CHAPTER - 1

INTRODUCTION AND SCOPE OF WORK

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1.1 INTRODUCTION

Energy is one of the most important requirements for the development of a nation, in fact per capita; consumption of energy is an index of a developed nation.

In this context, per capita energy consumption in U.S.A., Africa, China, India, is worth noting. Conventional energy sources, mainly fossil fuel such as coal, oil, gas etc. are limited, and cannot serve the society indefinitely. But the demand for energy is ever increasing as a result the whole world is going to face an energy crisis in near future unless alternate sources are developed to meet the growing energy demand.

Another associated problem with the use of fossil fuel is environmental pollution as a result of combustion of fossil fuels.

It is therefore, imperative to put efforts to find a solution for both these problems by developing alternative energy sources.

The alternatives that are being considered for exploitation are the following:

1. Solar energy
2. Bio-mass energy
3. Wind energy
4. Tidal energy
5. Fuel energy
6. Geothermal energy
7. Nuclear energy
8. Ocean thermal energy conversion (O.T.E.C.)

To encourage research and developmental work in the field of renewable energy Indian Renewable Energy Development Agency (I.R.E.D.A.) has been established under the Ministry of Non-conventional Energy Sources (M.N.E.S.), Govt. of India.

For a large country like India, energy development from food waste, agricultural residue and animal dung through bio-methanation is an attractive and viable proposal and deserves consideration for the following two reasons:

a) For energy potential &
b) For reduction of pollution load.

In India more than 600 million tons of agricultural wastes (i.e., agro-industrial waste & crop residue) are generated every year [1]. Most of this is burnt by the way of waste disposal, as the farmer wants his fields ready for next crop. A small part of the residues may be used for mulching, for fuel (for cooking) or as fodder. Instead of burning the agricultural waste directly, it is preferable to use the agricultural waste as feedstock for bio-methanation because the nuisance of smoke and ash can be avoided and thus pollution level can be minimized.

So far, these processes did not take off in a big way mostly because of the following difficulties:

1. Inadequate documentation and lack of past experiences.
2. Lack of techno commercial supports.
3. Shortage of qualified and experienced personnel for providing guidance right from design, manufacture, installation, marketing and training for maintenance as per the norms of Ministry of Non-conventional Energy Sources (M.N.E.S.)

Energy sources are classified as commercial and non-commercial: coal, oil, natural gas and electric power which are priced and easily marketable are commercial sources and bulk of non-commercial supplies come from vegetable waste, fuel wood& cow dung etc.

Asian Development Bank (A.D.B.) has approved a loan of $ 100 million for development of renewable energy resources in India and promoting the development of four major areas: Bio-methanation, bagasse- based co-generation, wind energy and solar thermal energy conversion system [2].

Biomass seems to be one of the most attractive and viable sources of renewable energy available on recurring basis for country like India as the large part of the country is rural.

Firstly biomass includes dedicated energy crops and trees, agricultural crop residues, wood and wood waste, aquatic plants, grasses, industrial waste and municipal waste. The process of bio-methanation involves a very low financial input per kWh of output. Anaerobic digestion of various feed stocks and their potential in terms of methane production is given in Table no 1.

Table No. 1: Production of biogas from various types of biomass

Nature of Biomass	**Biogas Production**
MARINE SEA GRASS	
Thalassia testidium shoot	10.4 lit/kg. (wet) weight
Root	7.4 -do-
Syringodium filiforme	7.377 -do-
ALGAE	
Gracilaria tikrahiae	22.2 to 32.4 lit/kg. (wet) weight
Ulva sp	32 to.40 -do-
Hypnia musciformis	7.6 -do-
Sargassum fluitans	8.5 -do-
AQUATIC BIOMASS	
Eichhornia caussipes (Water hyacinth)	7.045 lit/kg. (wet) weight
Fresh water aquatics	0.07- 0.43 m^3 per kg.V.S.
WASTE BIOMASS	
Sugar beet pulp	0.45 m3 per kg.V.S.
Lignocellulosics	0.02to 0.27 m^3 per kg.V.S.
Crop residue	0.08 to 0.53 m^3 per kg.V.S.
Wheat straw	162 to 249 lit/kgVS added
Rice straw	241 to 367 -do-
Mirabilis leaves	290 to 341 -do-
Cauliflower leaves	358 to 423 -do-

Ipomopa fistulosa	387 to 429 -do-
Dhiub grass	137 to 228 -do-
Banana peeling	271 to 409 -do-
Market organic waste	0.478 m^3 per kg.V.S.added
Mixed vegetable waste	0.6 -do-
Wheat straw	0.37 -do-
Potato tops	0.61 -do-
Maize tops	0.52 -do-
Beets leaves	0.46 -do-
Grass	0.56 -do-
Brassica (leafy vegetables)	22.6 lit/kg.wet biomass
Sotanum tuberosum (potato)	79.0 -do-
Calotropis procera	1.6 - 2.4 lit./day
Municipal sewage, sludge	0.60 m^3 per kg.V.S.added
Municipal sewage, skimmings	0.57 -do-
Municipal garbage	0.63 . -do-
Waste paper	0.26 -do-
Municipal refuse	0.21 -do-
ABATTOIRES WASTE	
Cattle paunch contents	0.53 -do-
Intestines	0.09 -do-
Cattle blood	0.16 -do-
Diary waste, sludge	1.03 -do-
Yeast waste, sludge	0.80 -do-
Paper waste, sludge	0.25 m^3/ kg. dry solids
Horse manure	0.44 -do-
Cattle manure	0.32 -do-
Pig manure	0.42 -do-
Brewery waste	0.45 -do-

Sources: Green Energy (Biomass Processing and Technology), 2003, Capital Publishing Company, New Delhi, p109-110

Secondly, since generation of biogas mimics the natural environmental cycles, nutrients such as Nitrogen, Phosphorous and Potassium are conserved in the process and can be recycled back to the land in the form of soil nutrients.

Thirdly, through the digestion of degradable waste from large kitchens, hospital, hotels and hostels, can reduce various pathogens considerably thus reducing health hazard to a large extent.

Finally, since biogas is a clean fuel, its domestic use is free from health hazards particularly in respect of eye and lung problems. Bio-methanation of degradable waste has drawn considerable attention in the recent past as this process helps in improvement of environment. Thus anaerobic digestion (processing in the absence of air) of organic waste is going to be very commonplace in the near future to meet the ever-increasing energy demand.

Bio-methanation of organic waste through anaerobic digestion therefore will not only provide clean source of energy but also provide a means of boosting agricultural production through the use of nitrogen reach organic manure which is available from bio-methanation process. The process is thus going to play an important role in meeting the energy demand in near future and overall development of society.

It is estimated that there is potential of installing 12 million biogas plants in this country. However, up to March '94, 19 lac biogas plants have been installed under the national project on biogas development (N.P.B.D.) being promoted by the Ministry of Non-conventional Energy Sources (M.N.E.S.) [3].

During sixties and seventies Khadi and Village Industries Commission, State Agro-Industries Corporation and State Khadi boards were some of the major agencies that have promoted the biogas program in the country [4].

In India bio-mass co-generation potential has been estimated to be 3500 MW of which Indian Renewable Energy Development Agency (I.R.E.D.A.) has already sanctioned projects totaling 300 MW, Ministry of Non-conventional Energy Sources (M.N.E.S.) is continuously promoting installation of various bio-methanation units [5]. Enormous quantities of vegetable waste are dumped daily in the open air mainly in municipal and urban areas, which can be processed through anaerobic digestion to generate energy at the same time preserving the environment. This dumping causes the release of methane to the atmosphere thus contributing towards global warming.

Present research work has carried out a systematic study of bio-methanation of various kitchens waste and vegetables individually and then in the mixed form.

The study also includes the methods of material handling, slurry preparation and optimization of digestion period.

Attempt has also been made to find out a very practical methodology for the digester design, plant layout and analysis of solid remnants as organic manure.

1.2. SCOPE AND OBJECTIVE OF THE WORK

From time immemorial man has been dependent on nature's bounty of forest wealth and fossil fuels to meet to the energy needs. But this cannot continue indefinitely. The conventional method of generation of energy by burning of biomass is not energy efficient and further it adds to pollution load, hence the necessity of development of alternative method of generating energy from biomass has been felt. Following the energy crisis of 1973, a systematic study has been started. Electricity can be generated from a number of biomass sources i.e. renewable energy sources marketed as Green Power. Biomass also can be converted into transportation fuel such as ethanol, methanol, bio-diesel and gasoline.

Biomass resources can be converted to useful fuel using a number of conversion systems depending on the type of biomass and the end use. One of such conversion process is **Bio-methanation**.

In the present work particularly biomethanation of kitchen waste has been studied. Various problems related to handling the waste and feeding it to the digester has been studied. Attempt has also been made to co-relate the digester temperature, pH value of the slurry mixture and C/N ratio of the feedstock to the biogas output.

It has been observed in other countries that bio-methanation of organic matter is economic in large power plant. The problems encountered are mostly because of its volume (bulk density 30-180 kg/cu.m) [7] and low heat value and presence of nitrous oxide. Because of these problems and absence of an appropriate technology this conversion process of waste to wealth has not been adopted widely. As such it is imperative to design the most practical plant layout and also choice of handling equipment to be used in the biogas generation plant.

With the increasing population and increased consumerism more waste are being generated, hence it is essential to develop suitable methods for conversion of these waste to energy as a clean development mechanism (CDM) to meet the ever increasing energy demand while maintaining a clean environment.

Developed countries like Belgium, Denmark, Japan, Austria, Sweden, are using these waste as an alternative source of energy but in India we have yet to develop it in a large scale. That is how the present study is of great importance. The energy content of these waste ranges from 1900 kcal/ kg - 2300 kcal/kg [8] which is quite high energy and can be exploited via biomethanation mechanism.

Municipal solid waste in general (MSW) are having low contents of lignin, which is helpful for biological degradation, and thus this waste can be utilized for generating clean energy. The principal of bio-methanation has to be understood to enable suitable design and manufacture of equipment. The knowledge is also to be disseminated to the community to make them confident in the operation and maintenance of biogas plant with the aim of establishing a renewable source of clean energy.

It therefore, becomes essential to study bio-methanation using vegetable waste mainly from large kitchen of hotels, hospitals, hostels and market refuge. From literature survey it is found that lot of work has been done in various countries including India on bio-methanation of animal excreta, human excreta, crop residue but not much on vegetable waste particularly plant layout and handling equipment design. Thus the necessity of this study gains momentum.

In view of what has been stated so far, the present work has been undertaken with a view to study the following.

1. Optimization of digestion period for individual and mixed kitchen waste.
2. The development of an appropriate process for slurry preparation.
3. To develop the process for conveying feedstock to the digester in semi-batch and continuous digestion.
4. Up gradation of gas generated/produced in order to increase the calorific value per unit volume.
5. Evaluation of the remnants as organic manure.