Working Paper Series

Efficient Waste Management In Schools

By

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Content

Abstract

The problem with garbage is that it's a sum zero game. Garbage has to go somewhere but nobody wants it in their backyard. It's as if trash is deposited in the garbage can and somehow it's supposed to disappear into some magic black hole. Problem is, there is no black hole. There isn't even room for any more landfill. What was once thought to be a progressive solution - incinerating garbage - has become a major point of contention. Incineration of things such as plastics and medical waste raise serious doubts in regard to sound health practices.

The solution everybody can agree on - recycling - is not a panacea for all the garbage problems. Only so much trash is recyclable. It remains a problem with no easy or cheap solution. Indeed, there is a strong need for a quick solution to the country's garbage problem.

Community dwellings such as schools, hospitals, apartments and hotels are the generators of waste in a large quantity. In a day, they generate an average of 50-100 kg of waste every day. These wastes are not properly disposed off. The dumping of garbage as well as non biodegradable waste poses a serious threat to the environment. If waste is efficiently managed in public areas like this, the garbage problem that we face in Kochi can be reduced to a greater extend.

With regard to this, schools are identified as the acute area. School is one such public place where you generate lots of biodegradable waste and which can be disposed off effectively by proper enforcement alone. Moreover, schools can be made as the primary target in the drive for garbage-free Kochi.

Installation of biogas plant in such places not only solves the problem of waste disposal but also can be of economic use. The biogas can be used for cooking as well as generating electricity. Though the idea of constructing biogas plants is being implemented in some places, a widespread popularity has not been seen. It may be because of the high one time cost. . The government is providing subsidy as well as loans for the construction of biogas plants in households as well as in institutions.

Chapter 1

Objectives and Methodology of study.

The study probes into the feasibility of constructing biogas plants in schools in around Kochi. The study was done during the time period of a month. Schools have been identified for this study with a special focus as schools are supposed to be the ground for preparing future citizens of the country. The message of 'Clean Kerala' and Garbage-free Kerala can be propagated through schools. There are over 140 aided and unaided schools in Kochi. The strength of each school varies from 500 to 3500. Schools can be made the basic units for ushering the campaign for effective waste disposal.

Objectives

These are the objectives identified for the study:

- To identify the waste disposed by a given school in a day.
- To find out the feasibility of constructing a biogas within the school campus for effective garbage disposal.
- To suggest ways how to utilize the biogas produced effectively.

Methodology

The methodology adopted for the study is primary and secondary method of data collection. Primary methods include both interview as well as the questionnaire method. Secondary method used is by collecting information like the functioning of a biogas plant as well as the types of biogas plants available in the market and its cost of construction from published materials on the internet and other forms of media. Five schools were identified for the study with strength of 2000 to 3000 students within Kochi city.

The five schools were:

1. Sree Narayana Dharma Pariapalana Higher Secondary School, Udayamperoor
2. St. Joseph's Girls' Convent, Tripunithura
3. Government Girls' Higher Secondary School, Ernakulam
4. Sreenarayana Dharma Paripalana Yogam School, Palluruthy
5. St. Antony's Higher Secondary School, Kacheripady

The principal, the teachers and the peons were interviewed and the students were given a questionnaire with regard to the waste management in the institution. An enquiry was done to find out whether waste disposal is a serious problem in the school. Futher, the amount of free space in school campus was taken into account to decide the feasibility of the construction of a biogas plant. An analysis was done to find out the amount of waste generated in a day and whether it was enough to serve a biogas digester.

Two biogas suppliers in the city, Biotech and Welfare Services Ltd were also contacted. A new model was developed from the analysis that could solve the problem of waste disposal in schools in a cost-efficient as well as eco-friendly way.

Chapter 2

Literature survey

Biogas plants are biogas generating systems. Biogas formed after decomposition of organic wastes in biogas plants is piped or transported to homes for cooking and heating, and used on a large scale in many countries of the world today. The Biogas plants are considered to be the cheap sources of energy in rural areas. Biogas is also used for running engines for shaftand electrical power generation with little or no pollution.

What is biogas?

Biogas is a clean fuel produced through anaerobic digestion of several organic wastes like agricultural, animal, domestic and industrial. Made from organic waste matter after it is decomposed, biogas is used as fuel. A relatively clean burning, colourless, and odourless gas, biogas is composed of methane (CH_4), carbon dioxide (CO_2), and some traces of nitrogen, ammonia (NH_3), sulfur dioxide (SO_2), hydrogen sulfide (H_2S), and hydrogen, depending on the feedstock used. Biogas consists of about 2/3 methane (CH4), 1/3 carbon dioxide (CO2) a little hydrogen sulphide (H2S) and a little hydrogen (H2). It is created by the decomposition of manure and other forms of organic waste from industry or house holds in anaerobic (that is oxygen free) tanks where it is heated.

Manufacturing Process

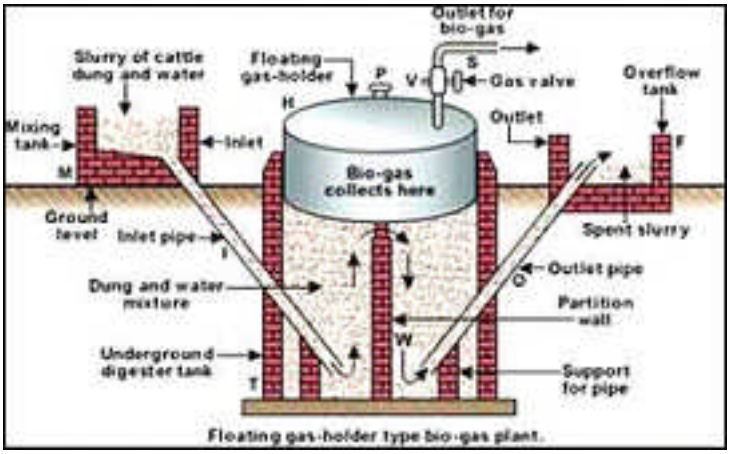
Biogas is produced in a "no oxygen" environment or in an anaerobic environment, when certain bacteria decompose organic material. The whole process is referred to as anaerobic digestion (AD). AD effectively treats the organic fraction of waste which has many benefits. The process not only leads to a healthy and clean environment, but also produces a renewable energy source like methane. In the reactor a biological decomposition takes place where the bacteria produce biogas. The biomass stays in the reactor for about 2-3 weeks. The by-product produced during the process is a solid residue which is high-grade manure. In a biogas plant, biomass like vegetable wastes, animal excreta, and weeds undergo decomposition in the absence of oxygen and form a mixture of gases. This mixture is the biogas which is used as a fuel for cooking and lighting.

Types of Biogas Plants

- Floating gas-holder type
- Fixed dome type
- Bag type

Floating Gas-holder Type

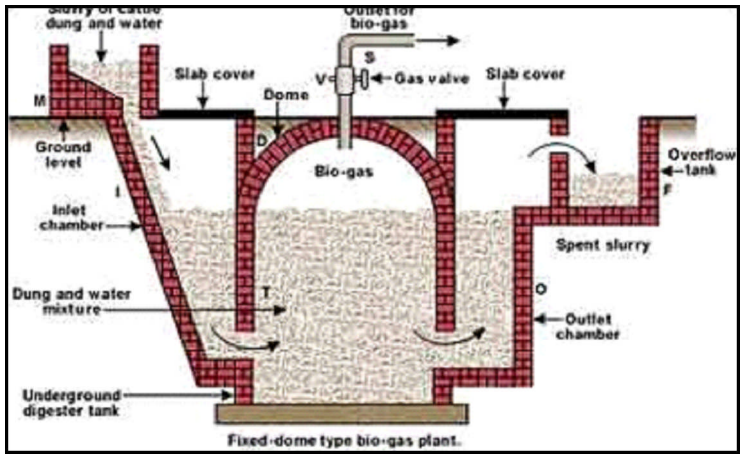
A digester tank or a well is made out of concrete and it called the digester tank T, which has two parts: the inlet and the outlet. The inlet is from where slurry is transported to the tank, which has a cylindrical dome H made of stainless steel. This dome floats on the slurry and collects the gas generated. That is why such a biogas plant is known as floating gas holder type. Fermentation of the slurry takes for about 50 days. The pressure inside H increases when more gas is formed by bacterial fermentation. The gas is then transported out through outlet pipe V. The decomposed matter moves into the next chamber in tank T. By using the outlet pipe this is then removed to the overflow tank, which is used as manure for cultivation purposes.



Floating gas-holder type bio-gas plant.

Fixed Dome Type

Here also, a well and a dome are made out of concrete, which is called the digester tank T. Since the dome is fixed, this gas plant is known as fixed dome type. The manufacturing process is similar to the floating holder type bio gas plant, where the slurry expands and overflows into the overflow tank F.



Fixed-dome type bio-gas plant.

Bag Type

The bag-type biogas plant is a portable unit. Made of rubberized nylon fabric, such a plant can be easily placed at any location. The appropriate type is selected on the basis of technical requirements like distance between kitchen and cattle shed, location, availability of dung and water, preferences of the beneficiaries etc.

Components of Biogas Plants

- **Inlet pipe:** The slurry is moved into the digester through the inlet pipe/tank.
- **Mixing tank**: The feed material like dung is gathered in the mixing tank. Using sufficient water, the material is thoroughly mixed till a homogeneous slurry is formed.
- **Digester:** Inside the digester, the slurry is fermented. Biogas is produced through bacterial action.
- **Gas holder or gas storage dome:** The biogas thus formed gets collected in the gas holder. It holds the gas till the time it is transported for consumption.
- **Outlet pipe:** The slurry is discharged into the outlet tank. This is done through the outlet pipe or the opening in the digester.
- **Gas Pipeline:** The gas pipeline carries the gas to the utilization point like a stove or lamp.

Biogas Plant Construction

Important criteria for biogas plant construction are:

- The amount of waste material available for processing.
- The amount of gas required for a specific use.

Application Areas

- **Cooking:** One of the most common uses of biogas is for cooking in a specially designed burner. A biogas plant with a capacity of 2 m3 is enough for providing cooking fuel to a family of four to five.
- **Lighting:** Another use of biogas is in lighting gas lamps. The biogas required to power a 100 candle lamp (60 W) is 0.13 m3 per hour.
- **Power generation:** This gas is also used to operate a dual-fuel engine. It can replace up to 75% of the diesel.

Benefits of Biogas Plants

- A non-polluting and renewable source of energy is created in biogas plants.
- It is an excellent way of energy conversion.
- Biogas plants produce enriched organic manure. This can be used as fertilizers
- Biogas as a gas provides improvement in the environment, and sanitation and hygiene.
- The biogas plants provide a source for decentralized power generation.
- Most important of all, such plants provide employment generation in the rural areas.

The bio-gas plant will be fully functioning after installation in about a month. During the initial phase, after depositing organic manure and considering the quality of output only does the bio-gas production take place. Only 75% organic waste can be put in initially, it takes around a month to be able to put in complete 100% organic waste materials. After the plant has started functioning fully, around 50-70% bio-gas production will take place. The amount of bio-gas obtained will depend on the amount of organic waste, proportion etc.

A Note of Caution: One should never add more organic waste thinking that it would increase the production of bio-gas as it will lead to adverse effects on the functioning of the plant.

Different types of biogas plant recognized by MNES (Ministry of Non-Conventional Energy Sources). After Gate, 1999.

1. Floating-drum plant with a cylinder digester (KVIC model).
2. Fixed-dome plant with a brick reinforced, moulded dome (Janata model).
3. Floating-drum plant with a hemisphere digester (Pragati model).
4. Fixed-dome plant with a hemisphere digester (Deenbandhu model).
5. Floating-drum plant made of angular steel and plastic foil (Ganesh model).
6. Floating-drum plant made of pre-fabricated reinforced concrete compound units.
7. Floating-drum plant made of fibre glass reinforced polyester.

Capacity wise bio-gas production

Capacity of plant(gas production per day)	Daily requirement of garbage	Area required for construction	Equivalent LPG In grams	No of persons served from cooking by LPG
0.5 cu:m	10 kg	5.5 sq:m	200 gms	1-2
1 cu:m	20 kg	6 sq:m	400 gms	3-4
2 cu:m	40 kg	11.25 sq:m	800 gms	5-8
3 cu:m	60 kg	15 sq:m	1200 gms	8-12
6 cu:m	100 kg	30 sq:m	2400 gms	20-30

Estimated cost for installing a biogas:

Capacity	KVIC Floating model	Deenbandhu	Pragti model
1 cu:m	8000	5500	6500
2 cu:m	11000	6500	9000
3 cu:m	14000	8000	11500
4 cu:m	16500	9500	13000

Chapter 3

Analysis of the study

From the interview and observations in the schools, the following analyses were made:

- Schools generate an average of 10-20 kgs of waste daily.
- This accounted only to the paper and plastic waste generated inside the classrooms.
- There was waste from leftover food from lunch, which weighed another 10 kgs.
- But leftover food were not supposed to be put in schools and students were supposed to take it back home.
- There were waste bins in each class but there were no separate waste bin provided to put leftover food waste.
- The paper and plastic waste were burned in the school campus itself and that too in the evening after school hours.
- All the 5 schools avail mid day meal scheme and the food is cooked in the campus itself.
- A combination of firewood and LPG was used to cook food.
- The waste generated after cooking is given to people who raise cattle in the neighbourhood or used as manure in the vegetable garden.

The schools are well aware of the health hazards created by burning of waste but there is lack of initiative for an alternative for waste disposal. From inspection, it was found that schools had enough free area for constructing a biogas plant near to the kitchen where lunch is prepared. By doing so, the gas formed can be easily connected to the kitchen for cooking food.

Chapter 4

The Model

The disposal of garbage in the world is a problem that continues to grow with the development of industrialized nations and the growth of population. Since the beginning of time people have needed to find a way of disposing of their trash. In 18th century England and France, carters were paid by individuals to carry trash and discard it on the outskirts of town. Disposal in open pits became routine and Benjamin Franklin initiated the first municipal cleaning program in Philadelphia in 1757. Since then we have come a long way and have developed types of waste that cannot simply be dumped into a hole.

There are many different methods of disposing of waste. Landfill is the most common and probably accounts for more than 90 percent of the nation's municipal waste even though Landfills have been proven as contaminates of drinking water in certain areas. It is the most cost affective method of disposal, with collection and transportation accounting for 75 percent of the total cost. In a modern landfill, waste is spread thin, compacted layers covered by a layer of clean earth. Pollution of surface water and groundwater is minimized by lining and contouring the fill, compacting and planting the uppermost cover layer, diverting drainage, and selecting proper soil in sites not subject to flooding or high groundwater levels. The best soil for a landfill is clay because clay is less permeable than other types of soil. Materials disposed of in a landfill can be further secured from leakage by solidifying them in materials such as cement, fly ash from power plants, asphalt, or organic polymers.

Refuse is also burned in incinerators. It is more expensive but a safer method of disposal than landfills. Modern incinerators are designed to destroy at least 99.9% of the organic waste material they handle. Numerous thermal processes recover energy from solid waste. Companies burn in-plant wastes in conventional incinerators to produce steam. Pyrolysis, a process of chemical decomposition, produces a variety of gases and inert ash. Garbage burned in incinerators has poisoned air, soil, and water. Communities near incinerators have objected to them because of fears about possible emissions.

Yet another method is the pumping of hazardous wastes into deep wells. There is a strong opposition to this method because of the apparent explosions and even earthquakes that have resulted from waste injection techniques.

Sewage treatment plants are notorious for having the incapability of handling the extra load of kitchen waste disposal units. The load of organic carbon that reaches the treatment plant increases, which in turn increases the consumption of oxygen. The result is larger amounts of solids. However, if the waste water treatment is finely controlled, the organic carbon in the food may help to keep the bacterial decomposition running. Carbon may be deficient in that process. If no waste water treatment is performed, the extra load of pollutants is detrimental to the environment and chemicals in the waste are problematic.

Organic materials that have little or no heavy metals can be detoxified biologically. Composting and land farming, in which materials are spread out over a large land area so that microbes can decompose them, are examples of biological treatment of hazardous waste. If the materials are not detoxified before they percolate into groundwater then obvious repercussions may occur. The practice of recycling solid waste is an old one. Metal implements were melted down and recast in prehistoric times. Today, recyclable materials are recovered from municipal refuse by a number of methods, including shredding, magnetic separation of metals, screening, and washing. Composting includes preparing refuse and breakdown of organic matter by aerobic microorganisms. Increasingly, municipalities and private refuse collection organizations are requiring those who generate solid waste to keep recyclable items separate from other waste.

All these methods of disposal of waste are ineffective in Kochi city and that is the reason that made me think about the idea of installing biogas plants in schools. Installation of biogas plants can thereby solve the problem of organic decomposable waste and there is an economic value for the product also.

Chapter 5

Community Biogas Plant

Kochi city is faced with a lot of problems like mosquito menace, gutter stutters, traffic problems etc of which garbage disposal is one of the most acute problems it faces. For effective disposal of garbage, biogas technology can be used. Apart from the advantages listed above, the biogas plants are really popular in the city and different varieties are available in the market according to the availability of waste.

Schools are focused as the target area of the study mainly because of two reasons:

1. Schools are already facing disposal of waste as a major problem and from the study conducted reveals that schools are in search for a better alternative for effective garbage disposal.
2. Unavailability of free land for disposal of waste is another problem. Since renting out private land is an expensive proposition in Kochi and schools have enough space for installation of biogas plants.

There are two feasible options for schools in setting up a biogas plant:

1. A biogas plant for the school alone which would be around 3 cu: m in size and the maximum expenditure for the construction would be Rs.15000.
2. A community biogas plant which would be around 6cu: m in size and the maximum expenditure for the construction would be Rs.100000.

Installation of biogas plant in the school by feeding the waste from school alone is feasible only if the school is generating adequate waste to be fed into the digestor and also if there are enough funds for the project to be undertaken. If a model is build with 3 cu: m capacity, the cost of constructing the biogas plant would be around Rs. 15000 with an additional cost of Rs. 300 for the person who operates it.

But the main drawback of this plan is whether the school would be able to generate the adequate amount of waste to be fed into the digestor and also whether the school is in a position to spend for all these.

Chapter 6

Community Biogas Plant

- Another solution is to build a community biogas plant in the school campus where the waste is collected from local households and hotels in and around the school along with the garbage generated in the school.
- The land can be rented out from the schools at a lesser rate as the garbage concern in the school would also be reduced by the installation of the plant.
- Private biogas suppliers can be approached for installing the plant. There is a central subsidy from NBMMP (National Biogas and Manure Management Programme) of Rs.2100 which would lessen the cost of construction.
- For operating the plant the cost is really minimal except for paying for the person who operates it.
- Waste could be collected from households on a daily basis as segregated into biodegradable waste and non-biodegradable waste. The collection cost can be fixed as a maximum of Rs.150 per month or Rs.5 a day.
- The non-biodegradable waste can be sent in for recycling and the biodegradable waste can be fed into the digestor.
- The bio-gas produced can be used in the school kitchen and can be given to them at a price say, Rs15 per litre which would be half the price of 1 litre LPG. In that way, school gets unlimited supply of cooking gas and also reduces its expenditure on firewood as well as LPG.
- The residue produced after the methanation process is good manure. The residue slurry needs to be removed once in a month. This can be sold in the market at a wholesale price of Rs. 5 per litre to a nursery or farmers located nearby.
- The return over the investment can be realised within 18 months of installment of the plant.
- There is no incurring and recurring cost with such a plant. As for the maintenance and operational cost, it is really very low and can be easily covered.
- The lifetime of a typical bio-gas plant is around 15-20 years. Putting in too much of organic waste will affect the functionality of the plant.

Chapter 7

Technicalities and Cost- Benefit Analysis

Size of plant	6 cu:m
Gas holding capacity	3000 litres
Cost of installing biogas plant	Rs. 100000
Maintenance and operating cost	Rs 300 per month
Minimum quantity of waste	No limit
Solid waste treatment	Around 10 kgs
Organic waste that can be treated	180-200 litres/day
Gas output per day	6 cu: m to 7 cu: m
Liquid fertilizer output per month	1000 litres
1 cu :m biogas	0.5 kg LPG
6 cu: m bio-gas	3.0 kg LPG
Cost of 1 kg of biogas	Rs 15
Cost of LPG for a year	Rs. 350 * 2 * 12 = 8400
Cost of biogas for a year	Rs. 225 * 2 * 12 = 5400

You can save up to Rs 3000 a year!

Potential Revenue Estimates

Sale of Liquid Fertiliser for a month	Rs. 5 * 1000 = Rs 5000
Sale of Liquid Fertiliser for a year	Rs. 5000 * 12 = Rs 60000
Sale of biogas for a year	Rs 15 * 6 * 365 = Rs. 32850
Total revenue from sales	Rs 60000 + Rs 32850 = Rs 92850

Chapter 8

School mapping for Pilot Study

In order to analyse the feasibility of constructing the biogas plants in the schools and thereby develop the idea of a community biogas plant, a school mapping should done and 5 areas have to be selected within the city. By constructing a community biogas in all these five areas our objective is to find out whether it will be effective and profitable to install biogas plants in these areas. If the results from the study indicate that this method of waste management is indeed effective and profitable, then it may be looked at as an effective solution to solving problems of waste management in Kerala and subsequently all over India as well. If the pilot study brings in the desired result within the time limit of 18 months, the project can be rated profitable.

Problems to be answered in the pilot survey:

1. What are the means of generating funds for construction of the plant?
2. Will it be a feasible proposition to go in for a tie-up with manufacturers of bio-gas plants
3. How does sensitization of people in the neighbourhood happen so that they contribute to the cause.
4. Who should be hired for collecting waste from nearby localities.
5. To whom should the biogas produced be sold?
6. To whom should the manure produced after methanation be sold?
7. What should be done with the non biodegradable waste?

Since there is an all time peak ushering among people to go green these days, many big shot companies as well as organisations are willing to support this cause, especially newspapers are into extensive coverage of eco-friendly ideas in the city these days.

People in the local neighbourhood would be ready to get rid of their waste since someone would come to their door front to collect the trash. With regard to the fee they have to pay, it is only a nominal fee which can be picked up by most households in the city.

As of now, Kudumbashree units are working in 22 wards for collecting waste from household at a cost of Rs 4000 a month. It can be planned in such a way that the Kudumbashree units can take up the collection of waste and retain the amount of Rs 150 per month from each household. This would be far more than the meager amount they get from corporation. Or else, 2 persons can be appointed for Rs. 300 per month to collect the waste from household of which one person can take care of the biodegradable waste and other person can give the non-biodegradable waste for recycling.

The biogas produced can be sold to the school itself at a lesser rate of Rs.15 per cu: m. or else there is technology available to store it in cylinders and can be sold to the neighbourhood.

With regard to the manure, nurseries are in high demand for organic manure. So if this manure could be sold at a minimum rate of upto Rs.5 per litre, the problem could be solved.

For this pilot survey, there is a need for five 6cu:m plants which could be acquired from the biogas suppliers at a concessional rate and installed in the five target areas.

Chapter 9

Disadvantages in constructing biogas plant

Why biogas plants are not popular?

Biogas plants are a one time investment and the same applies to its operation. Once you install it, care is taken only in the first year only. Afterwards, people do not take proper care in maintaining the plant and as a result, the plant life decreases and within a short times period it stops functioning.

For initializing the process of methanation there need to be the presence of cow dung along with the waste. People find it difficult to find cow dung, especially in cities and therefore, they discard the idea.

The amount of gas generated is uneven. It changes with the raw material fed into the digestor. The amount of gas generated by cow dung is more than kitchen waste. And one may not get equal amount of gas everyday. And if the gas production is less, one need to supply cow dung to hasten the process.

Another drawback is with regard to the raw material used. Kitchen waste consist of curry, fish and meat bones, vegetable peels, oil etc which has different types of constituent materials like oil, salt etc which are having lower pH values than water. These materials slow down the methanation process. And also onion peels and tomato peels do not get decomposed easily and hence they get deposited as residue at the bottom.

Another disadvantage noticed is with regard to the formation of gas. Biogas is composed of methane (CH_4), carbon dioxide (CO_2), and some traces of nitrogen, ammonia (NH_3), sulfur dioxide (SO_2), hydrogen sulfide (H_2S), and hydrogen and moisture. Of this, only methane is used for cooking purpose. There is no appropriate technology inbuilt in the biogas plant to remove other gas formed especially moisture.

Another disadvantage that remains unnoticed by most of the people using biogas plants at home is the pressure level. There is no mechanism to gauge the pressure of the gas chamber above the digestor.

The non degradable peels and mud settled beneath the digestor can choke the outlet pipe and thereby cause block in the plant.

Another disadvantage with fixed dome plant is once it is constructed, you cannot remove its lid.

With regard to the residue manure formed, there has been no such mechanism to remove the liquid fertilizer in dry form. Green Goa, an NGO group found a solution of removing the difficulty. This was by building a soak pit under the ground near to plants and trees. The trees and plants absorbed the moisture content in the residue and what was left was just dry matter. And this dry matter could be sold in the market as manure.

If not properly maintained, the slurry as well as the residue can create obnoxious odour. This makes the idea of biogas plants in houses not so popular.

Chapter 10

Conclusion

There is great potential in extracting biogas technology in India irrespective of urban- rural barriers. The only care one has to take is developing the appropriate technology to running the plant flawlessly by taking into consideration the minute technical details as well as the socio-economic conditions of the society. Once such things are taken care of, biogas can become the fuel of future generation.

References

- http://www.hedon.info/docs/20060406_Biogas_promotion_India.pdf
- http://www.unu.edu/unupress/unupbooks/80434e/80434E0k.htm
- http://en.wikipedia.org/wiki/Biogas
- http://www.indg.in/rural-energy/schemes/national-biogas-and-manure-management-programme-nbmmp
- http://www.ganesha.co.uk/Articles/Biogas%20Technology%20in%20India.htm
- http://biotech-india.org/Features/Brochure/Technical%20Details%20and%20return%20on%20Investment%20(ROI)%20of%201%20cum%20Domestic%20Bio%20Waste%20Treatment%20Plant.pdf
- http://www.indiatogether.org/2006/jul/env-karve.htm
- http://saleemindia.blogspot.com/2008/07/bio-gas-from-kitchen-waste_14.html
- http://www.umich.edu/~gs265/society/wastedisposal.htm