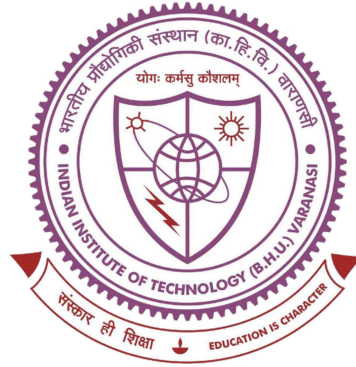


**Enhancing Geotechnical and Environmental
Properties of Municipal Solid Waste Fines via
Biopolymer Stabilization**
Characterization, Application, and Sustainability Analysis



*Thesis submitted in partial fulfillment for the Award of Degree
Doctor of Philosophy*

Submitted by
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**DEPARTMENT OF CIVIL ENGINEERING
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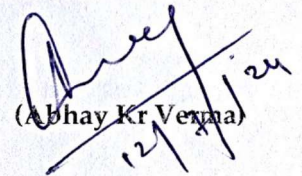
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Table of Contents

CERTIFICATE	ii
DECLARATION BY THE CANDIDATE	iii
COPYRIGHT TRANSFER CERTIFICATE	iv
Acknowledgements	v
Table of Contents	vii
List of Figures	xi
List of Tables	xiii
List of Abbreviations	xv
Preface	xvii
Chapter 1: Introduction	1
1.1 Overview of MSW and Legacy Waste Issues	1
1.2 Legacy Waste and Landfill Mining	3
1.3 Municipal Solid Waste Fines and its Characteristics	6
1.4 Scope of MSWF in Civil and Construction Applications and Need for Sustainable Utilization	7
1.4.1 Applications in Soil Stabilization and Construction	8
1.5 Challenges in Utilization and Disposal of MSWF, Guidelines, and Present Practice	9
1.6 Mechanical and Chemical Stabilization Waste before Utilization	10
1.7 Potential of Biopolymer in Stabilization of Soil and Industrial Waste and Scope in Stabilization of MSWF	12
1.8 Circularity and Sustainability Aspects of Sustainable and Safe Utilization of MSWF in Geotechnical Application Post-Stabilization through Biopolymers	13
1.9 Study's Objective in Brief	15
1.10 Key takeaways and Way forward	16
Chapter 2: Review of literature- Gap Identification, Objectives Setting, and Thesis Structure	17
2.1 Introduction to the chapter:	17
2.2 Study's Objectives:	17
2.3 Literature Review:	18
2.2.1 Characterization of MSW and Retrieved Fines	18
2.2.2 Utilization of Additives for Stabilization	19

2.2.3. Practical Application and Sustainability:	19
Part 1: Characterization of MSW and Retrieved Fines.....	21
Part 2: Utilization of Additives for Stabilization	25
Part 3: Practical Application and Sustainability.....	31
2.4. Research Gap.....	37
2.5. Key takeaways and Way forward.....	41
Chapter 3: Material and Methodology.....	43
3.1. Brief Overview of the Methodological Approach.....	43
3.2. Material Municipal Solid Waste Fines (MSWF).....	44
3.2.1. Site Description of Aged-MSW Collection.....	44
3.2.2. Sample Collection and Transport.....	46
3.2.3. Processing of MSWF.....	46
3.3. Biopolymers:.....	48
3.3.1. Xanthan Gum (XG).....	48
3.3.2. Agar Gum (AG).....	48
3.4. Methodology.....	50
3.4.1. Physical Analysis:.....	50
3.4.2. Chemical & Microstructure Analysis.....	52
3.4.3. Geotechnical Analysis.....	53
3.4.4. Analytical Determination.....	56
3.4.5. Sustainability Analysis.....	56
3.5. Key Takeaways and Way Forward:.....	57
Chapter 4: Depth-Wise Assessment of Engineering Properties of Legacy-Waste/Municipal Solid Waste Fines	59
4.1. Introduction of the Chapter:.....	59
4.2. Material and Method	60
4.3. Results of Experimental Investigation:.....	63
4.3.1. Composition Analysis of MSW at Varying Dumpsite Depths:.....	63
4.3.1. Effect of Depth on Organic Content of MSWF	64
4.3.2. Variation of pH of MSW of Varying Dumpsite Depth.....	65
4.3.3. Variation in Specific Gravity of MSWF with Depth.....	66
4.3.4. Particle Size Distribution of MSWF	67
4.3.5. Compaction Characteristics of MSWF with Depth.....	69
4.3.6. Variations in Consistency Limits of MSWF.....	70
4.3.7. Compressive Strength of MSWF with Depth.....	71
4.3.8. California Bearing Ratio (CBR) of MSWF with Depth.....	72

4.3.9.	Shear Strength Characteristics of MSWF with Depth	73
4.3.10.	Microstructural and Elemental Analysis of MSWF with Depth.....	75
4.4.	Significance of Geotechnical Findings.....	77
4.5.	Key takeaways and Way Forward.....	79
Chapter 5: Stabilization of Municipal Solid Waste Fines by Xanthan Gum & Agar Gum		81
5.1.	Introduction to the Chapter	81
5.2.	Materials & Method.....	82
5.3.	Results and Discussion.....	84
5.3.1.	Effect of Biopolymers on Compaction Characteristics of MSWF	84
5.3.2.	Effect of Biopolymers on Shear Strength Parameters.....	86
5.3.3.	Unconfined Compressive Strength of Bio-Stabilized MSWF.....	91
5.3.4.	Effect of Moisture Content on the Strength of MSWF.....	93
5.3.5.	Analysis of Soaked CBR of treated MSWF	94
5.3.6.	Analysis of Leachates of Bio-Treated MSWF.....	96
5.3.7.	SEM Analysis.....	98
5.4.	Statistical Evaluation of UCS.....	99
5.5.	Key Takeaways and Way forward	101
Chapter 6: Long-term Durability of Biopolymer in Stabilization of MSWF		103
6.1.	Introduction to the Chapter	103
6.2.	Material & Method	104
6.3.	Results and Discussion.....	106
6.3.1.	Effect of Biopolymer on the Cohesion ‘c’ of MSWF with Curing-Time.....	108
6.3.2.	Effect on the Angle of Internal Friction (Φ) with Curing Time.....	109
6.3.3.	Stress-Strain Relation of MSWF-Biopolymer Mix	111
6.3.4.	Effect of Curing Period and Biopolymer Content on Shear Strength.....	114
6.3.5.	SEM Analysis of MSWF Stabilized with Biopolymer.....	117
6.4.	Key Takeaways and Way forward	118
Chapter 7: Geotechnical Applications of Untreated and Treated MSWF		121
7.1.	Introduction to the Chapter	121
7.2.	Settlement Analysis of the Foundation Laid over MSWF	122
7.2.1.	Material Characterization.....	122
7.2.2.	Finite Element Method (FEM) Analysis	123
7.2.3.	Result and Discussion (Settlement analysis of the Foundation).....	124
7.3.	Pavement Thickness Analysis while using MSWF in Subgrade.....	127
7.3.1.	Pavement Design for MSWF Retrieved from Varying Depths.....	128
7.3.2.	Pavement Design from Treated MSWF with XG and AG	131

7.4. Potential Risks and Mitigation Strategies	134
7.5. Key Takeaways and Way forward.....	134
Chapter 8: Sustainability Analysis of Study	137
8.1. Introduction to the Chapter	137
8.2. Material and Method	138
8.3. Result and Discussion.....	140
8.3.1. Carbon footprint analysis	140
8.3.2. Financial Analysis.....	143
8.3.3. Financial Analysis in Terms of "Carbon Credit ‘CCT’ & Offsetting"	144
8.3.4. ESG Analysis- Aligned to the Global Reporting Initiative (GRI) Framework 145	
8.3.5. Resiliency cum Suitability Analysis of Stabilizers	147
8.3.6. SDG Goal Alignment Analysis of Study (of Sustainability Initiatives)	149
8.4. Key takeaways and Way forward	151
Chapter 9: Conclusions & Future-Research Scope.....	153
References	159
Abstract.....	171
List of Publications form thesis.....	172
Other collaborative work during PhD.....	173
About the Author	174

List of Figures

Figure 1: Ragpickers at the Bhalswa landfill site on April 28, 2022, in New Delhi, India. Sanchit Khanna/Hindustan Times/Getty Images (Sud et al., 2022)	2
Figure 2: Projected waste generation, by region (millions of tonnes/year) (World-bank).....	3
Figure 3: Typical Landfill/dumpsite mining process (Source: (Bir et al., 2022))	4
Figure 4: (a): GOI flagship scheme ‘Swachh Bharat Mission’ logo (b) Logo of “Garbage City free” (GFC) awarded to Indian cities based on their sustainable waste management practices.	5
Figure 5: (a) Illustration of subgrade preparation using stabilized soil, demonstrating its practical application in road construction. (b) Conceptual diagram of a landfill cover system incorporating engineered materials, highlighting potential applications of MSWF in waste management and environmental sustainability.....	9
Figure 6: (a) Common applications of Biopolymers: Broad range of biopolymer applications across different sectors, highlighting their versatility and sustainability. (b) Sources of Biopolymers: Diverse origins of biopolymers used in various applications.....	12
Figure 7: The circular economy model: Utilizing MSWF in civil engineering contributes to less raw material usage, waste reduction, and fewer emissions, promoting a sustainable and efficient waste management cycle (Source: European Parliament Research Service	14
Figure 8: Scheme for literature review.....	19
Figure 9: Schematic map for the research gap and objective	20
Figure 10: Thesis structure mapping.....	40
Figure 11: (a) Satellite Overview of Dumpsite with Indicated Sampling Locations (b) View of Legacy Waste Dumpsite from Adjacent Bridge (c,d) Contaminated Water Channels from Adjacent Settlements Traversing the Dumpsite.....	45
Figure 12: (a) Section of Excavated Dumpsite (b) Collection of Samples in Bags (c) Sorting Process of Legacy Waste (d) Sieved and Isolated Municipal Solid Waste Fines.....	47
Figure 13: Xanthan gum and agar gum gel in powder form, hydrated (wet), remoulded and dry conditions.	50
Figure 14: (a) A photograph of UCS testing machine, (b) A photograph of high-resolution scanning electron microscope (SUPRA 40, Zeiss 4.0).....	55
Figure 15: Detailed scheme of the chapters	58
Figure 16: Flow chart of the investigation plan.	62
Figure 17: Composition Breakdown of Legacy Waste Materials	63
Figure 18:(a) Organic content of MSWF with depth (b) pH variation of MSWF with the depth of dumpsite.	65
Figure 19: (a) Variation of specific gravity of MSWF (b) Particle size distribution of MSWF..	67
Figure 20: (a) Compaction curves of MSWF of different depths (b) Variation of OMC and MDD of MSWF	70
Figure 21: (a) Variation of consistency limits of MSWF (b) Variation of UCS with depth.....	71
Figure 22: (a) Compaction curves of MSWF (b) Variation of cohesion and angle of internal friction.....	73
Figure 23: Deviator stress vs. axial strain of MSWF for different depths of MSW collection at confining stress of (a) 50 kPa, (b) 100 kPa, (c) 150 kPa	74
Figure 24: Scanning Electron Microscopy Depictions of Municipal Solid Waste Fines at Varied Dumpsite Depths.....	76
Figure 25: Typical Flow chart of the experimental program	84
Figure 26: Compaction Characteristics (MDD and OMC) with varying percentages of Biopolymers: a Xanthan Gum, and b Agar Gum	86

Figure 27: Plot between deviatoric stress and axial strain for a Untreated MSWF, b 1.5% XG Mix and c 1.5% AG Mix MSWF with 7 days of open-air curing.....	88
Figure 28: Angle of internal friction (ϕ) and cohesion (c) with varying percentages of XG and AG in MSWF.	89
Figure 29: Plot between deviatoric stress and confining pressure for varying percentages of XG and AG mixed MSWF.....	91
Figure 30: (a-b) Error plot of UCS (c-d) Trendline plot of UCS of biopolymer treated MSWF.....	93
Figure 31: Variation in Biopolymer Content vs. Level of sample-dehydration and corresponding UCS value of MSWF at different curing periods.....	94
Figure 32: Variation of soaked CBR values (a) For Xanthan Gum (b) For Agar Gum	96
Figure 33: SEM images of (a) Natural MSWF, (b) XG stabilized MSWF, and (c) AG-stabilized MSWF.....	99
Figure 34: Plot showing the relative importance of parameters defining UCS.....	100
Figure 35: Biopolymer-treated MSWF samples placed in zipped polybags for curing to ensure minimal moisture loss.....	105
Figure 36: Flow diagram of the proposed experimental program	106
Figure 37: Mechanism of hydrogel formation, bio-clogging, bio-bridging, and hydration of biopolymer.....	107
Figure 38: Variation in cohesion ' c ' for the varying percentage of (a) AG and (b) XG	108
Figure 39: Variation in the angle of internal friction (ϕ) for the varying percentage of biopolymers:.....	111
Figure 40: Plots b/w deviatoric stress and axial strain for 7 days and 14 days cured MSWF samples treated with AG and.....	113
Figure 41: Plots between deviatoric stress and axial strain for 180 days cured MSWF treated with AG and XG	114
Figure 42: Variation of shear strength with curing time (a) Agar Gum (b) Xanthan Gum.	116
Figure 43: SEM image of untreated and treated MSWF samples at 5000x magnification.....	118
Figure 44: (a) Stress-strain graph to calculate secant modulus (b) Meshing of soil profile (MSWF).....	124
Figure 45: (a) Typical deformed mesh of MSWF (b) Final settlement of MSWF of varying depth	125
Figure 46: Settlement contours of the MSWF profile at varying depths. Negative values indicate downward displacement (U_y), with red showing maximum settlement near the load and blue showing minimal settlement farther away.....	126
Figure 47: Pavement Structure Overview (a) Schematic Representation of Pavement Layering (b) Comparative Layer Thickness for Pavements with Local Soil and MSWF Subgrades	128
Figure 48: Variation of soaked CBR values (a) For Xanthan Gum and (b) For Agar Gum	132
Figure 49: Bituminous layer thickness of pavement having biopolymer stabilized subgrade (a) Xanthan Gum (b) Agar Gum	134
Figure 50: Flowchart of the methodology analysis of the sustainability analysis.....	140
Figure 51: Market Prices of Stabilizers for MSWF Stabilization (source: indiamart.com)	144

List of Tables

<i>Table 1: Linkage of the study to the SDG goals.....</i>	<i>14</i>
<i>Table 2: Characterization of MSW and Retrieved Fines</i>	<i>21</i>
<i>Table 3: Utilization of Additives for Stabilization</i>	<i>25</i>
<i>Table 4: Practical Application and Sustainability.....</i>	<i>31</i>
<i>Table 5: Properties of biopolymers.....</i>	<i>50</i>
<i>Table 6: The fractions of MSW, collected from varying depths.....</i>	<i>64</i>
<i>Table 7: Particle Size Distribution of Municipal solid waste fines (MSWF) at Various Depths</i>	<i>68</i>
<i>Table 8: Elemental Composition and Spectrum Analysis of Municipal Solid Waste Fines (MSWF).....</i>	<i>76</i>
<i>Table 9: Comparative Analysis of Geotechnical Properties of MSWF and Various MSW Sources</i>	<i>78</i>
<i>Table 10: Average engineering properties of MSWF after mixing all depth sample.....</i>	<i>83</i>
<i>Table 11: Leachates analysis for heavy metals in MSWF (all quantities are in PPM)</i>	<i>97</i>
<i>Table 12: A statistical representation of influencing parameters for UCS.....</i>	<i>101</i>
<i>Table 13: MSWF properties with varying retrieval depth taken for settlement analysis.....</i>	<i>123</i>
<i>Table 14: Settlements of MSWF profile at different loading phases and depths</i>	<i>126</i>
<i>Table 15: Detail of CBR and Resilient modulus of different pavement layers.....</i>	<i>129</i>
<i>Table 16: Optimized Bituminous Layer Thickness and Strain Iterations for MSWF at Various Depths Versus Local Soil</i>	<i>131</i>
<i>Table 17: Details of pavement for the MSWF subgrade stabilized with Xanthan gum (XG) ...</i>	<i>133</i>
<i>Table 18: Details of pavement for the MSWF subgrade stabilized with Agar gum (AG)</i>	<i>133</i>
<i>Table 19: CO₂e Emission Factors for Different Stabilization Methods</i>	<i>141</i>
<i>Table 20: Financial Analysis of XG, AG and Lime.....</i>	<i>143</i>
<i>Table 21: ESG analysis aligned to GRI framework.....</i>	<i>146</i>
<i>Table 22: Resiliency and Suitability Analysis of Stabilizers</i>	<i>148</i>
<i>Table 23: SDG Alignment of Sustainability Initiatives</i>	<i>150</i>

List of Abbreviations

Abbreviation	Full Form
w	Water content
<i>mb</i>	Mass of biopolymer
<i>mb /mw</i>	Biopolymer-to-water ratio
qu	Unconfined compressive strength (kPa)
P	Biopolymer content (%)
c	Cohesion
ϕ°	Peak Friction angle
XRD	X-ray diffraction
SEM	Scanning Electron Microscopy
MSW	Municipal Solid Waste
MSWF	Municipal Solid Waste Fines
LW	Legacy Waste
LWF	Legacy Waste Fines
SLM	Soil-like Material
RDF	Refuse-Derived Fuel
CBR	California Bearing Ratio
OMC	Optimum Moisture Content
MDD	Maximum Dry Density
UCS	Unconfined Compressive Strength
XG	Xanthan Gum
AG	Agar Gum
GG	Guar Gum
MICP	Microbial-Induced Calcite Precipitation
PIB	Press Information Bureau
CRRI	Central Road Research Institute
MoRTH	Ministry of Road Transport and Highways
Adj SS	Adjusted Sums of Squares
Adj MS	Adjusted Mean Squares
CaCO ₃	Calcium Carbonate
ESG	Environmental, Social, and Governance
SDG	Sustainable Development Goals
GRI	Global Reporting Initiative

Preface

This thesis presents research on the stabilization of Municipal Solid Waste Fines (MSWF) using biopolymers such as Xanthan Gum and Agar Gum. The study addresses the significant environmental challenges posed by MSWF by proposing sustainable utilization methods. It explores mechanical and chemical stabilization approaches and evaluates their potential applications in geotechnical engineering.

The motivation for this research stems from the need for sustainable solutions in waste management, particularly in rapidly urbanizing regions where municipal solid waste generation is increasing at an alarming rate. The use of biopolymers offers an eco-friendly alternative to conventional stabilization methods, with the potential to transform waste materials into valuable resources for construction and geotechnical applications.

The research methodology involved extensive laboratory experiments to characterize the physical, mechanical, and chemical properties of MSWF and to assess the effectiveness of biopolymer stabilization. The thesis is structured as follows:

1. **Introduction** – Provides an overview of MSW and legacy waste issues, characteristics of MSWF, and the scope for sustainable utilization.
2. **Literature Review** – Presents a comprehensive review of existing research related to legacy waste remediation and biopolymer stabilization.
3. **Material and Methodology** – Outlines the methodological approach, including waste profiling and experimental procedures for biopolymer treatment.
4. **Depth-wise Assessment of Engineering Properties** – Discusses the geotechnical properties of MSWF at varying depths.
5. **Stabilization of MSWF by Xanthan Gum and Agar Gum** – Explores the effects of biopolymers on the stabilization of MSWF.
6. **Statistical Evaluation of UCS** – Presents statistical analysis to evaluate the effectiveness of the stabilization process.
7. **Geotechnical Applications and Sustainability Analysis** – Assesses the practical applications of both treated and untreated MSWF in civil engineering projects.

The findings of this research contribute to the broader field of sustainable waste management and provide valuable insights into the practical applications of biopolymer-treated MSWF. This work aims to support future research and development in waste utilization, environmental sustainability, and geotechnical engineering, encouraging the adoption of eco-friendly materials and sustainable construction practices.