred, grind, mix and transport the wastes to respective biological processing section. Pipes are used as the transportation medium. The processed wastes are sent through a pipe of diameter 6 inches. The pipe is constructed slantly to enhance transportation to long distance without using any external force apart from gravitation. The slope of the pipe is 1/8 inch per feet, to avoid settling of particles [7].

3.2 Biological processing (Digestion) section

Feed (Grinded waste) from mechanical processing section is to be biologically processed i.e. anaerobically digested. Microbes or bacteria are the main components in digestion. Acid producing bacteria (Propionic bacterium, Bacteroides, Clostridium, Peptostrepto coccus) and methanogenic bacteria (Methanobrevi bacterrum inatium, Methano bacterium formicium, Methanosarcinifrisia, Methnothrixsoehngent) are present in the digester along with the waste to be digested [4]. On mixing equivalent water with cow dung it can be used as bacteria source. Also panchagavya & pig dung can be used in addition to cow dung [4].

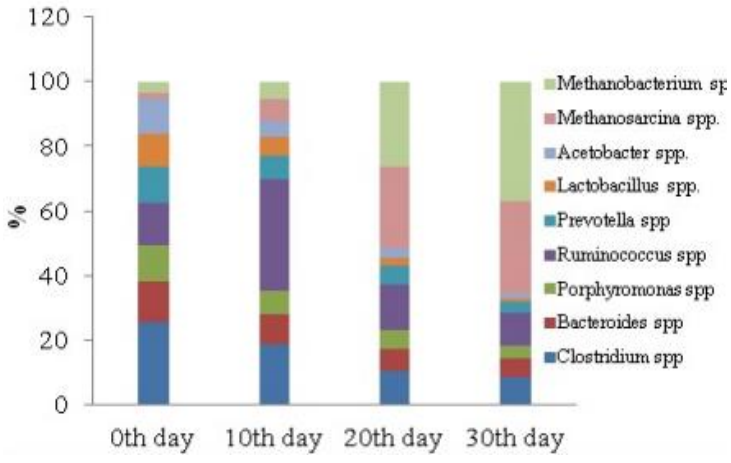

Figure 2 Composition of bacteria in cow dung

There are four stages in anaerobic digestion,

1. Hydrolysis - Macromolecules are cut into monomer by cellules, hydrolyses and amylases.
2. Acitogenesis - Monomers are converted to organic acid and alcohol, also ammonia, carbon dioxide and hydrogen are produced in this stage.
3. Acetogenesis - organic acids are converted into acetic acids.
4. Methanogenesis - methane gas is formed by methanogenic bacteria.

It has been proved that bacteria in cow dung achieve all these four tasks. Thus considering the availability and experimental report, cow dung is used as the source of bacteria in digestion section. The slurry which is left over after extraction of methane is good fertilizer, thus it is further sent for processing fertilizer. Normally once a digestion process is over the slurry which also contains bacteria is directly used for fertigation followed by dilution. But the bacteria are recycled using membrane separation techniques.

3.3 Chemical processing (Scrubbing) section

The biogas from digestion is sent for scrubbing where other gases like carbon dioxide, hydrogen sulphide and moisture etc. are removed.

1. *Carbon separation unit*-It contains lime stone, it reacts with carbon dioxide and gives calcium carbonate.
2. *Hydrogen sulphide separation unit*-It is removed by using iron oxide, once biogas comes in contact with Iron oxide it gets converted to elemental sulphur.
3. *Moisture*-Replaceable silica gel crystal present inside absorbs moisture.

Then the bio methane is compressed and bottled. This bottled gas can be used for various energy applications.

4. Objectives

A. To implement biogas project to save nature.

Cauvery delta needs four thousand million cubic volume water and lot of sand for extracting methane from two thousand wells per day and the process is non-renewable. Bio methane extraction is renewable and eco friendly. Thus biogas project can be implemented as an alternative to this project in order to save one lakh sixty four thousand acre agricultural land and natural resources. Our method of extraction is also economical.

B. To generate fuel

After purification (scrubbing) of bio methane, it is compressed and can be used as fuel for vehicles; its thermal efficiency is up to sixty percent, whereas petrol and diesel are seventy and sixty six percent respectively [6]. So fuel shortage is reduced.

C. To generate cooking gas

The compressed bio methane is also used as cooking gas. 40 kilogram of gas is evolved from one tone waste, which could be scrubbed into bio methane and compressed in two cylinders.

D. To generate electricity

4.698 kilo watt hour electricity is generated with 1 cubic meter of biogas. (The biogas is used as the heat source in steam based electricity generation and in home scale compressed bio methane can be used in gas portable generator).

E. To reduce land pollution

If the current processing of municipal solid waste continues then by 2030 India needs total

landfill of size equivalent to the size of Bangalore[2][3]. Thus by processing the biodegradable waste using this project land pollution and landfill area are reduced.

F. *To extract fertilizer* The slurry leftover after the extraction of biogas is used as fertilizer. Average Nitrogen, Phosphorous, Potassium (NPK) rich 50 kg fertilizer costs eight hundred rupees. But the 1 litre liquid slurry has the NPK ratio of 1.5:1.0:0.8 whereas the compost pit manure contains ratio- 1/2:0.2:1/2 gram per litre. Thus slurry is used as fertilizer after processing.

G. *Raw material availability*
India produces municipal solid wastes of 1.3 Billion tonnes per year [2][3]. Thus plenty of raw materials are available.

H. *To provide job opportunity*
In this project individual plants have been designed in each waste generation area and utilizing the output produced within that waste source area. This provides a huge job opportunity to youngsters.

5. Methodology

Throughout this process the materials used for construction is made of concrete, pipes are made by furnace baking process, machines are made of steel with corrosion coatings. Initially this project needs the support of each and every citizen. Awareness of this project and basic knowledge of difference between biodegradable and non-biodegradable wastes is given initially to the people of this country. The trash produced in their home are collected at door step by waste pickers in two different wheeled dustbins (a pair of common dustbins are kept in each ward). Normally Material recovery facilities (MRF) are used for municipal solid waste segregation in developed countries. Manual disposal followed by segregation will reduce the time, work and money spent on separation. A set of dustbin is kept on public places for disposing wastes followed by segregation. Human faeces (stools) cannot be disposed by physical method. Thus earthen pipeline of six inches can be used for collecting them [7]. Animal wastes (dung) have high economic value, so these wastes alone are bought for a reasonable price. Wastes collected/bought from various source from each wards are merged in their respective mechanical processing section (India has 82607 wards. According to the work plan it has been planned to construct 82607 plants i.e. 1:1 ratio). In this section the wastes are shredded and mixed with a giant waste shredder. Then the fresh cow dung with equivalent water is further mixed to the waste. The pH of this slurry is 2-6. The whole mixture is sent to biological processing section through pipelines. One biological section contains fifteen digesters. Each digester could be capable of processing 1 ton waste in thirteen days. 400kg of gas is produced from 100 ton waste. From experimental reports [3] it has been found that 2.460653 kg gas is produced per cubic meter, thus a gas holder or a digester with enough capacity is needed to store the gas. The digester takes maximum thirteen days to complete the process. Catalyst to speed up the reaction is under research. However cashew apples are used to increase production as said above. So the feed through inlet pipe (furnace baked earthen pipe) from mechanical processing section in day 1 is fed into the first digester and kept undisturbed for thirteen days, at the end of the thirteenth day gas is taken out and the digester is kept ready for the next cycle. In between days the feed from inlet pipe is engaged with their respective digester and kept undisturbed for better evolution of gas i.e. feed on day 1 is engaged with digester 1, day 2 with digester 2 and so on for 13 days. When the digester 13 is engaged with its feed for digestion, the next day digester 1 will be ready to engage its feed. This cycle is repeated for every 13 day and biogas is produced daily. Two digesters are kept as spare during maintenance work. If the catalyst is invented to improve rate of reaction, the number of digesters required will be reduced. During digestion the ambient temperature, sample temperature and atmospheric temperature are to be equal. The digesters are thermally insulated or gently heated in order to maintain the above condition in cold countries. Most probably external heating will not be required

due to the climatic condition of India. The produced gas is then sent for chemical processing. Here the biogas is purified or converted to bio methane. Co_2, H_2S, moisture and other such gases are removed by scrubbing as in Fig.2 and Fig.3 [5].

- CO_2 separation unit -The raw biogas is first passed through a CO_2 separation unit. Limestone crystals are used to remove carbon dioxide. Limestone reacts with carbon dioxide to form calcium carbonate [5]. The chemical reaction is as follows:

  $CaO + CO_2 => CaCO_3$
- H_2S separation unit - Hydrogen sulphide is removed by iron oxide in the form of oxidised steel wool or iron turning from any workshop. Once biogas comes in contact with this wool, iron oxide is converted into elemental sulphur [5]. The chemical equations are as follows:

  $2Fe_2O_3 + 6H_2S => 2Fe_2S_3 + 6H_2O$

  $2Fe_2S_3 + 3O_2 => 2Fe_2O_3 + 6S$
- Moisture separation unit – Finally the biogas is passed through a moisture separation unit. Here silica gel crystals are proposed to separate moisture. Silica gel crystals should be replaced after a specific time according to the rate of purification. The capacities of the scrubbing units are decided according to the size of the biogas plant.

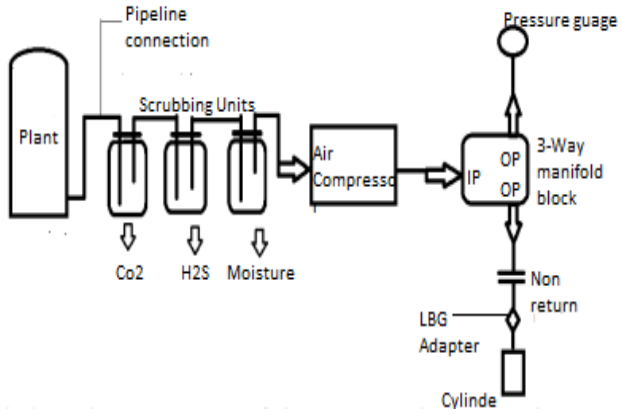

Figure 1: Flow diagram of scrubber

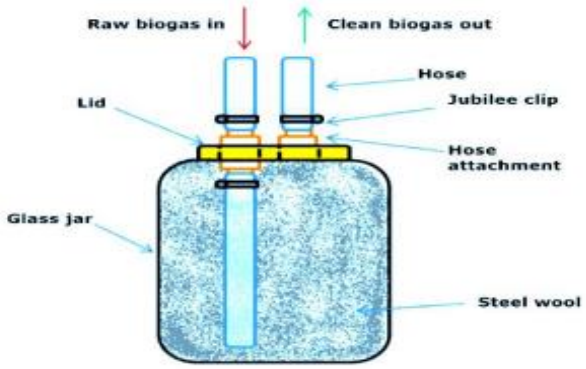

Figure 2: Scrubber

6. Work Plan

i. Basic knowledge between biodegradable and non-biodegradable wastes should be given to the people of the country.
ii. Citizens are supposed to dispose the trash from their home in two different dustbins (a pair of common dustbins should be kept in each ward) according to the type / category.
iii. Human faeces (stools) are to be collected with earthen pipeline of six inches.
iv. Animal wastes (dung) are to be bought for reasonable price.
v. Mechanical Processing sections should be constructed in certain areas.
vi. Wastes collected/bought from various source and various areas should be merged in their respective mechanical processing section.
vii. Wastes are grinded and mixed with a giant waste grinder.
viii. The whole mixture is sent to biological processing section through pipelines.
ix. The mixture is anaerobically digested.

x. The biogas evolved is collected and sent to scrubbing section.
xi. In scrubbing section the biogas is converted to bio methane and sent for compression.
xii. After compression bio methane is bottled.
xiii. The slurry left over is processed into fertilizer by dilution.

7. Novelty and Innovation

i. Sweden's liquefied biogas plant has giant equipments which collects waste produced in the Linkoping city through pipelines. It is the Worlds' largest biogas plant. But according to the area of India collection of waste through construction of pipelines is not economical. So, individual plants have been designed in each waste generation area and utilizing the output produced within that waste source area. This also provides a huge job opportunity to youngsters. Comparing to pipeline construction this idea have low budget.
ii. Alternate for Cauvery Delta hydrocarbon extraction.
iii. Importance and sustainable environment is given to methanogenic bacteria.
iv. Shredding helps size reduction and feed is given to bacteria for digestion according to their capacity.
v. Using multiple digesters for waste processing and gas production every day.
vi. Usage of spherical digesters for long life.
vii. Usage of up flow anaerobic sludge blanket to filter high organic contents.
viii. Special care is given for the construction of digester wall.
ix. Utilizing gravitation force for transportation in pipes.
x. Carbon content in smoke released during combustion is precipitated using high potential electricity (Cottrell's Electro Static precipitator).
xi. Gas leakage is detected using ultrasonic flow detector.

8. Deliverables

i. Agricultural land around Cauvery delta could be saved by implementing this project instead of hydro carbon extraction.
ii. Vehicle fuel alternate.
iii. Natural gas alternate.
iv. Produces NPK enriched Fertilizer.
v. Cooking gas alternate.
vi. Land pollution is controlled.
vii. Job opportunity to youngsters.
viii. Eco friendly energy generation.
ix. Renewable energy generation.

9. Case study of accidents in Cauvery delta hydrocarbon extraction

A. Leakage of methane

- California methane leak - 3rd week of Dec 2015
- Colarado 2004 methane leak.
- Methane gas leak creates ghost town in California
- Siberia - Methane leaks Erupting Methane Mud Volcano: Russia. 28 Oct 2015.

B. Earth quake

- Oklahomaa, New York, cancers –In 2016-Over 20 earthquake - Hydraulic fracking caused earth quake.

C. Water become inflammable

- River on fire: Australian MP calls for fracking ban after setting gas-filled river ablaze – TomoNews

D. Explosion/Accident while extraction

- Nautilus Island-Explosive Methane Burst and Bubble Streams.
- More than 7,000 underground methane gas bubbles explode in the Arctic.
- The Kilauea, Hawaii, USA - June 27th Lava Flow boils pond water after destroying a home on November 10, 2014. An underground build-up of methane from vegetation ignites from the 2,000F lava flow. The multi-million dollar Pahoa Transfer Station property is breeched by a breakout on the North side of the lava flow.
- Jharkhand coal bed - 100 years continuous burning.

E. Sudden craters

- 20-40 craters Siberia 2014-3 craters/holes

F. Leakage from toxic waste (after extraction of methane) tank.

- Bromination in American water bodies (murky lake), HoustonTexas, USA due to integration of flood and toxic wastes.
- 13 of 41 Superfund sites, the nation's most toxic industrial waste sites, were flooded by Hurricane Harvey.

10. Budget (including Goods service tax)

A. Split up of budget-

Table 1 Split up of total budget

S.N	Component	Specification	Quantity*Individual's amount	Price in INR (Indian Rupees)	Reference
1	Trash trolleys	1100 Liter capacity	82607*1000	8.2607 Crores	India Mart
2	Pipe	8" diameter earthen pipeline with thickness ¾ " and 1 meter length	50000*200	1 Crore	India Mart
3	Solvent cement for pipe joints	Water resistant and per liter should cover63cm circumference.	50000*30	15 lakhs	All wholesale hardware shops
4	Shredder	Capable of processing 1.7 ton/hour.	82607*1 lakh	827 Crores	India Mart

5	Digesters construction materials	1.7 ton/13day	82607*1 lakh	827 Crores	Lidkoping Liquefied Biogas Plant, Sweden
6.a	Manpower for plant construction-plumber	1 plumber/ward	82607*190	1.5695 Crores	Orissa cost estimate for rainwater collection unit - 2015
6.b	Manpower for plant construction-load man	1 load man/ward	82607*150	1.2391 Crores	Orissa cost estimate for rainwater collection unit - 2015
6.c	Manpower for plant construction-masoner	2 masoner/ward	82607*170	1.4043 Crores	Orissa cost estimate for rainwater collection unit – 2015
6.d	Manpower for plant construction-engineer	2 engineer/5 ward	16521*1000	1.6521 Crores	Orissa cost estimate for rainwater collection unit – 2015

B. Average total budget in Indian Rupees

The average total budget is 1700 Crores inclusive of Goods Service Tax. But the budget of Cauvery delta coal bed methane or hydrocarbon extraction is 4500 Crores as per Right To Information (RTI) data.

CONCLUSION

Thus, production of bio methane from integrated small scale biogas plant is preferable to Cauvery delta Coal Bed Methane (CBM) extraction method.

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