Development of a Mathematical Model for Calculating Accumulated Solid Waste: An Experimental and Statistical Sampling

Taiwo Alare (✉ alaretaiwopeter@gmail.com)

Federal University of Technology <https://orcid.org/0000-0002-3939-9990>

Kehinde Alare

Ladoke Akintola University of Technology

Research Article

Keywords: Waste management, solid waste collection, data collation, mathematical model

Posted Date: May 20th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-431933/v1>

License: This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

**Development of a Mathematical Model for Calculating Accumulated Solid Waste: An
Experimental and Statistical Sampling**

Taiwo Alare¹ and Kehinde Alare²

Department Of Medicine, Ladoke Akintola University Of Technology, Ogbomosho² & Department
Of Mechanical Engineering, Federal University Of Technology, Akure¹

Corresponding Author: Taiwo Alare

Email Address: alaretaiwopeter@gmail.com

1.0 Abstract

In newest development, waste is being refined into a biofuel or recycled. Waste management has being an important factor in community development. The transformation of waste into useful materials has received much work. Therefore, database must be developed to know the amount of waste accumulated or generated over a given period of time. Taken into consideration the burning and recycle reduction factor, incremental factor and degradable waste ratio.

This paper look for a mathematical formula that can be used to generate data for amount of solid waste accumulated over time for geographical location in respect of mass.

Keywords: Waste management, solid waste collection, data collation, mathematical model

1.1 Introduction

Estimation has been given of waste generated in a geographical location per day (Alare, 2020). The formula works with the estimated figures of waste generated per day geographical location using statistical models sampling (Castle, 1993).

The importance of data in this present age cannot be overemphasized. It is important because it provide useful information for institutions, organizations and researchers of past record.

The aim of this research is to develop a formula that will help companies, institutions and researcher of biofuel, bioenergy system and other waste transformation related fields determine the amount of solid waste available to them in a geographical location based on the data derived from the formula and waste chart.

2.0. Methods

To determine the estimated accumulated waste of a geographical location for a given time interval. Three factors were considered and these factors varies from different geographical locations. Therefore, geographical locations should be experimental samples. The factors are:

Waste incremental ratio (i)

Degradable waste ratio (c)

Burning and recycle reduction factors

These factors tend reduce or increase the accumulated waste from expected waste generated. The availability of waste to waste companies can be examined using these

factors. To determine these factors, statistical model and experimental sample methods will be employed.

2.1. Statistical Model of Waste Incremental Ratio (i)

$$\bar{i} = \frac{1}{t} \sum_{k=1}^{\infty} \left(\frac{N_k - N_{k-1}}{N_{k-1}} \right) \bar{i} = \frac{1}{t} \sum_{k=1}^{\infty} \left(\frac{N_k - N_{k-1}}{N_{k-1}} \right) \quad (\text{Dass, 2008})$$

where, N is amount of waste generated per

day and k is the number of days

t is number of days used which is $k_{\max}$

2.1.1. Experimental Method Procedure

Create an open boundary space samples of dumpsites A,B,C,D,E,..... ∞

Determine the mass of solid waste of each samples

Check the increment in mass of each samples per day for given period of days

Sample	Day1	Day2	Day3..... Day k
A	N_1a	N_2a	N_3a
B	N_1b	N_2b	N_3a
C	N_1c	N_2c	N_kaN_ka
D	N_1d	N_2d	N_3b
E	N_1e	N_2e	N_3b
.	.	.	N_kbN_kb
.	.	.	N_3c
.	.	.	N_3c
.	.	.	N_kcN_kc
∞	$N_1\infty$	$N_2\infty$	N_3d
			N_3d
			N_kdN_kd
			N_3e
			N_3e
			N_keN_ke
			.
			.

			.
			.
			$N_{3\infty}$
			$N_{3\infty} \dots\dots\dots$
			$N_{k\infty} N_{k\infty}$

61 Waste incremental ratio for each samples

62
$$i_A = \frac{1}{t} \sum_{k=1}^{\infty} \frac{N_{ka} - N_{(k-1)a}}{N_{ka}} i_A = \frac{1}{t} \sum_{k=1}^{\infty} \frac{N_{ka} - N_{(k-1)a}}{N_{ka}}$$

63
$$i_B = \frac{1}{t} \sum_{k=1}^{\infty} \frac{N_{kb} - N_{(k-1)b}}{N_{kb}} i_B = \frac{1}{t} \sum_{k=1}^{\infty} \frac{N_{kb} - N_{(k-1)b}}{N_{kb}}$$

64
$$i_C = \frac{1}{t} \sum_{k=1}^{\infty} \frac{N_{kc} - N_{(k-1)c}}{N_{kc}} i_C = \frac{1}{t} \sum_{k=1}^{\infty} \frac{N_{kc} - N_{(k-1)c}}{N_{kc}}$$

65
$$i_D = \frac{1}{t} \sum_{k=1}^{\infty} \frac{N_{kd} - N_{(k-1)d}}{N_{kd}} i_D = \frac{1}{t} \sum_{k=1}^{\infty} \frac{N_{kd} - N_{(k-1)d}}{N_{kd}}$$

66
$$i_E = \frac{1}{t} \sum_{k=1}^{\infty} \frac{N_{ke} - N_{(k-1)e}}{N_{ke}} i_E = \frac{1}{t} \sum_{k=1}^{\infty} \frac{N_{ke} - N_{(k-1)e}}{N_{ke}}$$

67 .

68 .

69
$$i_{\infty} = \frac{1}{t} \sum_{k=\infty}^{\infty} \frac{N_{k\infty} - N_{(k-1)\infty}}{N_{k\infty}} i_{\infty} = \frac{1}{t} \sum_{k=\infty}^{\infty} \frac{N_{k\infty} - N_{(k-1)\infty}}{N_{k\infty}}$$

70 2.1 2. Average waste incremental ratio

71
$$\bar{i} = \frac{\sum_{k=A}^{\infty} i_k}{\text{number of samples}} \bar{i} = \frac{\sum_{k=A}^{\infty} i_k}{\text{number of samples}}$$

72 In order to avoid or minimize mathematical and computational error, a small number of samples
73 and minimum duration of days is advice.

74 2.2. Statistical Model of Degradable Waste Ratio (c)

75
$$c = \frac{1}{t} \sum_{k=1}^{\infty} \left(\frac{N_k - N_{k+1}}{(k+1) - k} \right) c = \frac{1}{t} \sum_{k=1}^{\infty} \left(\frac{N_k - N_{k+1}}{(k+1) - k} \right)$$

76 *where, N is amount of waste generated per day and*

77 *where, N is amount of waste generated per day and*

78 *k is the number of days*

79 *t is the number of month of experiment*

80

81 2.2.1 **Experimental Method Procedure**

82 Create space samples of dumpsite A,B,C,D,E,..... ∞ in a closed and isolated system

83 Determine the mass of solid waste of each samples

84 Check the decrement in mass of each samples per day for given period of days

85

86

Sample	Month 1	Month 2	MonthMonth 3k
A	N_1a	N_2a	N_3aN_3a
B	N_1b	N_2b	N_kaN_ka
C	N_1c	N_2c	N_3bN_3b
D	N_1d	N_2d	N_kbN_kb
E	N_1e	N_2e	N_3cN_3c
.	.	.	N_kcN_kc
.	.	.	N_3dN_3d
.	.	.	N_kdN_kd
.	.	.	N_3eN_3e
∞	$N_1\infty$	$N_2\infty$	$N_k\infty N_k\infty$
			.
			.
			.
			.
			$N_3\infty N_3\infty$
			$N_k\infty N_k\infty$

87

88 Waste incremental ratio for each samples

89
$$c_A = \frac{1}{t} \sum_{k=1}^{\infty} \frac{N_{ka} - N_{(k+1)a}}{((k+1)-k)a} c_A = \frac{1}{t} \sum_{k=1}^{\infty} \frac{N_{ka} - N_{(k+1)a}}{((k+1)-k)a}$$

90
$$c_B = \frac{1}{t} \sum_{k=1}^{\infty} \frac{N_{kb} - N_{(k+1)b}}{((k+1)-k)b} c_B = \frac{1}{t} \sum_{k=1}^{\infty} \frac{N_{kb} - N_{(k+1)b}}{((k+1)-k)b}$$

91
$$c_C = \frac{1}{t} \sum_{k=1}^{\infty} \frac{N_{kc} - N_{(k+1)c}}{((k+1)-k)c} c_C = \frac{1}{t} \sum_{k=1}^{\infty} \frac{N_{kc} - N_{(k+1)c}}{((k+1)-k)c}$$

92
$$c_D = \sum_{k=1}^{\infty} \frac{N_{kd} - N_{(k+1)d}}{((k+1)-k)d} c_D = \sum_{k=1}^{\infty} \frac{N_{kd} - N_{(k+1)d}}{((k+1)-k)d}$$

93
$$c_E = \frac{1}{t} \sum_{k=1}^{\infty} \frac{N_{ke} - N_{(k+1)e}}{((k+1)-k)e} c_E = \frac{1}{t} \sum_{k=1}^{\infty} \frac{N_{ke} - N_{(k+1)e}}{((k+1)-k)e}$$

94 .

95 .

96
$$C_{\infty} = \frac{1}{t} \sum_{k=\infty}^{\infty} \frac{N_{k\infty} - N_{(k+1)\infty}}{((k+1) - k)_{\infty}} C_{\infty} = \frac{1}{t} \sum_{k=\infty}^{\infty} \frac{N_{k\infty} - N_{(k+1)\infty}}{((k+1) - k)_{\infty}}$$

97

98 Note

99 $((k+1) - k) =$
30days k should be in days

100 $((k+1) - k) =$
30days k should be in days

101 2 2.2 Average waste degradable ratio

102
$$C = \frac{\sum_{k=A}^{\infty} C_k}{\text{number of samples}} C = \frac{\sum_{k=A}^{\infty} C_k}{\text{number of samples}}$$

103 2 3 Burning and Recycle Factor

104 The assumed burning factor is in the range of 0.005 to 0.006 depending on the burning and
105 recycling activities of the geographical area considered.

106

107

108 3.0 Result

109 A reduction constant k is developed from the mathematical combination of all the factors
110 ensuring that reduction is at a reasonable range.

111 $k = i^{bc} k = i^{bc}$

112 The amount of solid waste accumulated over a given period in term of the mass is given
113 as

114 $M = kTN + NM = kTN + N$

115 $T = T_0 - 1$

116 Where

117 M is accumulated waste over a period of time

118 K is reduction constant

T₀ is period of time taken in days

4.0 Conclusion

This paper has shown a method of calculating the amount of accumulated solid waste in mass. The factors considered varies from one geographical area to another. We employ researchers to further the research, with the aim of obtaining the factors for different geographical locations in the world. Develop a chart that will contain the data of all i , c and k for all experimented geographical area.

Declaration of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability Statement: Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

Funding statement: Not Applicable

Authors' Contributions: All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Taiwo Alare and Kehinde Alare. The first draft of the manuscript was written by Taiwo Alare and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

5.0 Reference

Castle, G. (1993). *hazardous waste facility siting in manitoba-Case study of a success*. Journal of the Air and Waste Management Association.

Dass, H. (2008). *Advance Engineering Mathematics*. New Delhi: S. Chand.

Alare K, Alare T., Ojelola K., Akinnawo O. (2020). Smart and Clean Environment: An Importance Qualification of a Smart City (ecosystem engineering). *Alare's Research Institute Annual Conference*. Retrieve from: <http://dx.doi.org/10.13140/RG.2.2.35939.27684>