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**AEROBIC THERMOPHILIC COMPOSTING OF
PIGGERY SOLID WASTES**

A thesis presented in partial fulfilment of
the requirement for the degree of
Doctor of Philosophy
in Environmental Engineering at
Massey University

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For

My wife Rita

My children Amit, Dipak and Meena

ABSTRACT

Commercial piggery operations produce substantial quantities of solid waste requiring further treatment and disposal. Screened piggery solids contain recyclable nutrients and pathogenic organisms. Point source contribution from piggeries to surface and ground water pollution can be minimised by the application of composting process and technology. This process can serve as the treatment component of an overall waste management plan of a commercial piggery to biologically convert the putrescible to a stabilised form free of pathogenic organisms.

The rate of biochemical reaction determines the speed at which composting can proceed. Solids Retention Time (SRT) is the most important factor in determining the stability of the compost product. SRT is function of, among many other factors, the type of substrate and amendments and their corresponding reaction rate constants. In order to establish the minimum SRT, it is important to correctly derive the reaction rate constant from decomposition data. Rates of decomposition vary widely depending on the organic substrate. Although numerous guidelines are available for the design of effective composting plant, most of these guidelines or studies deal with sewage sludge or municipal solid waste. There is a complete lack of data on composting process design or reaction rates for piggery solids.

Due to these specific concerns, the main objectives of this thesis were to examine the composting process in relation to bulking material and operating conditions; analyse the disappearance of Total Organic Carbon with temperature development in order to determine first order reaction rates; and to analyse the inactivation or decay of indicator pathogens in piggery solids and sawdust composting trials and experiments.

Aerobic static pile composting of piggery solids was investigated at pilot (5 m³) scale. Sawdust was used as the bulking agent to provide additional carbon and to increase the porosity of the substrate. Composting trials, using different substrate to bulking agent ratios

and aeration frequencies were performed. The composting mixture was placed over an aerated base in the form of a pile. Temperature development, pH, Total Nitrogen, Total Phosphorus, Total Organic Carbon, Total Solids, Volatile Solids and pathogenic indicators were monitored until the completion of the trial.

The development of temperature profiles in three layers of the pile in each trial was similar and in agreement with trials conducted by various researchers. The change in moisture levels at two sampling points within the compost heap for each trial were similar. The moisture removal results demonstrated that the moisture removal from the compost pile depends not only upon a suitable temperature range, but also on the mode of heat movement. The increase in Total Solids and decrease in the fraction of Volatile Solids during the composting period in many trials were in agreement with trends described by many authors and demonstrated the decomposition process.

The nutrient analysis showed that up to 75% of initial nitrogen was conserved in the compost while there was no significant change in phosphorus concentration. There was varying order of magnitude reduction in Streptococci numbers in different trials. Similar trends were observed for total coliform (MPN) reduction. The high temperatures of the pile for prolonged periods were expected to decrease the bacterial counts to levels lower than those observed. The high values of MPN indicate that there are certain spore formers which survive the composting process.

The decomposition curve of Total Organic Carbon was used to calculate rate constant (k) over time from the temperature development data. A medium-order, Newton-Raphson algorithm, which solved non-stiff differential equation was used to solve the reaction rate equation numerically. Two models were compared for the determination of reaction rate constant. Values of reaction rate constant varied under different operating conditions of compost piles. The best values of reaction rate constant of the order of 0.008 and 0.007 per day were obtained from trial 4 that used a 25:75 (volume basis) sawdust-waste ratio; and was aerated for 10 minutes every hour. Same trial had the lowest Mean Residence Time (MRT) of approximately 115 days.

Two controlled laboratory experiments at 70 °C and 60 °C, respectively were also performed to independently verify rate constants developed from pilot trials. Laboratory experiments gave similar reaction rate constants to those mentioned above. This is beside the fact that a constant temperature profile was maintained throughout the composting period in these two experiments. The average residence time of solids under controlled conditions was not very different from MRT values obtained in the same pilot trial.

A comparison of two models showed that a simple first-order kinetic model can be used for the determination of inactivation coefficient, but using Arrhenius equation incorporating the reference temperature would provide a better thermal inactivation coefficient estimates. In trial 4, inactivation rate coefficient values were of the order of 0.394 and 0.380 per day at two sampling positions, respectively. The laboratory experiments provided inactivation rate coefficient values of the order of 61.97 and 47.34 per day, respectively. The significant difference in the reduction of indicator microorganisms between pilot trials and controlled experiments emphasises that homogeneity is critical in any composting process. It also emphasises the need for a temperature feedback aeration system.

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TABLE OF CONTENTS

ABSTRACT	i
ACKNOWLEDGEMENTS	iv
TABLE OF CONTENTS	vi
LIST OF TABLES	xi
TABLE OF FIGURES	xiii

CHAPTER 1

INTRODUCTION	1
--------------------	---

CHAPTER 2

REVIEW OF LITERATURE

2.1	Introduction	4
2.2	Properties of agricultural wastes	5
	2.2.1 Nitrogen	7
	2.2.2 Phosphorus	8
	2.2.3 Potassium and other nutrients	8
	2.2.4 Environmental concerns related to nutrients	9
	2.2.5 Health concerns related to nutrients	10
	2.2.6 Odour and ammonia emission	11
	2.2.7 Health risks associated with aerosols from wastes	11
	2.2.8 Piggery waste management alternatives	13
	2.2.9 Waste treatment alternatives	15
2.3	Composting	15
	2.3.1 Factors controlling composting	18
	2.3.3.1 <i>Microbial population</i>	18
	2.3.3.2 <i>Aeration</i>	19
	2.3.3.3 <i>C/N ratio</i>	19
	2.3.3.4 <i>Temperature</i>	20
	2.3.3.5 <i>pH</i>	20
2.4	Composting process fundamentals	22
	2.4.1 Biochemical aspects	23
	2.4.2 Microbiology	27
	2.4.3 Heat generation and temperature	29
	2.4.4 Heat - Temperature interaction	29
	2.4.5 Aeration, heat, and moisture removal	30
	2.4.6 Pathogenic Organisms	30
2.5	Composting technologies	33

2.5.1	General aspects	33
2.5.2	Conventional windrow process	34
2.5.3	Aerated windrow process	35
2.5.4	Aerated static pile system	35
	2.5.4.1 <i>Process control</i>	35
2.5.5	Reactor (In-vessel) systems	36
	2.5.5.1 <i>Vertical flow reactor</i>	36
	2.5.5.2 <i>Horizontal and inclined flow reactors</i>	37
	2.5.5.3 <i>Agitated solid bed (or bin) reactors</i>	37
2.6	Losses of N from animal manures	38
2.6.1	N mineralisation and immobilisation	40
2.6.2	Nitrification	40
2.6.3	Denitrification, nitrification and chemodenitrification losses	41
2.6.4	Ammonia volatilisation	43
2.7	Design approach for composting systems	45
2.7.1	Rate of biodegradation	47
2.7.2	First order reaction rates	47
2.8	Conclusions from literature review	49

CHAPTER 3 MATERIAL AND METHODS

3.1	Equipment and materials	51
3.1.1	Piggery solid: Source and characteristics	51
3.1.2	Bulking agent	51
3.1.3	Experimental site conditions	52
3.1.4	Aeration equipment	52
	3.1.4.1 <i>Piping materials</i>	52
	3.1.4.2 <i>Material for laboratory experiments</i>	53
	3.1.4.3 <i>Air supply</i>	53
3.1.5	Temperature recorder	55
3.1.6	Sampling	55
3.2	Experimental procedure	56
3.2.1	Mixing of solid and bulking agent	57
3.2.2	Aeration distribution	57
3.2.3	Construction of static piles	60
3.2.4	Laboratory experimental setup	61
3.2.5	Aeration pattern	62
3.2.6	Sampling procedure	63
3.3	Analytical methods	63
3.3.1	Chemical analysis	63
	3.3.1.1 <i>pH measurement</i>	63
	3.3.1.2 <i>Total and volatile solids</i>	64
	3.3.1.3 <i>Total Nitrogen and Phosphorus</i>	64
	3.3.1.4 <i>Total Carbon</i>	65
3.3.2	Microbial Analysis	66
	3.3.2.1 <i>Media</i>	66

3.3.2.2	<i>Media preparation</i>	<u>66</u>
3.3.2.3	<i>Sterilisation of media, glassware and equipment</i>	<u>66</u>
3.3.2.4	<i>Sample preparation</i>	<u>66</u>
3.3.2.5	<i>Analysis for indicator microorganisms</i>	<u>67</u>

CHAPTER 4

EXPERIMENTAL RESULTS

4.1	Analysis of variables	<u>70</u>
4.1.1	Temperature development	<u>70</u>
4.1.2	Total Solids and Volatile Solids	<u>74</u>
4.1.3	Total Nitrogen	<u>80</u>
4.1.4	Total Phosphorus	<u>86</u>
4.1.5	Total Organic Carbon	<u>92</u>
4.1.6	pH	<u>97</u>
4.1.7	Microbiological counts	<u>99</u>
4.2	Statistical analysis	<u>114</u>
4.2.1	Data transformation	<u>114</u>

CHAPTER 5

COMPOSTING PROCESS RATES

5.1	Introduction	<u>121</u>
5.2	System parameters	<u>121</u>
5.3	The rate of disappearance of carbon	<u>123</u>
	<u>123</u>
5.3.1	The reaction rate constant	<u>125</u>
5.3.2	Effect of temperature	<u>125</u>
5.4	Results of carbon degradation	<u>128</u>
5.4.1	The rate of disappearance of carbon mass	<u>128</u>
5.4.2	Reaction rate constant	<u>128</u>
5.4.3	Effect of temperature	<u>130</u>
5.5	Discussion on carbon degradation	<u>133</u>
5.5.1	Mean residence time	<u>134</u>
5.5.2	Carbon/Nitrogen ratio	<u>136</u>
5.5.3	Time required to obtain required decomposition	<u>139</u>
5.6	Conclusions on carbon degradation	<u>141</u>
5.7	Rate of thermal inactivation	<u>143</u>
5.7.1	Kinetics of heat inactivation	<u>143</u>
5.7.2	Thermal inactivation coefficient	<u>145</u>
5.7.3	Effect of temperature	<u>146</u>
5.8	Results and Discussion on thermal inactivation	<u>148</u>
5.8.1	Rate of disappearance of pathogens	<u>148</u>
5.8.2	Inactivation rate coefficient	<u>148</u>
5.8.3	Effect of temperature	<u>150</u>
5.8.4	Decimal Reduction Factor	<u>154</u>
5.8.5	Limitations on pathogenic inactivation	<u>157</u>
5.9	Conclusions on thermal inactivation	<u>159</u>

CHAPTER 6 PROCESS PERFORMANCE

6.1	General observation	<u>161</u>
6.2	Performance comparison between pilot scale and laboratory scale conditions	<u>162</u>
	6.2.1 Method of parallelism for mathematical analysis	<u>162</u>
6.3	Decomposition activity	<u>166</u>
	6.3.1 Temperature development	<u>166</u>
	6.3.2 Moisture	<u>168</u>
	6.3.3 Total Solids and Volatile Solids	<u>172</u>
	6.3.4 Nutrients	<u>176</u>
	6.3.5 pH	<u>186</u>
	6.3.6 Microbiology	<u>187</u>
	6.3.7 Reaction Rate constants	<u>191</u>
	6.3.8 Inactivation rate coefficient	<u>192</u>
6.4	Conclusions	<u>194</u>

CHAPTER 7 CONCLUSIONS AND APPLICATION

7.1	Review of literature	<u>197</u>
7.2	Composting operation	<u>198</u>
7.3	Composting process performance	<u>199</u>
7.4	Reaction rate constant (k)	<u>200</u>
7.5	Mean residence time	<u>201</u>
7.6	C/N ratio	<u>201</u>
7.7	Rate of thermal inactivation	<u>201</u>
7.8	Application of research	<u>202</u>
7.9	Suggestions for future research	<u>203</u>

REFERENCES	<u>206</u>
------------------	------------

APPENDIX 1	<u>230</u>
Temperature profile during composting at thermocouple positions T1 to T6	<u>230</u>
APPENDIX 2	<u>233</u>
Changes in Total Solids and Volatile Solids content at positions S1 and S2	<u>233</u>
APPENDIX 3	<u>236</u>
Changes in Total Nitrogen content at positions S1 and S2	<u>236</u>
APPENDIX 4	<u>239</u>
Changes in Total Phosphorus content at positions S1 and S2	<u>239</u>
APPENDIX 5	<u>242</u>
Changes in Total Organic Carbon content at positions S1 and S2	<u>242</u>
APPENDIX 6	<u>245</u>
Changes in pH values at positions S1 and S2	<u>245</u>
APPENDIX 7	<u>248</u>
Changes in coliform (MPN) and streptococci counts during composting at positions S1	<u>248</u>

APPENDIX 8 251
Changes in coliform (MPN) and streptococci counts during composting
at positions S2 251
APPENDIX 9 254
Best fit curves to calculate parameter values for Eq. 5.8 at S1 and S 254

LIST OF TABLES

CHAPTER 2

Table		Page
Table 2.1	Pig population (000) in various regions of the world	<u>4</u>
Table 2.2	Freshly voided pig manure characteristics	<u>6</u>
Table 2.3	Nutrient content (g/kg dry weight basis) of animal manures	<u>6</u>
Table 2.4	Characteristics of Piggery wastewater	<u>7</u>
Table 2.5	Composition of organic matter	<u>24</u>
Table 2.6	The relative rate of microbial decomposition of organic materials . . .	<u>26</u>
Table 2.7	Number of microorganisms isolated in raw sludge	<u>27</u>
Table 2.8	Temperature range for microorganisms	<u>28</u>
Table 2.9	N losses during the storage or composting of animal manure	<u>39</u>
Table 2.10	First order rate constants at 25 ⁰ C for various substrates incubated with soil	<u>48</u>

CHAPTER 3

Table 3.1	Aeration and sawdust-waste ratios for various trials	<u>56</u>
-----------	--	-----------

CHAPTER 4

Table 4.1	Calculated F values and probability levels for Trial 1	<u>116</u>
Table 4.2	Calculated F values and probability levels for Trial 2	<u>117</u>
Table 4.3	Calculated F values and probability levels for Trial 3	<u>118</u>
Table 4.4	Calculated F values and probability levels for trial 4	<u>119</u>
Table 4.5	Calculated F values and probability levels for Trial 5	<u>120</u>

CHAPTER 5

Table 5.1	Controllable factors for composting	<u>122</u>
Table 5.2	Major compost system parameters required for optimization analysis of the system	<u>123</u>
Table 5.3	Reaction rate constants of carbon loss without temperature correction	<u>129</u>
Table 5.4	Temperature coefficients over time	<u>131</u>
Table 5.5	Reaction rate constants over time with temperature corrections	<u>131</u>
Table 5.6	Residual Sum of Squares for two models used to compare reaction rate constants over time	<u>134</u>
Table 5.7	Mean Residence Time of carbon	<u>135</u>
Table 5.8	Initial and final Carbon/Nitrogen ratios	<u>139</u>
Table 5.9	Time (days) required to achieve a C/N ratio of 20 in various trials . .	<u>141</u>
Table 5.10	Overall thermal inactivation coefficient for Total coliforms	<u>149</u>
Table 5.11	Overall thermal inactivation coefficient for Streptococci	<u>149</u>
Table 5.12	Thermal inactivation coefficient for Total coliforms	<u>151</u>
Table 5.13	Thermal inactivation coefficient for Streptococci	<u>152</u>
Table 5.14	Residual Sum of Squares (RSS) for two models used to compare thermal inactivation coefficient for total Coliform over time	<u>153</u>
Table 5.15	Residual Sum of Squares for two models used to compare thermal inactivation coefficient for Streptococci over time	<u>154</u>
Table 5.16	Decimal reduction factor for Total coliforms	<u>155</u>
Table 5.17	Decimal reduction factor for Total coliforms	<u>155</u>

Table		Page
Table 5.18	Decimal reduction factor for Streptococci	<u>156</u>
Table 5.19	Decimal reduction factor for Streptococci	<u>156</u>

CHAPTER 6

Table 6.1	Change in moisture content	<u>168</u>
Table 6.2	Residual Sum of Squares for moisture contents	<u>171</u>
Table 6.3	Change in total solids	<u>173</u>
Table 6.4	Residual Sum of Squares for total solids	<u>174</u>
Table 6.5	Change in volatile	<u>175</u>
Table 6.6	Change in total nitrogen	<u>178</u>
Table 6.7	Residual Sum of Squares for total nitrogen	<u>180</u>
Table 6.8	Change in total phosphorus	<u>181</u>
Table 6.9	Residual Sum of Squares for total phosphorus	<u>182</u>
Table 6.10	Change in total organic carbon	<u>183</u>
Table 6.11	Residual Sum of Squares for total organic carbon	<u>184</u>
Table 6.12	Residual Sum of Squares for C/N ratios	<u>186</u>
Table 6.13	Change in pH	<u>187</u>
Table 6.14	Change in MPN	<u>188</u>
Table 6.15	Change in Streptococci counts	<u>189</u>
Table 6.16	Residual Sum of Squares for microbial indicators	<u>190</u>
Table 6.17	Calculated F values and probability levels (5%) for different variables	<u>194</u>

LIST OF FIGURES

Figure		Page
CHAPTER 2		
Figure 2.1	The composting process	<u>16</u>
Figure 2.2	Temperature-time pattern indicating the phases of microbial activity	<u>23</u>
Figure 2.3	Generalised schematic for the composting process	<u>34</u>
CHAPTER 3		
Figure 3.1	Schematic representation of the aeration piping layout used in the composting trials	<u>54</u>
Figure 3.2	Timer configuration for the 'on-off' regime of the aeration and the temperature measurement	<u>55</u>
Figure 3.3	Position of thermocouples and sampling points	<u>61</u>
Figure 3.4	Schematic of the setup used for laboratory experiments	<u>62</u>
CHAPTER 4		
Figure 4.1	Temperature profile during composting in fourth trial at thermocouple positions T1 to T6	<u>73</u>
Figure 4.2	Changes in Total solids content during composting in fourth trial at positions S1 and S2	<u>76</u>
Figure 4.3	Changes in Volatile solids content during composting in fourth trial at positions S1 and S2	<u>77</u>
Figure 4.4	Changes in Total solids content during composting in experiment 6 .	<u>78</u>
Figure 4.5	Changes in Total solids content during composting in experiment 7 .	<u>79</u>
Figure 4.6	Changes in Total Nitrogen contents during composting in fourth trial at positions S1 and S2	<u>83</u>
Figure 4.7	Changes in Total nitrogen content during composting in experiment 6	<u>84</u>
Figure 4.8	Changes in Total nitrogen content during composting in experiment 7	<u>85</u>
Figure 4.9	Changes in Total Phosphorus contents during composting in fourth trial at positions S1 and S2	<u>89</u>
Figure 4.10	Changes in Total phosphorus content during composting in experiment 6	<u>90</u>
Figure 4.11	Changes in Total phosphorus content during composting in experiment 7	<u>91</u>
Figure 4.12	Changes in Total Organic Carbon content during composting in fourth trial at positions S1 and S2	<u>94</u>
Figure 4.13	Changes in Total Organic Carbon content during composting in experiment 6	<u>95</u>
Figure 4.14	Changes in Total Organic Carbon content during composting in experiment 7	<u>96</u>
Figure 4.15	Changes in pH values during composting in fourth trial at positions S1 and S2	<u>98</u>

Figure		Page
Figure 4.16	Changes in coliform (MPN) and streptococci counts during composting in fourth trial at positions S1	<u>104</u>
Figure 4.17	Changes in coliform (MPN) and streptococci counts during composting in fourth trial at positions S2	<u>105</u>
Figure 4.18	Changes in total coliform (MPN) during composting in experiment 6	<u>106</u>
Figure 4.19	Changes in faecal coliform (MPN) during composting in experiment 6	<u>107</u>
Figure 4.20	Changes in <i>E.coli</i> (MPN) during composting in experiment 6	<u>108</u>
Figure 4.21	Changes in enterococci numbers during composting in experiment 6	<u>109</u>
Figure 4.22	Changes in total coliforms (MPN) during composting in experiment 7	<u>110</u>
Figure 4.23	Changes in faecal coliforms (MPN) during composting in experiment 7	<u>111</u>
CHAPTER 5		
Figure 5.1	Best fit curve to calculate parameter values for Eq. 5.8 at S1 in Trial 1	<u>132</u>
Figure 5.2	Best fit curve to calculate parameter values for Eq. 5.8 at S2 in Trial 1	<u>132</u>
Figure 5.3	Survival of Total coliform at different controlled temperatures	<u>158</u>
Figure 6.1	Two parallel lines fitted to x and y_1 & y_2 values	<u>165</u>
CHAPTER 7		
Figure 7.1	Roofed aerated composting facility at Lepperton Piggery	<u>205</u>
Figure 7.2	Piggery compost at curing stage	<u>205</u>