BIOTECHNOLOGY AND OTHER ALTERNATIVE TECHNOLOGIES

for Utilisation of Biomass/Agricultural Wastes

AMALENDU CHAKRAVERTY

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BIOTECHNOLOGY AND OTHER ALTERNATIVE TECHNOLOGIES: *Amalendu Chakraverty*

To

Mrs. S. CHAKRAVERTY

PREFACE

Biomass is generated by various life processes. But the organic matter produced by plants through photosynthesis are most significant. Biomass has been in use from primitive ages. Till today, firewood is considered to be one of the most common non-commercial sources of energy all over the world, particularly to the third world. In India about 44 per cent energy is derived from non-commercial sources of energy. The wood charcoal used in the metallurgical and other industries could not be replaced by any chemical synthetic carbon as yet. The alcohol, a base material for many synthetic organic compounds, is produced from biomass rich in carbohydrate. The pulp and paper industry is also based on fibrous cellulosic biomass. There is ample scope for the development of improved technologies for the conversion of vast renewable biomass sources into food, feed, fuel, energy, chemicals and value-added materials. Development of indigenous technologies, creation of new employment in the rural areas, recycling and efficient management of wastes and controlling the environmental pollution and improvement of the quality of rural life should be the prime concern of these schemes.

A large number of research and review papers, reports, etc. on utilisation of biomass/agricultural wastes are being published in the national periodicals and seminar proceedings. These are mostly of academic nature. On the other hand the know-how of the important commercially successful biomass conversion technology is a guarded secret. The diversity in the characteristics of different biomass and their conversion technologies is so much that it is difficult to bring the details of all the processes in a book. Probably these are the factors which discourage any specialist to publish a comprehensive treatise on biomass utilisation. In consequence students and professionals have been handicapped for the lack of reliable data and a systematic text on the subject.

Hence an introductory text covering all aspects of biomass

conversion technologies namely, thermal, thermochemical, chemical and biochemical processes would be of real use to the undergraduate and postgraduate students, teachers, researchers and others engaged in the fields of agricultural science and engineering, rural energy engineering and biotechnology. The purpose of this book is to organise all scattered information in a format and deal with the recent development of all promising biomass conversion processes in a volume. As emphasis has been placed on fundamental principles, actual practice, and state of the art, the book would fill in the present gap.

The author wishes to acknowledge the co-operation of Mr. K.T. Maru, M.Tech., Mr. A.K. Dutta, M.Tech., Dr. V.V. Srinarayanan, Dr. H. Dasgupta in providing some useful information. He is grateful to Professor V.L. Chopra for his valuable suggestion. He is indebted to Mrs. S. Chakraverty, M.Sc., for her painstaking assistance in the preparation of the book. Best wishes are due to Masters Soumendu Chakraverty and Krishnendu Chakraverty for their assistance in the conversion of units of some important tables.

The author pays homage to the pioneers in research and development of the alternative technologies.

I.I.T. Kharagpur
February, 1989

A. CHAKRAVERTY

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CHAPTER 1

SOURCES, CLASSIFICATION AND CHARACTERISTICS OF BIOMASS AND OTHER SOLID WASTES

INTRODUCTION

The term biomass refers to all organic matter generated through photosynthesis and other biological processes. Biomass may also be referred to renewable and biodegradable organic matter generated through life processes. The ultimate source of this renewable biomass is the inexhaustible solar energy, which is captured by plants through photosynthesis. The total biomass produced annually by land and aquatic plants is equivalent to an energy content of (2.6–3.5) $\times$ 10^{21} J, which is ten times the world's present consumption of energy (Slesser and Lewis, 1979). Their sound management has become a prime concern to man. It is in this context the alternative biomass conversion technologies assume great importance.

The pattern of the energy consumption in India as shown in Table 1.1 indicates that biomass is the major non-commercial form of energy source used mostly in the domestic sector (Report, 1979). But in future with the scarcity and increase of the costs of fossil fuels, biomass is likely to play a dominant role in the commercial sector as well. Availability of biomass resources in India along with their coal equivalent is shown in Table 1.2. Table 1.2 reveals that there is a vast resource of lignocellulosic residues in India, which poses critical problems in bioconversion.

The biomass conversion technologies mainly include biochemical, chemical, thermal and thermochemical processes. These alternative technologies for biomass conversion offer sound and attractive options for meeting the future fuels, chemicals, food and feed requirements.

Table 1.1: Energy consumption pattern in India

		1975-76	1978-79
Commercial energy: 56.5% of total energy (1975-76)			
Coal (MTCR)		70.96	68.80
Oil (MTCR)		17.79	21.70
Electricity (MTCR)		65.97	84.20
Demand for non-commercial energy: 43.5% of total energy (1978-79)*			
Biomass	Firewood and charcoal		132 million tonnes
	Vegetable wastes and Agricultural residues		45 million tonnes
	Cow-dung		65 million tonnes

*Report, 1978-79.

Three main approaches can be adopted for generation and utilisation of biomass:

1) Collection of urban and industrial wastes as supplementary fuel in boilers and as a feedstock for producing methane and some liquid fuels.

2) Collection of agricultural and forest residues to produce fuels, organic manures and chemical feedstock.

3) Growth of some specific energy plants for use as energy feedstock and cultivation of commercial forestry, aquatic and marine plants for different products.

Since more than three-fourths of Indian population live in about 5,60,000 remote villages, the non-commercial biomass fuels are the main sources of energy available to the local inhabitants. The most efficient utilisation of these resources and introduction of the appropriate biomass conversion technologies in the rural areas call for immediate attention (Ramachandran, 1978). Inspite of all biomass resources available in India, these are not being properly utilised. In fact a large amount of it is disposed of by burning in open fields causing serious pollution problems. If these are used for the production of materials like ceramics, silicon, activated char, charcoal, etc., energy chemicals like ethanol; chemical products like pulp and paper, furfural; fuels like producer gas, biogas, etc., they can meet a sizeable fraction of the country's demand for fuels, and other materials.

Table 1.2: Major biomass resources in India

Biomass	Availability (tonnes/year)	Coal equivalent (tonnes/year)
	Agricultural residues	
Rice straw	90.0	58.4
Rice husk	19.9	15.7
Jute sticks	2.5	2.3
Wheat straw	50.5	37.5
Cotton stalks	—	—
Linters and hulls	13.0	11.0
	Agro-industrial by-products	
Bagasse	28.1	22.4
Molasses	2.1	0.8
Coconut husk and shell	1.0	1.1
Oilseed cakes	6.7	0.9
Sawdust	2.0	3.4
Cattle-dung (wet)	1,335.0	128.0
	Forest products/residues	
Mahua flower	1.0	0.4
Leaves, tops, etc.	3.3	3.0
Total	1,555.1	284.9

Ghose, 1983.

But the problems associated with the biomass and their conversion technologies are to be reckoned with before execution of any such project. These are as follows:

1) The cost of collection and handling of biomass of low bulk density.

2) The cost of pretreatment and enrichment of some solid wastes like municipal solid waste (MSW) having high moisture and low organic contents.

3) Problems associated with the bioconversion of the lignocellulosic wastes into energy chemicals and other chemicals.

4) Lack of reliable statistics of the availability of local biomaterials and their steady supply according to the need of a plant.

5) Selection of an alternative economically viable technology for biomass conversion according to the need of the local market.

6) Development of an integrated system of the biomass conversion processes for the total utilisation of their products and co-products.

7) Unsuitability of some of the capital intensive imported technologies for conversion of biomass for the developing countries.

8) To scale up the alternative biomass conversion technologies to the commercial levels in competition with the existing technologies.

9) Ecological balance.

10) Socio-economic and cultural problems.

In India the major part of the agricultural residues are used as cattle-feed, fibre, fuel, organic fertiliser and housing materials. With the increase in land productivity, the production of food grains along with the residues and by-products will increase. Some of these residues are likely to become surplus. The residues and by-products of paddy are pertinent examples. Surplus paddy straw and husk pose a critical disposal problem in Punjab and Haryana. A large quantity of paddy straw are burned in the open fields after harvesting of paddy in October and November in Punjab every year, creating serious problems of air pollution. But rice husk and paddy straw can be profitably con verted into fuel gas, energy chemicals, chemicals and other materials.

In India around 1,335 million tonnes of cattle-dung are produced annually. In addition, a large quantity of some useless plant residues are also generated. These are generally used as fuel. It may be pointed out that burning of a known quantity of dry cattle-dung in the open, fire, will provide 1.65 times the number of kilo calories available from methane gas generated by biogasification of the same quantity of dung. But only about 5% of the heat released in open fires is usually utilised, while 50% of the energy in methane can be used in gas burners. As a result, biogasification of cattle dung makes six times as much

energy available to man (Ramachandran, 1978). Moreover, the dry fermented (digested) slurry can be used either as a feed supplement for cattle and other ruminant animals, or as a direct organic fertiliser for crop land. It is heartening that the viability of biogas plants has been realised and more and more plants are being installed in India. Although over 5,00,000 households are currently being benefitted from biogas plants, 15,00,000 biogas plants are proposed for the seventh plan (1985-1990) (*Science Today*, May, 1987).

Nowadays in India, the fibrous agricultural wastes and residues are being profitably utilised for making pulp for cheap grade paper.

Recent research activities at Biochemical Engineering Research Centre (BERC), IIT, Delhi clearly indicate that the lignocellulosic wastes can be converted into various energy chemicals and other co-products.

Research findings by Post Harvest Technology Centre (PHTC), IIT, Kharagpur also reveal that highly silicious agricultural residues like rice husk and rice straw, can be converted into energy, useful chemicals, amorphous silica, silicate products and solar grade silicon.

It is now apparent that the alternative biomass conversion technologies, particularly thermal, thermochemical, biochemical and chemical processes have great potentialities in India. Hence, all aspects of biomass and their conversion technologies are to be thoroughly gone into.

CLASSIFICATION

Utilisable biomass and other solid wastes may be classified under the following principal categories:

1) Crop residues and farm wastes
2) Industrial wastes
3) Forest products
4) Municipal solid wastes
5) Municipal sewage sludges
6) Animal wastes
7) Marine products
8) Silvicultural energy farm products and
9) Aquatic biomass.