



Ecological sanitation via thermophilic co-composting of humanure and biochar as an approach to climate-smart agriculture

Daniela Castro Herrera

Energie & Umwelt / Energy & Environment

Band / Volume 573

ISBN 978-3-95806-622-9

Forschungszentrum Jülich GmbH
Institut für Bio- und Geowissenschaften
Agrosphäre (IBG-3)

Ecological sanitation via thermophilic co-composting of humanure and biochar as an approach to climate-smart agriculture

Daniela Castro Herrera

Schriften des Forschungszentrums Jülich
Reihe Energie & Umwelt / Energy & Environment

Band / Volume 573

ISSN 1866-1793

ISBN 978-3-95806-622-9

CONTENTS

Acknowledgements.....	I
Abstract.....	II
Zusammenfassung.....	III
Resumen.....	V
Contents.....	VII
List of figures.....	XI
List of tables.....	XV
List of abbreviations.....	XVII
1 Introduction.....	1
1.1 Motivation and background.....	1
1.2 State of the art.....	5
1.2.1 Ecological sanitation.....	5
1.2.1.1 Dry toilets.....	7
1.2.2 Fertilizer value of human excreta.....	7
1.2.3 Thermophilic composting.....	9
1.2.3.1 Compost parameters.....	11
1.2.3.2 Nitrogen losses during composting.....	12
1.2.3.3 Maturity and stability indicators.....	13
1.2.3.4 Compost application in soil.....	14
1.2.3.5 Composting human excreta and using human excreta-derived fertilizers.....	16
1.2.4 Biochar.....	18
1.2.4.1 What is biochar?.....	18
1.2.4.2 Biochar production with pyrolytic cook stoves.....	19
1.2.4.3 The origin of interest in biochar.....	22
1.2.4.4 Biochar as compost amendment and co-composted biochar application in soil.....	23
1.3 Objectives and outline of this work.....	26
2 Nutrient dynamics during composting of human excreta, cattle manure and organic waste affected by biochar.....	29
Abstract.....	29

2.1 Introduction.....	30
2.2 Materials and methods	31
2.2.1 Biochar production.....	31
2.2.2 Thermophilic composting and experimental design	32
2.2.3 Compost sampling and sample preparation	33
2.2.4 Control and indicator parameters of the composting process	33
2.2.4.1 Temperature	33
2.2.4.2 Moisture content, pH, electrical conductivity, and cation exchange capacity	33
2.2.4.3 Germination index.....	34
2.2.5 Total organic matter, total organic carbon and nutrients analysis.....	34
2.2.6 Determination of losses of organic matter, C and nutrients.....	34
2.2.7 Statistical analysis	35
2.3 Results and Discussion	35
2.3.1 Ecological sanitation.....	35
2.3.2 Control and indicator parameters.....	35
2.3.2.1 Temperature	35
2.3.2.2 Moisture content, pH, electrical conductivity, and cation exchange capacity	36
2.3.2.3 C:N ratio.....	38
2.3.2.4 Germination index.....	39
2.3.3 Total organic matter, organic C and N dynamics	39
2.3.4 NH_4^+ and NO_3^- dynamics.....	41
2.3.5 Phosphorus and K dynamics	41
2.3.6 Calcium, Mg and micronutrients	42
2.4 Conclusions.....	46
3 Biochar addition reduces non-CO ₂ greenhouse gas emissions during composting of human excreta and cattle manure	47
Abstract.....	47
3.1 Introduction.....	48
3.2 Materials and methods	49
3.2.1 Biochar production.....	49

3.2.2 Thermophilic composting and experimental design	50
3.2.3 Greenhouse gases and ammonia flux measurements	50
3.2.4 Statistical analysis	52
3.3 Results and Discussion	52
3.3.1 Gas fluxes during composting.....	52
3.3.1.1 CO ₂ emissions	52
3.3.1.2 CH ₄ emissions	52
3.3.1.3 N ₂ O emissions.....	53
3.3.1.4 NH ₃ emissions.....	54
3.3.2 Cumulative gas emissions.....	54
3.3.2.1 Cumulative CO ₂ emissions	54
3.3.2.2 Cumulative CH ₄ emissions	56
3.3.2.3 Cumulative N ₂ O emissions	57
3.3.2.4 Cumulative NH ₃ emissions	59
3.3.3 Total greenhouse gas emissions.....	60
3.4. Conclusions.....	63
4 Nutrient and CO ₂ dynamics after application of biochar-amended human excreta compost and cattle manure compost to sandy soil under tropical conditions	64
Abstract.....	64
4.1 Introduction.....	65
4.2 Materials and Methods.....	67
4.2.1 Incubation experiment and experimental design.....	67
4.2.2 Greenhouse gases flux measurements.....	70
4.2.3 Soil sampling and sample preparation	71
4.2.4 Chemical analysis	71
4.2.5 Statistical analysis.....	72
4.3 Results and discussion	72
4.3.1 Greenhouse gas fluxes and cumulative emissions	72
4.3.1.1 CO ₂	72
4.3.1.2 CH ₄ and N ₂ O.....	77

4.3.2 Dynamics of plant-available nutrients	78
4.3.2.1 NH_4^+ , NO_3^- , and available N	78
4.3.2.2 P and K	82
4.4 Conclusions	84
5 Synopsis	86
5.1 Summary	86
5.2 Synthesis	90
5.3 Conclusions and outlook	95
Appendices	98
Appendix A: supplemental material for chapter 2	98
Appendix B: supplementary material for chapter 3	108
Appendix C: supplementary material for chapter 4	110
Appendix D: supplementary material for chapter 5	112
References	113

Energie & Umwelt / Energy & Environment
Band / Volume 573
ISBN 978-3-95806-622-9