BIOGAS TECHNOLOGY – PRESENT STATUS; PROBLEMS & FUTURE PROJECTIONS

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Abstract— **The acute shortage of energy available from traditional sources has prompted intense and research activities in the field of alternate sources of energy especially from the renewable source like one such biomass, biogas etc. Potential source is the biogas generated through anaerobic digestion wastes like cattle sung, crop residues, etc. Anaerobic digestion, not only leaks to valuable energy in the form of methane but also enhances the fertilizer value of the waste. Additionally, it provides a safe, convenient, non-offensive and economical waste disposal method.**

Keywords— ***Biogas technology, Anaerobic process, Problems and Future projection*.**

I. Introduction

The anaerobic digestion process is too well known to be described in detailed here. It is being practiced in municipal sewage treatment plants since the last over a century. It is a complex biological process, during which the organic matter is decomposed by anaerobic bacterial organisms. The bacteria are capable of decomposing organic substance and producing methane gas. These bacteria are present in abundance in the nature, particularly in the decaying matters. The organic substance need not be pure and may comprise organic substances coming from various sources, if the process is allowed to continue long enough. The entire substrate (carbohydrates, fats and proteins) through the digestion process, yields methane and carbon dioxide etc.

During the course of digestion of the organic matter, two phase of decomposition, namely liquefaction and gasification occurs. Both these stages are brought about by the bacterial action. The majority of the bacteria are of the saprophytes group. These bacteria are capable of rapid reproduction and are less sensitive to environmental changes as compared with the bacteria responsible for gasification.

The gasifying organisms are also mixed culture of bacteria and are strict anaerobes. They have a low rate of reproduction and are extremely sensitive to temperature, acid and alkalial conditions as well as to varieties. These bacteria require carbon dioxide for conversion of volatile acids into methane. The conversion of acid to methane is accomplished with the help of the enzymes secreted by the methane forming bacteria. Once the anaerobic process is set in, thereafter it continues provided the organic waste are fed regularly and the sludge is taken out at regular intervals.

Biogas is a mixture of methane, carbon dioxide, nitrogen and hydrogen sulphide gases as well as some water vapours. On an average biogas contains about 50-65% methane, 30 to 35% of carbon dioxide and the traces of nitrogen, hydrogen sulphides etc. calorific valve of the gas is about 4700 Kcal. The gas unlike the LPG cannot be liquefied easily. The gas is generally used for cooking, heating, lighting, operating dual fuel engines, electricity generation etc.

II. Methods & Materials

In India, as many as about 45.45 Lakhs family size biogas plants are reported to have been installed till date. Of these, as many as about 1.60 Lakh biogas plants are reported to have installed in the Punjab. The number of the biogas plants in the State is reported to be increasing slowly. The retreated reduction of installation of biogas plants in the Punjab state can be ascribed to the following factors:

a. High initial cost: the cost of installing a biogas plant of the available design varies from Rs. 40,000/- to 50,000/- for a plant of 4 – 6 m^3/day capacity.
b. Non-availability of raw material required for the construction.
c. Phenomenal increase in the cost of steel, bricks, sand, bajri, labor etc. is another problem.
d. In some cases, the improper management of the slurry discourages the persons to install the biogas plants. The slurry coming out of the digester gives ugly look, if not properly handled.
e. Reduced rate of generation of the gas especially during winter months.
f. Non-availability of efficient cooking devices (ehullahs) etc.

III. POTENTIAL OF BIOGAS IN PUNJAB:

The two major potential sources of raw material for production of biogas in the Punjab are the cattle dung and surplus crop residues. The details about these two sources have been described in the Punjab that follows:

- The combined population of cattle and buffalos in the Punjab is 8.033 million according to the 2003 statistical abstract of Punjab. The details of manure, nitrogen, phosphorous, potassium and energy equivalence of the dung are given vide Appendix I. It can be seen from this Appendix that available dung is equivalent to 0.862 billion liters of kerosene oil/ 0.723 billion liters of diesel/ 0.598 billion Kg of LPG per annum. The energy potential of the 7.91 million tons of manure or 1.49 million tons of N,P,K per year. A large proportion of the available potential can behearnessed through the anaerobic fermentation.
- Crop residues form another major source for generation of the biogas. However, not all the crop residues such as that of wheat, jowar, bajra, barley, gram pulses, oil seeds, cotton etc. are available for methane generation as they are being utilized for other purposes such as cattle feed, cooking fuel etc. However, crop residues of many crops such as rice, maize, sugarcane, potato etc. hold great promise for generation of methane by anaerobic fermentation. Details of crop residues and their energy equivalents are given vide Appendix II. From this Appendix, it can be seen that the energy equivalents of the potential crop residues comes to about 0.486 billion liters of kerosene oil/ 0.0407 billion liters of diesel/ 0.337 billion Kg of LPG. Additionally it could produce additional manure amounting to about 12.546 million tons of manure or 3.011 million tons of N.P.K.

It could, however, require intensive research effort to explore the effective methods of fermentation of the surplus crop residues through the anaerobic process for production of methane to supplement the manure requirements for higher agricultural production.

IV. RESULTS & DISCUSSION

From a survey about non-functional plants located at different places, the following defects were noted:

(i) **Organization problems** (i.e. selection of suitable size of biogas plants, selection of trained masons for the construction of biogas plants etc.)

(ii) **Operational defects** (i.e. defects in biogas stove, proper size and slope of gas pipeline, functioning of different valves and water traps in the gas pipeline system and proper feeding to the plant etc.).

(iii) **Installation** (structural) defects (i.e. design parameters, leakage in dome and gas storage chamber, proper levels and adequate size of outlet chamber and slurry outlet channel etc.).

In order to overcome the above mentioned problems the relevant remedial measures have been suggested.

- **Gas formation during winter months**

  Research conducted in this context has shown that gas production during winter is reduced to about 20% of the rated capacity. The temperature of the dung during the winter month, viz November through February is lowered to about 16°C at which microbial activity retards leading to less gas production. Therefore, suitable measure is required to be adopted to maintain a favourable slurry temperature of about 30°C. Some of the means like composting require to be adopted, the details of which are discussed later in this note.

- **Addition of chemical fertilizers for better yield of biogas**

  It has been seen that the farmers add chemical fertilizers and/or molasses to get better yield of biogas. However, for maximizing the yield of the biogas, an optimal substrate for efficient anaerobic digestion requires a Carbon – Nitrogen ratio of around 30. If this ratio is not maintained, the rate of methane generation is retarded and an excess quantity of carbon-dioxide is produced. Hence, addition of unestimated amount of chemical fertilizer and molasses loads to low rate of production of methane owing to unfavourable Carbon-Nitrogen ratio. Besides, pH value between 7 and 8 should be maintained for the digester slurry. Poultry droppings and animal urine also help in increasing the yield of biogas provided pH valve is maintained between 7 and 8.

Resume of biogas research work carried out at PAU

The School of Energy Studies for Agriculture, College of Agricultural Engineering & Technology at PAU has been engaged in the research on various aspects of biogas technology. The different aspects of the biogas Technology on which the research has been conducted are enumerated as follow:

Perspective Research Areas in the Field of Biogas:

The perspective research areas and their brief details are outlined as follows:

- **Integrated Animal Wastes Recycling**

Integrated Animal Wastes recycling models have been developed in Taiwan and these are reported to be working efficiently. Such models, however, need to be developed for Punjab conditions. Necessary data on the Integrated Process of Animal Wastes recycling for production of biogas is, therefore, considered to be quite valuable and relevant.

- **Research on Plant Residues for Biogas Production**

Since the cattle population varies from village to village, materials other than cattle dung need to be examined for production of biogas and manure. Theoretically non-woody plant wastes can be fermented anaerobically into Biogas and manure. However, the chemistry of fermentation and bio-engineering problems need to be studied and solved. The straw available from rice and other cereal crops, holds a possibility for utilization in biogas plants but its light density creates problems by way of floatation and feeding into the plant. Batch type biogas plants utilising crop wastes developed in Europe are considered to be suitable for India. Hence, research needs to be intensified on the feasibility of using crop residues and other biomass for production of biogas.

- **Studies on Large Capacity (Community Type-Bio-Gas Plant)**

The large capacity Biogas plants have been reported to be more economical and commercially viable. Studies on the design, construction, operational and sociological aspects of such plants need to be intensified.

- **Research on Handling and Use of Digested Slurry**

Spot checks on the existing biogas plants installed in the villages have revealed that many farmers are reluctant to install biogas plants due to the difficulty in preparing the slurry and in handling the digested slurry coming out from the plant every day. Quick methods for dewatering and drying of the digested slurry need to be evolved. Research on this aspect needs to be intensified.

- **Use of Human Wastes for Generation of Bio-Gas**

It is known that the human faeces are being utilised in Japan and China for generation of biogas. The possibilities for utilising these wastes to produce the biogas in the Punjab need to be investigated as a long range project.

- **Need for Extension Education in Biogas**

The construction of a biogas plant is a skilled job which requires the services of trained masons who are usually not available in the villages. It is, therefore necessary to train unemployed village youths by imparting masonry skills so that they can help in biogas development programmes in rural areas of the State. Punjab Agricultural University had organized 30 Trunkey/ SEW Training Courses (duration of 15 to 25 days for each course), Mason Training Courses (duration of 10 to 16 days for each course), 19 Staff Training Courses (duration of 3-4 days for each course), 1200 Users Training Courses (duration of One day for each course). Under these training courses 252 Trunkey workers, 595 Mesons and 113 Staff Members have been trained for proper development of biogas technology in the State of Punjab.

The efficiency of biogas plants depends upon proper construction, operation and maintenance of these plants. There is thus need to advise owners of small and large-sized biogas plants so that they face minimum problems in the production and use of biogas. The problem, if any, can be tackled both at the State level and the University level. At the State level, the Punjab Energy Development Agency (PEDA) working on programmes of biogas development can be imparted training on biogas technology for which requisite facilities exist at PAU. At the University level, Krishi Vigyan Kendras (KVKS) and Farm Advisory Service Centres (FASSs) have to be involved with biogas research at PAU so that the farmers may be rendered necessary advisory service and results of research transferred to the individual owners of biogas plants and others who might be desirous of installing such plants.

V. Conclusion

There are many gaps in the existing information on the anaerobic fermentation to produce the biogas. No information is available on the growth and proliferation of the "Methane-Producing Bacteria" under low temperature conditions. Hence, there is need for scientific study on these microbes to investigate the possibility of increasing the rate of gas production under low-temperature conditions as prevalent during winter months in the Northern Part of India. The nutritional requirement, Carbon-Nitrogen ratio also warrant detailed study. Basic research to work out the ideal chemical and environmental conditions for efficient fermentation of cattle dung and bio-mass is also required.

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APPENDIX – I

CATTLE DUNG POTENTIAL FOR BIOGAS BASED ON 2003 ANIMAL CENSUS OF PUNJAB

1.	Total population of cows & buffalos	:	8.033 million
2.	Average dung produced per animal	:	15 kg
3.	Total dung produced per day	:	120.495 million kg/day
4.	Total dung produced per year	:	43980.675 million kg/year =43.980million tonnes/year
5.	Consider 75% available for anaerobic fermentation	:	32.985 million tonnes/year
6.	Total Biogas potential (40 cu M gas per tonne)	:	1391.4 million cu.m/year
7.	Equivalent kerosene in litres (coefficient .62)	:	862.668 million lit/year
8.	Equivalent Diesel in litres (coefficient .52)	:	723.52 million lit/year
9.	Equivalent LPG in Kg (coefficient 0.43)	:	598.30 million lit/year
10.	Equivalent of Coal (coefficient 1.6)	:	2226.24 million tones/year
11.	Equivalent of Firewood (coefficient 3.50)	:	4869.9 million tones/year
12.	Equivalent of Dung cakes (coefficient 12.30)	:	17114.22 million tones/year
13.	Equivalent of Charcoal (coefficient 1.46)	:	2031.44 million tones/year
14.	Available Manure (15% dry weight, 1.20% manure of dry wt.)	:	7.91 million lit/year
15.	Available N P K (1.5% N, .4% P, 1.5% K)	:	1.49 million tonnes of NPK/year

APPENDIX – II

CROP RESIDUE POTENTIAL FOR BIO-GAS BASED ON 2012 – 2013 FOOD PRODUCTION STATISTICS

1.	Rice Production 11.30 million tonnes will produce dry crop residue (crop residue coefficient 1.6)	:	18.08 million tonnes
2.	Maize production of 0.445 million tonnes will produce dry crop residue (crop residue coefficient 1.2)	:	0.534 million tonnes
3.	Sugarcane of 4.89 million tonnes will produce dry crop residue (crop residue coefficient 0.25)	:	1.22 million tonnes
4.	Potato production of 2.13 million tonnes will produce dry crop residue (crop residue coefficient 0.51)	:	1.08 million tonnes
5.	Total dry crop residue	:	20.91 million tonnes
6.	Available Bio-Gas Potential (50 cu. m. per Ton dry residue)	:	1045.5 million cu.m.
7.	Consider 75% Residue could be fermented, so net available Bio-Gas	:	784.12 million cu.m.
8.	Equivalent Kerosene (0.62)	:	486.15 million litre
9.	Equivalent Diesel (0.50)	:	407.74 million litre
10.	Equivalent LPG in Kg	:	337.17 million lit/year
11.	Equivalent of Firewood	:	2744.42 million tones/year
12.	Equivalent of Dung cakes	:	9644.67 million tones/year
13.	Equivalent of Charcoal	:	1144.81 million tones/year
14.	Available Manure (60%)	:	12.546 million litre
15.	Available N P K (N = 0.8%, P = 0.4%) K=1.2%)	:	3.011 million litre

