

Handbook of Bio-Gas Technology

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HANDBOOK OF BIOGASTECHNOLOGY

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Dedicated to our daughter

Preface

To feed ever-increasing human population we have to grow more food from given area of land. Industrial growth is also necessary for development of nation. The agricultural, industrial and household (kitchen, hotels *etc.*) sectors generates huge amount of wastes whose management is becoming a serious problem today. Environmental pollution is increasing day by day due to these wastes. Landfilling, composting, incineration etc are the most common technologies adopted for management of these wastes but biogas technology would be the most prominent one for it. In this technology wastes are degraded anaerobically through microorganisms. Simultaneously, biogas and digested slurry are produced. The technology is quite simple and requires digester unit which holds the waste material and provides anaerobic environment. Many types of digesters have been developed each having its own advantages and disadvantages. Use of a particular type of digester depends on a number of factors including nature of waste to be degraded, its composition, cost and availability of construction material, prevailing environmental conditions in the area *etc.*

Biogas is a mixture of gases and contains methane (50 to 70%), carbon dioxide (30 to 40%), hydrogen (5 to 10%), nitrogen (1 to 2%), water vapors (0.3%) and hydrogen sulphide (traces). It can be used for cooking and lightning purposes; to run the water lifting pumps; to generate energy and electricity; and as vehicle fuel but before this it requires purification. Purification means removal of all unwanted gases from biogas except methane. For it a number of techniques are available today.

Besides biogas the second by product of biogas digester *i.e.* digested slurry also have a number of uses due to its high nutrients content. It can be used as feed for earthworms, carps, fishes or microorganisms. Its well known use is as fertilizer which gives increased crop yield with better quality. Application of biogas slurry to soil also improves its fertility and productivity.

Biogas technology is an economically sound technology conditioned that the biogas and digested slurry are being managed with high skill. It requires one time investment of construction of biogas digester which operates successfully for a longer period of more than decade. Biogas technology is the best source of employment generation especially in rural areas.

Biogas digester have highly diverged microbial communities due to which a number of waste materials can be used for production of biogas. The

composition, pH, salinity and toxicity of compounds present in waste materials affects the biomethanation process. Microorganisms are quite sensitive to change in these parameters from their normal acceptable values. Any deviation from normal range may result in decreased biogas production or in extreme cases biogas production may cease. Practically it is quite difficult to maintain all of these factors within the functional limits of microorganisms but nowadays these changes may be monitored on-line using many instruments.

Certain compounds are being successfully used as additive to increase biogas production. Biogas potential of waste material depends on its accessibility to microorganisms of digester. Easy microbial accessibility will increase biogas production. The accessibility can be increased by physical, chemical, microbial or enzymatic treatment of waste material before its addition to digester.

Much work has been done in above fields and in present book authors compiled the important findings of these studies. The economics; microbiology and kinetics of biogas technology; potential of various wastes for biogas production; potential uses of biogas slurry; factors affecting biogas production; techniques for purification and efficient use of biogas; simulation models and other controlling technologies of anaerobic digestion; and role of additives and pretreatment methods in enhancement of biogas production are being reviewed and presented in this book with a brief experimental methodology for the benefit of reader. Types of biogas plant; green house effect and carbon credit of biogas; techniques for cultivation of anaerobic bacteria and analytical methods for biogas and digested slurry are also discussed in detail to provide complete information on biogas technology.

We hope that the book would serve as a milestone in the field of biogas technology for planners, government officials, scientists, research scholars, educationists, social scientists and industrialists interested in this field.

Critical suggestions about the book are heartily welcomed by the authors.

Sadara

Prateek Shilpkar
Deepti Shilpkar

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Sadara

Prateek Shilpkar
Deepti Shilpkar

About the book

The pace of improvement in people's life standards becomes very fast in last few decades and it comes at the cost of energy. Utilization of energy is being increasing day-by-day and this energy is produced mainly from conventional sources which have a limited life span. Among Non-conventional energy sources biogas is the prominent one due to its multifacet benefits. Since eighteenth century, with invention of biogas, many researchers contributed their ideas in this field and made the use of biogas technology viable at decentralized level. Today, the time changed again and we have to think on centralized biogas plants for maximum economic utilization of the technical know-how in this field. Governments of most of the leading countries welcome innovations in biomethanation due to the role played by methane, the chief component of biogas, in global warming. Developing or under-developed countries may get carbon-credit by reducing methane emission through proper use of biogas. Many entrepreneurs are interested in the field of electricity generation and bottling of biogas. Value- addition in digested slurry, another by-product of biogas plant, makes the technology economic by nullifying the poor economy of using biogas in either of the fields stated above. Present book provides basic knowledge of biogas technology along with outcomes of recent research works in this field all over the world. The book includes important research findings with a little experimental background to give better understanding of the experimental work for further improvement. The book starts with the importance of anaerobic degradation of wastes and covers recent research outcomes on pathogen removal and toxicity reduction efficiency of biomethanation; economics of biogas unit; characterization of microbial structure; biogas production potential of different animal manures, agricultural residues, plant wastes, chicken and slaughter house wastes, fruit and vegetable wastes, municipal wastes, industrial wastes and plastic; various physico-chemical, enzymatic and microbial treatment of wastes to improve their biogas potential; use of additives; factors affecting biogas production; kinetics and controlling of biogas production technology with use of simulation models; multipurpose utilization of biogas slurry; effect of biogas slurry addition on growth and yield of different crops as well as on soil fertility; and purification techniques of biogas to improve its fuel use efficiency. Different types of biogas plant, cultivation techniques of anaerobic bacteria and analytical methods of biogas as well as of digested slurry are discussed in detail. The aim to write the book is to gather the scattered research findings in the field of

biogas technology at a single stage for its better channelization towards sustainable development.

The book guides planners, policymakers, research scholars, government officials, field workers, students and plant owners and provides highest value-addition to their efforts. The information presented in the book will guide research scholars working in the field of anaerobic fermentation to formulate research experiment. For planners and policy makers the book supplies basic data useful in preparing plans for long run; selection of raw materials, pretreatment techniques and digester types; essential conditions required for installation and operation of biogas unit with expected outcomes; viability of biogas technology; and contacts of research persons for any explanation, if required. The book opens the door for University Professors, Lecturers and Scientists to work in biogas technology and to break the myth that biogas technology is not a successful one. The book also helps the institutions or individuals having biogas units to get maximum biogas production from it.

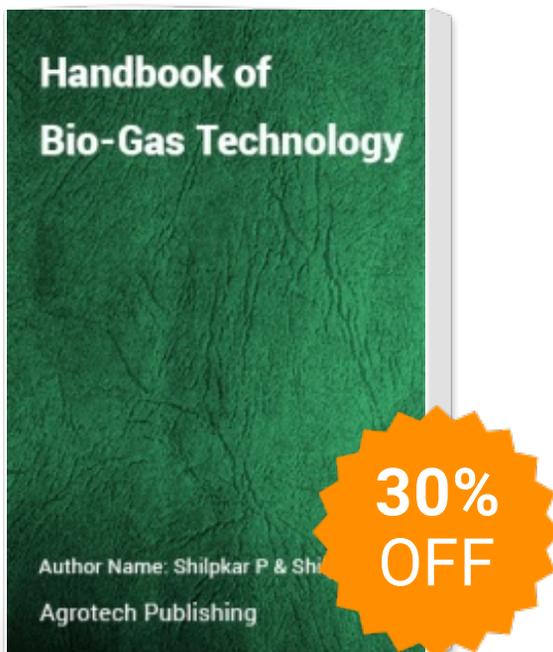
About the authors

Dr. Prateek Shilpkar, born in March 1975, is presently working as lecturer in Biogas Research and Extension Centre, Gujarat Vidyapith, Ahmedabad since March 23, 2002. He obtained his B.Sc. (Ag.) Hons. and M.Sc. (Soil science) degrees from Rajasthan Agricultural University, Bikaner and Ph.D. (Soil science) from Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan). Besides doing research and extension activities in the field of biogas technology he also teaches in M.Sc. and M.Phil (Microbiology) in the University. He has guided more than 20 students of M.Sc. and 4 students of M.Phil for their dissertations in the field of biogas technology, biodynamic farming, organic farming, vermicomposting, soil microbiology and integrated nutrients management. He attended number of workshops, seminars and training programmes of national as well as international levels on non-conventional energy sources, biofuels, dairy products, computer aided teaching material preparation, writing project proposals, education etc. and presented papers. He has organized workshops for farmers on "biodynamic farming" and for masons on biogas plant construction. He has published more than 15 research papers in national and international journals. He is also engaged in many social activities aimed to upliftment of rural people. He has published one booklet for biogas plant owners in gujarati entitled "Biogas Labharthi Pustika".

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