

Table of Contents

| | <u>Content</u> | <u>Page</u> |
|-------|--|-------------|
| | Preface | iv |
| | Dedication | v |
| | Acknowledgement | vi |
| | Abstract | viii |
| | List of Tables | xiii |
| | List of Figures | xvi |
| | Abbreviations | xix |
| 1. | Introduction | 1 |
| 1.1 | General Introduction | 1 |
| 1.2 | Anaerobic Digestion | 2 |
| 1.3 | Methanogenic Activity | 4 |
| 1.4 | Methanogenic Activity Test | 5 |
| 1.5 | Aim of Research | 6 |
| 1.6 | Research Schedule | 9 |
| 2. | Literature Review | 10 |
| 2.1 | Theory | 10 |
| 2.1.1 | <i>Methanogenic Activity</i> | 10 |
| 2.1.2 | <i>Methanogens</i> | 10 |
| 2.1.3 | <i>Bioassays</i> | 11 |
| 2.1.4 | <i>Methanogenic Activity Assay</i> | 12 |
| 2.1.5 | <i>Kinetics of Anaerobic Processes</i> | 13 |
| 2.1.6 | <i>SMA Determination</i> | 14 |
| 2.1.7 | <i>Factors affecting the Methanogenic Activity Assay</i> | 16 |

| | | |
|-------|---|----|
| 2.2 | <i>Experimental Aspects</i> | 25 |
| 2.2.1 | <i>Monitoring Techniques</i> | 25 |
| 2.2.2 | <i>Operational Conditions</i> | 30 |
| 2.3 | <i>Published Results</i> | 34 |
| 2.3.1 | <i>SMA Units</i> | 34 |
| 2.3.2 | <i>Effect of S_o, X_o and the ratio S_o/X_o on</i> | 35 |
| 2.3.3 | <i>Effect of Shaking (mixing)</i> | 36 |
| 2.3.4 | <i>Effect of Nutrients</i> | 36 |
| 2.3.5 | <i>Effect of Sludge Storage</i> | 36 |
| 2.3.6 | <i>pH and Buffering</i> | 36 |
| 3. | Materials and Methods | 37 |
| 3.1 | Activity Bottles Preparation | 37 |
| 3.1.1 | <i>Sludge Collection and Preparation</i> | 38 |
| 3.1.2 | <i>Substrate Preparation</i> | 38 |
| 3.1.3 | <i>Media Preparation</i> | 39 |
| 3.1.4 | <i>Sodium Sulfide Solution Preparation</i> | 40 |
| 3.1.5 | <i>Shaking and Incubation</i> | 41 |
| 3.1.6 | <i>Methane Gas Measurement</i> | 42 |
| 3.1.7 | <i>Substrate Second and Third Feedings</i> | 42 |
| 3.2 | Laboratory analyses | 43 |
| 3.2.1 | <i>pH</i> | 43 |
| 3.2.2 | <i>VFA</i> | 44 |
| 3.2.3 | <i>Solids Contents</i> | 44 |
| 3.3 | Experimental Procedure | 45 |
| 3.4 | Data Collection and Analysis | 48 |
| 3.4.1 | <i>Data Collection</i> | 48 |
| 3.4.2 | <i>Data Analysis</i> | 48 |
| 4. | Results and Discussion | 52 |
| 4.1 | Characteristics of Sludge being Used | 52 |
| 4.2 | Characteristics of the Contents of Activity Test Bottles | 53 |

| | | |
|------------|---|-----|
| 4.21 | <i>Characteristics of the contents of the activity test bottles at the start of the tests</i> | 54 |
| 4.2.2 | <i>Characteristics of activity test bottles at the end of the activity tests</i> | 55 |
| 4.3 | Determination and Discussion of SMA | 71 |
| 4.3.1 | <i>Part 1: Effect of S_o on SMA.</i> | 71 |
| 4.3.2 | <i>Parts 2 and 3: Effect of X_o and S_o/X_o on SMA</i> | 77 |
| 4.3.3 | <i>Part 4: Effect of Other Parameters</i> | 85 |
| 4.4 | Comparison Between Zero Order and Modified Gompertz Models | 95 |
| 5. | Conclusions and Recommendations | 99 |
| 5.1 | Conclusions | 99 |
| 5.2 | Recommendations | 102 |
| | References | 106 |
| | Appendices | 116 |
| Appendix 1 | <i>Research Mission Schedule</i> | 117 |
| Appendix 2 | <i>Preparation of Methanogenic Activity Bottles</i> | 118 |
| Appendix 3 | <i>UASB-Digester System</i> | 121 |
| Appendix 4 | <i>VFA Contents of the Activity Bottles</i> | 124 |
| Appendix 5 | <i>AQUASIM</i> | 128 |
| Appendix 6 | <i>Gompertz Model (Sample)</i> | 131 |
| Appendix 7 | <i>Gompertz Model Graphic Result (sample)</i> | 138 |
| Appendix 8 | <i>Linear Trend Lines of CH₄ Cumulative Production Curves</i> | 139 |
| | Arabic Summary | 145 |