TABLE OF CONTENTS

| Title Page | i |
| Acknowledgements | ii |
| Table of Contents | iv |
| List of Tables | ix |
| List of Figures | xi |
| List of Abbreviations | xiv |
| ABSTRACT | 1 |

PART - A
STUDIES ON AERATION

CHAPTER-I INTRODUCTION
1.1 Importance of Studies on Aeration 3
1.2 Various Aeration Methods 4
1.3 Venturi and Sudden Expansion Aerators 4
1.4 Scope of Present Studies 5

CHAPTER-II REVIEW OF AERATION METHODS
2.1 General 7
2.2 Diffusion of Compressed Air through Porous Diffusers 7
2.3 Diffused Air with Submerged Turbine Dispersers 8
2.4 Mechanical Surface Entrainment Aerators 9
2.5 Venturi Aerator and its Modifications 10
2.6 Miscellaneous Aeration Methods 11
2.7 Sudden Expansion Type of Air Aspirator 12
<table>
<thead>
<tr>
<th>CHAPTER-III</th>
<th>PERFORMANCE EVALUATION OF SUDDEN EXPANSION AND VENTURI AERATORS</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>General</td>
<td>14</td>
</tr>
<tr>
<td>3.2</td>
<td>Theory of Aeration</td>
<td>14</td>
</tr>
<tr>
<td>3.3</td>
<td>Performance Evaluation Methods</td>
<td>16</td>
</tr>
<tr>
<td>3.3.1</td>
<td>Steady-State Method</td>
<td>17</td>
</tr>
<tr>
<td>3.3.2</td>
<td>Non-Steady-State Method</td>
<td>17</td>
</tr>
<tr>
<td>3.3.3</td>
<td>Laboratory Measurement of Oxygen Uptake Rate</td>
<td>18</td>
</tr>
<tr>
<td>3.3.4</td>
<td>Horsepower Input to Aerator</td>
<td>19</td>
</tr>
<tr>
<td>3.4</td>
<td>Performance Evaluation Equations</td>
<td>19</td>
</tr>
<tr>
<td>3.5</td>
<td>Performance Evaluation Experiment</td>
<td>21</td>
</tr>
<tr>
<td>3.5.1</td>
<td>Experimental Set-Up</td>
<td>21</td>
</tr>
<tr>
<td>3.5.2</td>
<td>Experimental Procedure</td>
<td>25</td>
</tr>
<tr>
<td>3.5.2.1</td>
<td>Calibration of Orificimeter</td>
<td>25</td>
</tr>
<tr>
<td>3.5.2.2</td>
<td>Measurement of Loss of Head through the Aerator</td>
<td>25</td>
</tr>
<tr>
<td>3.5.2.3</td>
<td>Measurement of Oxygen Transferred by the Aerator</td>
<td>26</td>
</tr>
<tr>
<td>3.5.3</td>
<td>Sample Data and Calculations</td>
<td>27</td>
</tr>
<tr>
<td>3.5.3.1</td>
<td>Loss of Head through Aerator</td>
<td>27</td>
</tr>
<tr>
<td>3.5.3.2</td>
<td>Oxygen Transfer Efficiency of Aerator</td>
<td>29</td>
</tr>
<tr>
<td>3.5.4</td>
<td>Experimental Results</td>
<td>31</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CHAPTER-IV</th>
<th>SCALE-UP OF SUDDEN EXPANSION AND VENTURI AERATORS</th>
<th>32</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Scale-Up Considerations</td>
<td>32</td>
</tr>
<tr>
<td>4.2</td>
<td>Review of Scale-Up Attempts and their Limitations</td>
<td>33</td>
</tr>
<tr>
<td>4.3</td>
<td>Scale-Up Parameters</td>
<td>34</td>
</tr>
<tr>
<td>4.4</td>
<td>Dimensionless Relationships</td>
<td>36</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CHAPTER-V</th>
<th>DISCUSSION AND CONCLUSIONS</th>
<th>37</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>General</td>
<td>37</td>
</tr>
</tbody>
</table>
5.2 Performance of Venturi Aerator with Different Throat Sizes 38
5.3 Performance of Venturi Aerator with Different Divergence Angles 39
5.4 Performance of Sudden Expansion Aerator with Different Throat Sizes 41
5.5 Performance of Sudden Expansion Aerator with Different Expansion Ratios 41
5.6 Scale-Up of Sudden Expansion and Venturi Aerators 42
5.7 Conclusions 43

PART - B
STUDIES ON OPERATIONAL PROBLEMS OF EXTENDED-AERATION PLANTS

CHAPTER-VI INTRODUCTION 45
6.1 General 45
6.2 Package Sewage Treatment Plants 45
6.3 Extended-Aeration Plant 46
6.4 Scope of Present Studies 48

CHAPTER-VII REVIEW OF EXTENDED-AERATION PLANTS 50

CHAPTER-VIII OPERATIONAL PROBLEMS OF EXTENDED-AERATION PLANTS 54
8.1 General 54
8.2 Shock Loadings 54
8.2.1 Organic Shock Loadings 54
8.2.2 Hydraulic Shock Loadings 55
8.3 Inadequate Control of Air Supply 56
8.3.1 Excessive Turbulence in Aeration Tank 56
8.3.2 Denitrification 56
8.4 Foaming in Aeration Tank 57
8.5 Excessive Rate of Return Sludge 58
8.6 Clogging of Return Sludge Line 58
8.7 Scum Formation in Sedimentation Tank 59
8.8 Low Temperatures 60

CHAPTER-IX DESIGN AND OPERATION OF MODEL EXTENDED-AERATION PLANT 61
9.1 Theory of Extended-Aeration Process 61
9.1.1 Importance of Microorganisms in the Extended-Aeration Process 63
9.2 Design Considerations for an Extended-Aeration Plant 65
9.2.1 Loading Rates 65
9.2.2 Aeration and Mixing 66
9.2.3 Settling and Returning of Settled Sludge 67
9.2.4 Nitrification and Denitrification 67
9.2.5 Polishing of Clarifier Effluent 68
9.2.6 Maintenance 68
9.3 Design of Model Extended-Aeration Plant 68
9.3.1 Aeration Tank 70
9.3.2 Denitrification Tank 72
9.3.3 Clarifier 73
9.3.4 Polishing Tank 74
9.4 Materials and Experimental Set-Up 74
9.4.1 Raw Waste Water 74
9.4.2 Experimental Set-Up 75
9.5 Startup Period and Solids Accumulation 77
9.6 Operation of the Model Extended-Aeration Plant 78
9.6.1 Microbiological Fauna Observed in Mixed Liquor 82
9.6.2 Results 86

CHAPTER-X DISCUSSION AND CONCLUSIONS 87
10.1 General 87