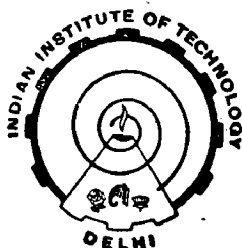


# OPTIMIZATION OF METHANE PRODUCTION FROM AGRICULTURAL RESIDUES

by  
DEBABRATA DAS

Thesis submitted to the Indian Institute of Technology Delhi  
For the Award of the Degree  
of  
DOCTOR OF PHILOSOPHY



**BIOCHEMICAL ENGINEERING RESEARCH CENTRE**  
**INDIAN INSTITUTE OF TECHNOLOGY DELHI**  
HAUZ KHAS, NEW DELHI-110016  
DECEMBER, 1984

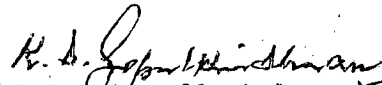
*Dedicated*

*to*

*my beloved parents*

CERTIFICATE

We are satisfied that the thesis entitled 'Optimization of Methane Production from Agricultural Residues' presented by Debabrata Das is worthy of consideration for the award of the degree of Doctor of Philosophy and is a record of the original bona fide research work carried out by him under our guidance and supervision and that the results contained in it have not been submitted in part or full to any other Universities or Institutes for award of any degree.

  
(K.S. Gopalkrishnan)

  
(T.K. Ghose)

## ACKNOWLEDGEMENT

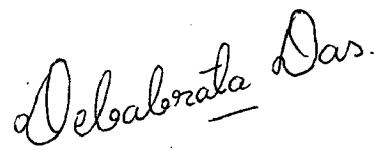
I express my deep sense of gratitude to my research supervisors, Prof. Tarun K. Ghose and Prof. K.S. Gopalkrishnan, for their inspiring, dynamic and meaningful guidance, stimulating discussions and keen interest shown throughout the course of this investigation.

I am much obliged to Prof. S.N. Mukhopadhyaya, Prof. A.P. Joshi, Dr. P. Ghosh, Dr. B.K. Guha and Dr. A. Malhotra for their valuable comments, suggestions and cooperation.

I wish to express my thanks to all my colleagues for their help, cooperation and encouragement.

I am thankful to Mr. D. Banerjee and Dr. M. Hanmandlu of Electrical Engineering Department for their help in computer analysis.

I appreciate the skilful technical help of Mr. V.K. Ghosh. I also acknowledge the assistance received from the Technicians, Mr. Keshav Prasad, Mr. Masood Ali and Mr. J.A. Khan.

  
(Debabrata Das)

## CONTENTS

|  | Page No. |
|--|----------|
| CERTIFICATE  | i        |
| ACKNOWLEDGEMENT                                      | ii       |
| FIGURE CAPTIONS                                      | iv       |
| LIST OF TABLES                                       | ix       |
| CHAPTER 1  |          |
| 1.1 Introduction                                     | 1        |
| 1.2 Objective  | 11       |
| 1.3 Literature Survey                                | 12       |
| CHAPTER 2  |          |
| 2.1 Materials  | 28       |
| 2.2 Analytical Methods                               | 31       |
| 2.3 Medium and Culture Conditions                    | 35       |
| 2.4 Experimental Set Up                              | 36       |
| CHAPTER 3  |          |
| Theoretical Considerations                           | 42       |
| CHAPTER 4  |          |
| Results and Discussion                               | 48       |
| CHAPTER 5  |          |
| Summary, Conclusion and Scope of<br>Further Research | 141      |
| BIBLIOGRAPHY   | 151      |
| APPENDIX I   |          |
| Glossary of Symbols and Terminology                  | 165      |
| APPENDIX II  |          |
| Computer Analysis                                    | 168      |