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Optimization of Waste Management System in Anambra State: A Case Study of Ifite-Awka

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ABSTRACT: *Indiscriminate dumping of solid wastes along the streets and road corners causes a lot of deadly infectious diseases which could be responsible for the large proportion of morbidity and mortality in Nigeria. A deterministic model needed for short and long term waste management and management information system in Anambra State waste management authority (ASWAMA) was considered in this report. A review of literature on model methods was presented, with brief method of the study and analysis used for the determination of the required results. Moreover, this study was aimed to determine which type of integrated solid waste management option or an optimal programme will be used to implement maximized benefit over a long period of planning. Consequently, the model will definitely be used by decision makers in finding the solution to environmental, economical, sanitary, technical and social goals, through the use of equipment, routine maintenance, personal and sundry. From our study, we found out that the maximum waste that can be generated daily in Ifite-awka region is about 15,000kg and this comprises of food products at 2,100.2kg, glass products at 1556.5kg, wooden materials at 1659.1kg, plastics at 1744.6kg, paper at 3335.6kg, grass at 2445.9kg.*

I. INTRODUCTION

The examination of the history of waste management practise would show that common wastes produced during the pre-modern era was mainly ashes and bio-degradable wastes and they were released back into the ground locally, with minimum environmental impact (US EPA,1999). It was discovered that tools were made out of wood or metal and were generally reused and passed down to generations. However, it was not until the mid 19th century that Edwin Chadwick published his report “The sanitary condition of the labouring population” in 1842. And the report attracted international attention because he argued for the importance of adequate removal and management facilities to improve the health and well being of the population (Barbalace, 2003). The dramatic increase in waste for disposal led to the creation of the first incinerator by Albert Fryer in 1874. The first waste disposal trucks were introduced in Britain in the 1920s and the engineering design was based on a dumping lever mechanism. These were soon equipped with scooper mechanisms where the scooper was loaded at the floor level then hoisted mechanically to deposit the waste in the truck. In 1938, Garwood Parker incorporated a hydraulic compactor in these trucks for efficient operation(Herbert, 2007).

Humans have always produced trash and have always found a medium of disposing it in any suitable way available, therefore the issue of solid waste management is not new. The only thing that has changed are the types and amounts of waste produced, the methods of disposal and the human values and perceptions of what should be done with it. In the past, refuse was typically discarded in the most convenient manner possible with little regard to the effects on human health or the environment(Alexander,1993). Before modern notions of hygiene developed, city streets were typically open sewers that breed all sought of contaminated diseases. Even until the middle of the twentieth century household trash was commonly disposed off and burned up in open dumps that were neighborhood eyesores and they emitted offensive odours and attracted rats and other pests (Denisson, 1990). The solid wastes are with the human beings from the very beginning of civilization, but only in the last decades we have started seeking the solutions to this problem using scientific methods.

Development of technical methods, and the increase of economic burden on the society made the problem of reducing the environmental and social impact of waste more and more important. One of the ways to obtain this goal is to build a waste disposal model, which would measure and evaluate the important impact factors of the selected systems of waste treatment (Denisson, 1990). Chemical wastes were often haphazardly stored in on-site industrial piles or treatment ponds. Poisinous waste might be buried, but a few controls existed to avoid the contamination of ground water. It will be interesting to note that over the past few decades, nigerians have become interestingly concerned about not only the management and disposal of waste but also the difficulty of balancing the benefits of a healthy environment with the economic costs of achieving those benefits. Conflict often arises over what disposal methods should be used, whether the costs of certain disposal methods outweigh the benefits and who should bear the economic burden. Many factors must be considered in the discussion of the topic of waste management: economic, environmental, personal and ethical issues all play major roles in engineering decision making process (Davidson ,2011).

However, some modern cultures do seem to have been more profligate in thier waste output than others. For example, in western germany there is a fixed monthly activity were people would gather and burn thier rubbish in large dumps. Following the onset of industrialisation and sustained urban growth of large population cities in nigeria, the build up of waste in cities caused a rapid deterioration in the levels of sanitation and general quality of urban living. This caused the streets to become choked with filth due to the lack of effective waste management regulations (Kaufman et al ,1996). It is important to note at this point that as the preservation of the health of people is of great importance it is proposed that the cleaning up of the city should be put under one uniform public management and the filth should be conveyed properly.

A proper, efficient, reliable and hygienic waste handling and disposal technique tells more of our maintenance culture but the capacity and ability to efficiently manage the waste becomes inadequate. The need for this study arose because effective waste management is a tool for sustainable development. This can be achieved by adopting the appropriate waste handling technique and strategy for an efficient and environmental friendly waste disposal. The basic aim here is to allow decision makers to be able to determine the optimal times to implement and discontinue or close the waste management programme and facilities. This study seeks to achieve the following objectives; to identify the challenges encountered in waste management, to identify the methods for storage of solid wastes in Anambra State, to assess the methods used in solving solid waste handling problems, to determine an effective waste management strategy.

II. METHODOLOGY

Different waste management options must be combined intelligently in a way as to reduce the environmental and social impact at an acceptable cost for the masses in the state. This combined option is called the integrated solid waste management and system approach should be used for the assessment of the competing option. Data were collected from both primary and secondary sources. Some tools of participatory appraisal techniques namely semi-structured interview schedule and focus group discussion were employed in data collection. Optimisation model for solid waste management system engineering approach to planning, scheduling, cost minimizing, maintenance and general management of solid waste management system, serves as a control tool for decision makers in the areas of solid waste management (Mckenzie and David, 1998). The necessity for this system approach lies in the fact that waste management in recent times have developed a complex task. The system for the optimal model is focused on the Anambra state waste management authority, as a means of eradicating waste littering along the streets and roads that concern municipal and local waste management system.

Table 1: Presentation of 2013 to 2014 Generated Solid Waste System in Ifite Zone; Awka South Local Government Area, Anambra State

Time (month)	Food Products	Metallic Products	Glass Products	Wooding Materials	Plastics	Paper	Grass	Generated Solid Waste
2013/Jan	1738.152	2733.504	1351.896	1441.032	1515.312	3951.696	2124.408	14856
Feb.	1846.26	2903.52	1435.98	1530.66	1609.56	4197.48	2256.54	15780
Mar.	1501.11	2360.72	1167.53	1244.51	1308.66	3412.78	1834.69	12830
April	1467.18	2307.36	1141.14	1216.38	1279.08	3335.64	1793.22	12540
May	1957.293	3078.136	1522.339	1622.713	1706.358	4449.914	2392.247	16729
June	1742.13	2739.76	1354.99	1444.33	1518.78	3960.74	2129.27	14890
July	1664.559	2617.768	1294.657	1380.019	1451.154	3784.382	2034.461	14227
Aug.	1781.91	2802.32	1385.93	1477.31	1553.46	4051.18	2177.89	15230
Sept.	1509.885	2374.52	1174.355	1251.785	1316.31	3432.73	1845.415	12905
Oct.	2001.168	3147.136	1556.464	1659.088	1744.608	4549.664	2445.872	17104
Nov.	1852.11	2912.72	1440.53	1535.51	1614.66	4210.78	2263.69	15830
Dec.	1605.24	2524.48	1248.52	1330.84	1399.44	3649.52	1961.96	13720
2014/Jan	1835.028	2885.856	1427.244	1521.348	1599.768	4171.944	2242.812	15684
Feb.	1735.11	2728.72	1349.53	1438.51	1512.66	3944.78	2120.69	14830
Mar.	1779.57	2798.64	1384.11	1475.37	1551.42	4045.86	2175.03	15210
April	1494.675	2350.6	1162.525	1239.175	1303.05	3398.15	1826.825	12775
May	1921.725	3022.2	1494.675	1593.225	1675.35	4369.05	2348.775	16425
June	1975.194	3106.288	1536.262	1637.554	1721.964	4490.612	2414.126	16882
July	1893.879	2978.408	1473.017	1570.139	1651.074	4305.742	2314.741	16187
Aug.	1855.62	2918.24	1443.26	1538.42	1617.72	4218.76	2267.98	15860

1.1. Development of the surface response methodology

The development of the regression model and execution process are ordered and streamlined to effectively achieve the required result, as in the determination of required result to be adressed by the model and area of focus in implementation. This was done first to determine the scope of the design and to ensure a necessary guideline for the project work with the full aim of achieving a competitive result even both in analysis and design work. Also, it determined planning models for project execution, which consist of planning of models and modules needed for the execution of the model.

Polynomial models are generalized to any number of predictor variables X_i (where i = 1,2,3,4,5,6,7,8,9.......N) as follows:

$$Y(x) = \beta_0 + \Sigma\, \beta_i X_i + \Sigma\, \beta_{ij} X_i X_j + \Sigma\, \beta_{ii} X_i^2 + \dots \quad (1)$$

Where; Y(x) = Response variable, β_0 = constant, $\Sigma\, \beta_i X_i$ = linear terms, $\Sigma\, \beta_{ij} X_i X_j$ = quadratic interaction terms, $\Sigma\, \beta_{ii} X_i^2$ = squared terms. Higher order terms would follow as necessary.

Response surface models are multivariate polynomial models. They typically arise in the design of experiments where they are used to determine a set of design variables that optimize a response. Linear terms alone produce models with response surfaces that are hyper-planes. The addition of interaction terms allows for warping of the hyper-plane. Squared terms produce the simplest models in which the response surface has a maximum or minimum, and so an optimal response. Response surface methodology (RSM) is the process of adjusting predictor variables to move the response in a desired direction and, iteratively, to an optimum. The method generally involves a combination of both computation and visualization. The use of quadratic response surface models makes the method much simpler than standard non-linear techniques for determining optimal designs. When treatments are from a continous range of values then a response surface methodology is useful for developing,improving and optimising the response variable. The response variable is a function of the independent variables such that;

$$Y(x) = f\,(x_1,x_2) + e \dots \quad (2)$$

The variables x1 and x2 are independent variables where the response Y depends on them. The dependent variable y is a function of x_1,x_2 ,and the experimental error term, denoted as e. The error term represents any measurement error in the response as well as other type of variations not counted in f .In order to develop a proper approximation for f , the experimenter usually starts with a low order polynomial in some small region. If the response can be defined by a linear function of independent variables, then the approximating function is a first order model. A first order model with two independent variables can be expressed as;

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + e \dots \quad (3)$$

If there is a curvature in the response surface, then a higher degree polynomial should be used. The approximating function with 2 variables is called a second order model:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_{11} x_{11}^2 + \beta_{22} x_{22}^2 + \beta_{12}\, x_1 x_2 + e \dots \quad (4)$$

In general, all RSM problems use either one or the mixture of both of these models. In each model, the levels of each factor are independent of the levels of the other factors. In order to get the most efficient result in the approximation of polynomials, a proper design was used to collect data. Once the data are collected the method of least square is used to estimate the parameters in the polynomials. The response surface analysis is performed by using the fitted surface. The response surface designs are designs for fitting response surface.

The objective of studying RSM can be accomplished by: Understanding the topograghy of the response surface (local maximum, local minimum, ridge lines) and relating it to the practical significance of the warped surface and Finding the region where the optimal response occurs. The goal is to move rapidly and efficiently along a path to get to a maximum or a minimum response so that the response is optimized. When the constraints are on the design data, then the experimental design has to meet the requirements of these constraints. The second goal is to understand how the response changes in a given direction by adjusting the design variables.

III. RESULTS

3.1 Analysis of Waste Management System

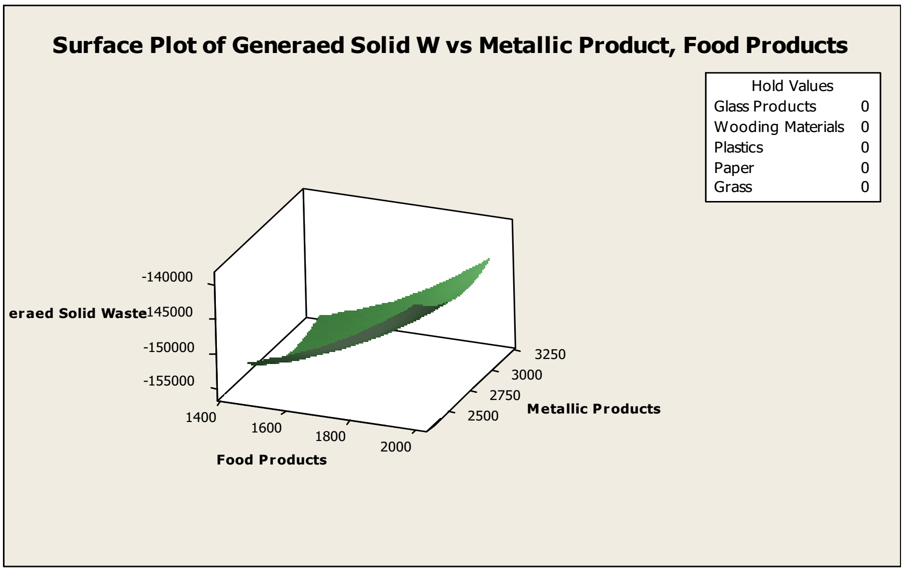

Figure 1: Surface Plot of Generated Solid Waste versus Metallic Product, Food Products

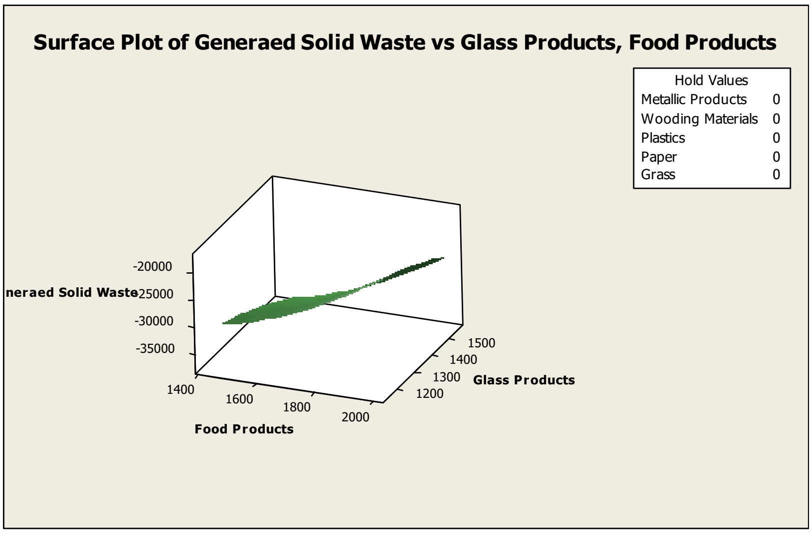

Figure 2: Surface Plot of Generated Solid Waste versus Glass Products, Food Products

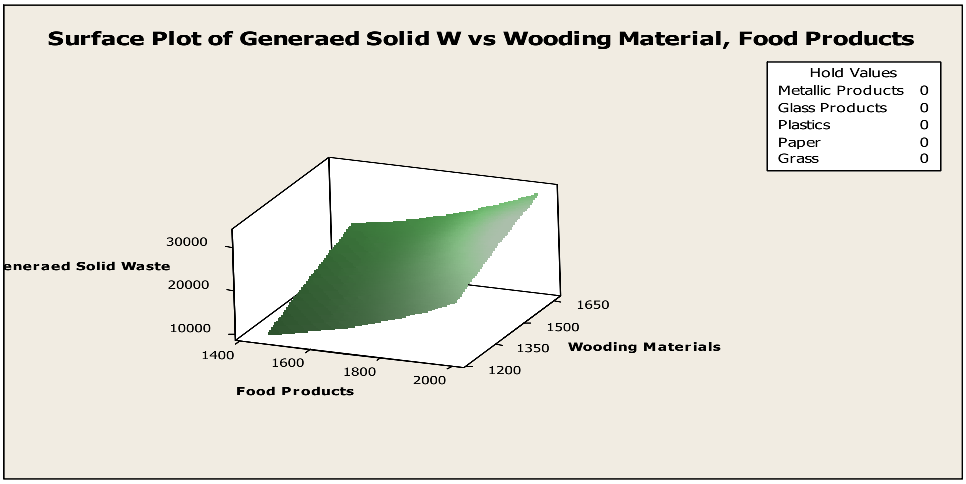

Figure 3: Surface Plot of Generated Solid Waste versus Wooding Material, Food Products

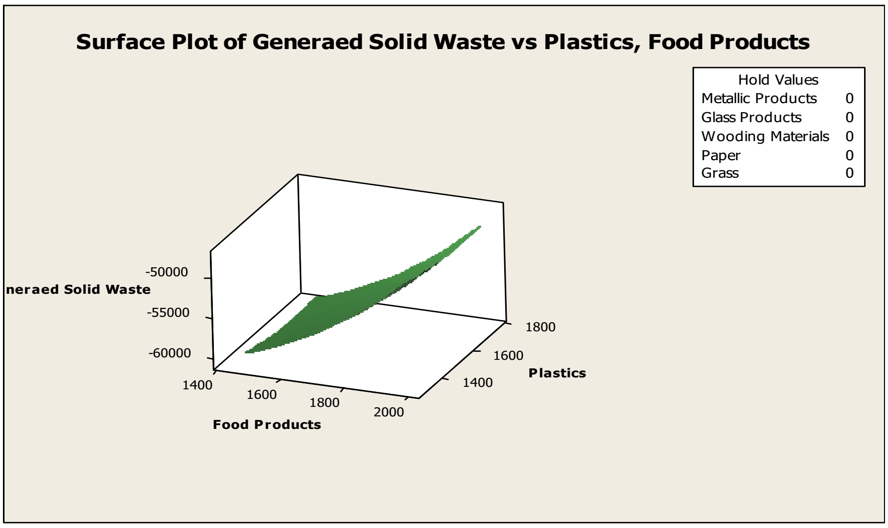

Figure 4: Surface Plot of Generated Solid Waste versus Plastics, Food Products

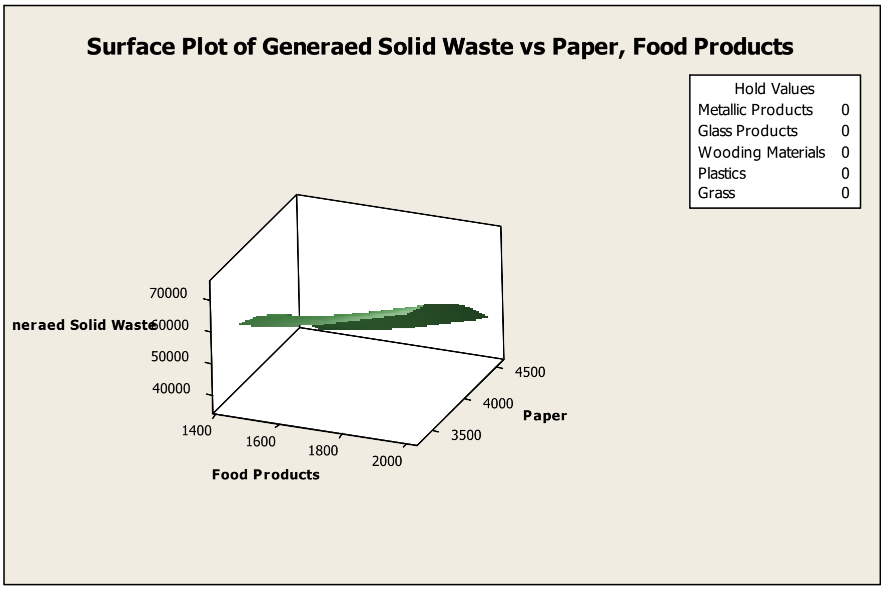

Figure 5: Surface Plot of Generated Solid Waste versus Paper, Food Products

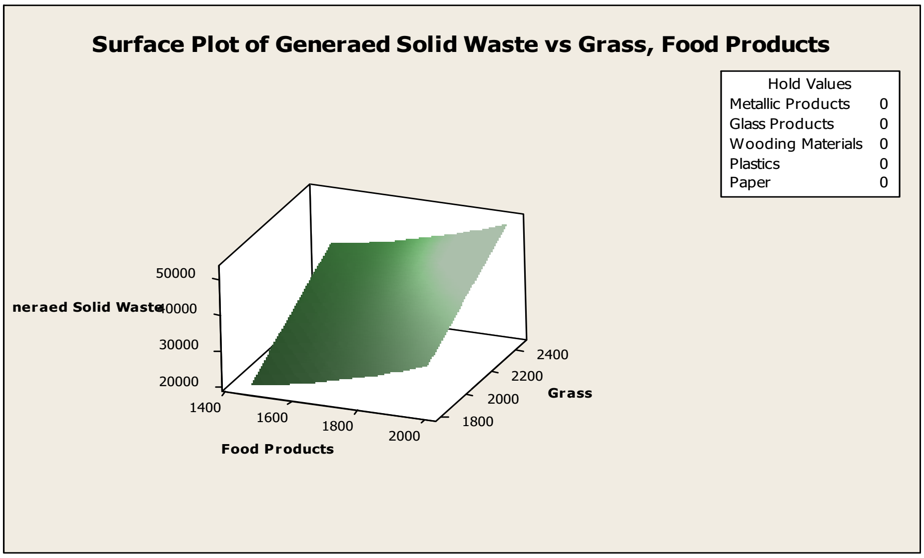

Figure 6: Surface Plot of Generated Solid Waste versus Grass, Food Products

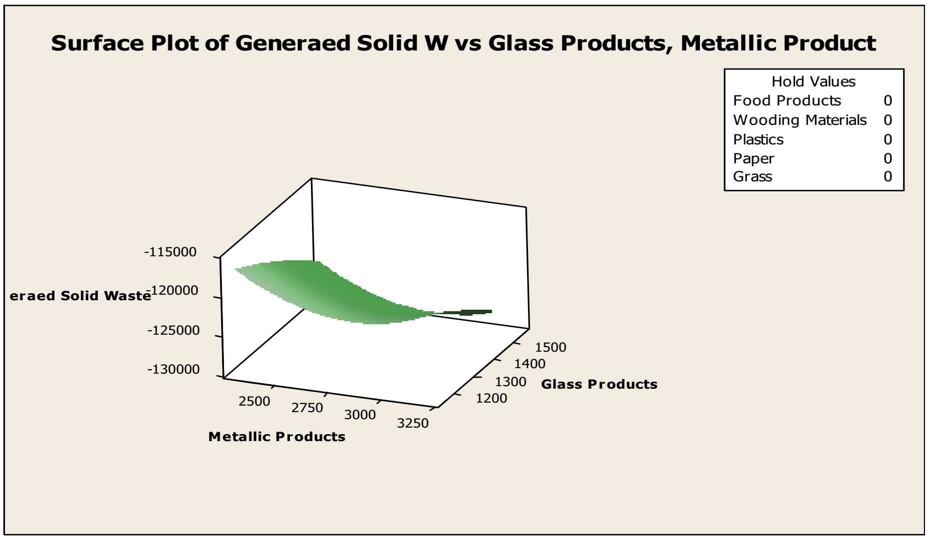

Figure 7: Surface Plot of Generated Solid Waste versus Glass Products, Metallic Product

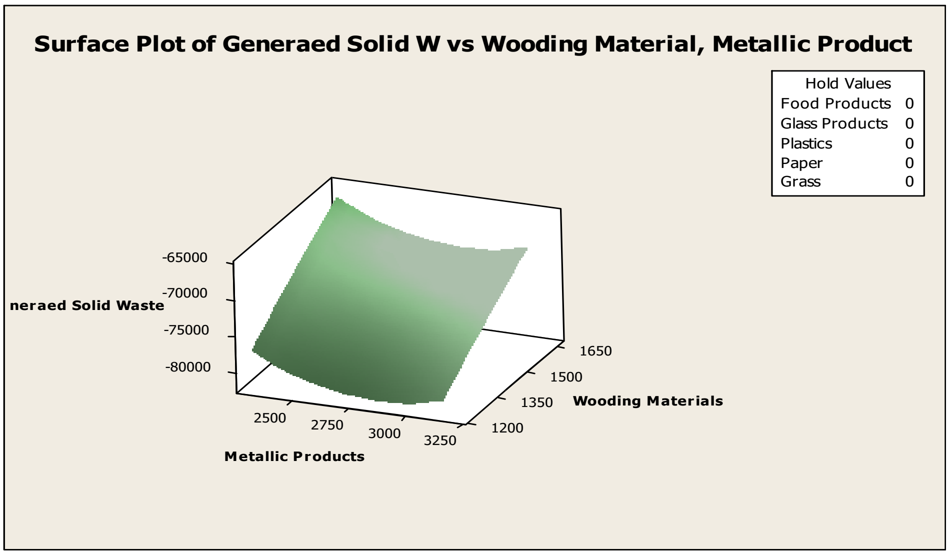

Figure 8: Surface Plot of Generated Solid Waste versus Wooding Material, Metallic Product

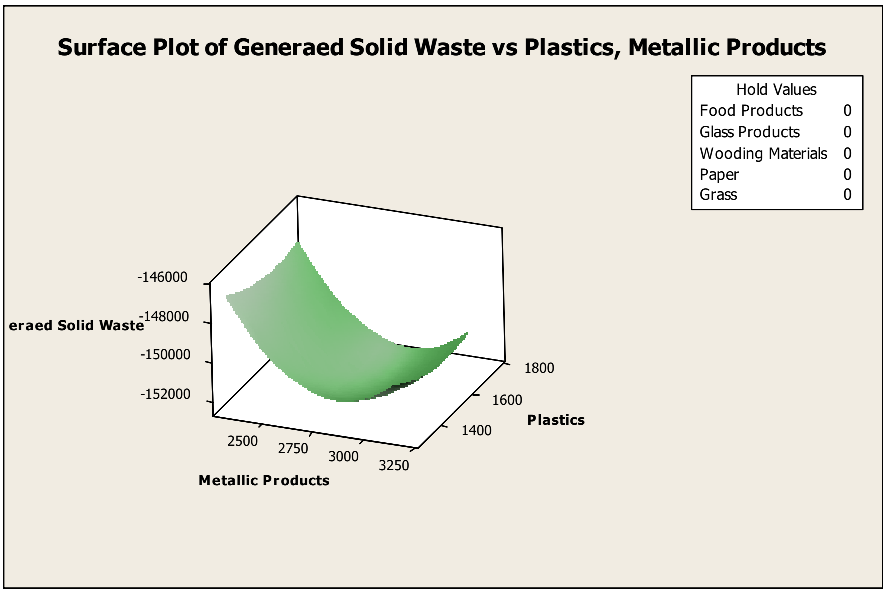

Figure 9: Surface Plot of Generated Solid Waste versus Plastics, Metallic Products

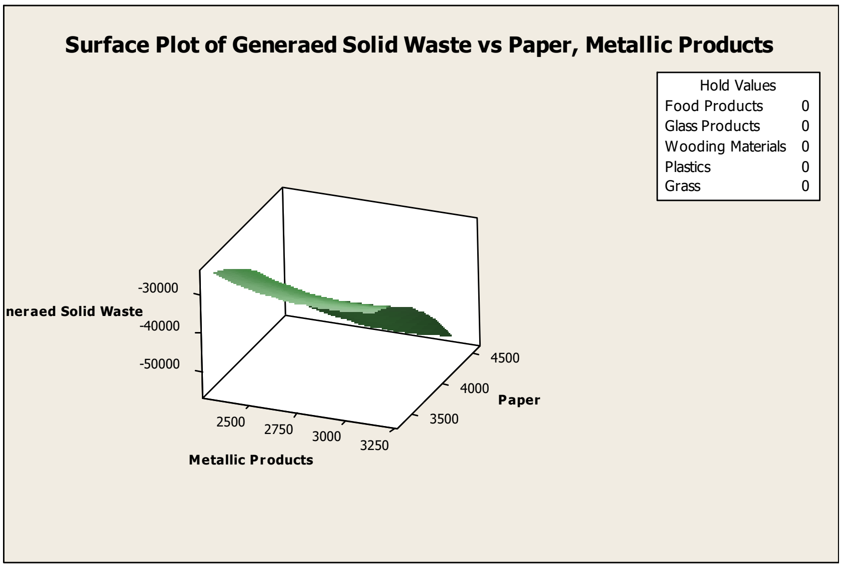

Figure 10: Surface Plot of Generated Solid Waste versus Paper, Metallic Products

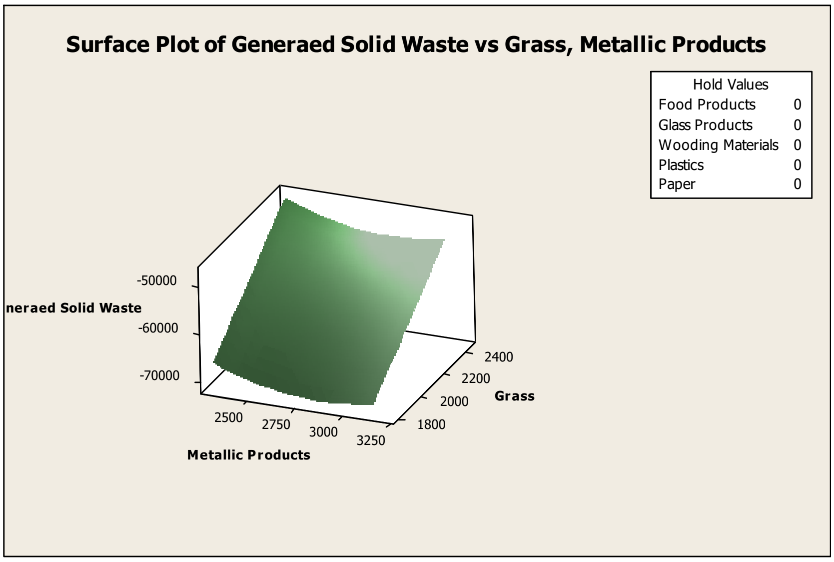

Figure 11: Surface Plot of Generated Solid Waste versus Grass, Metallic Products

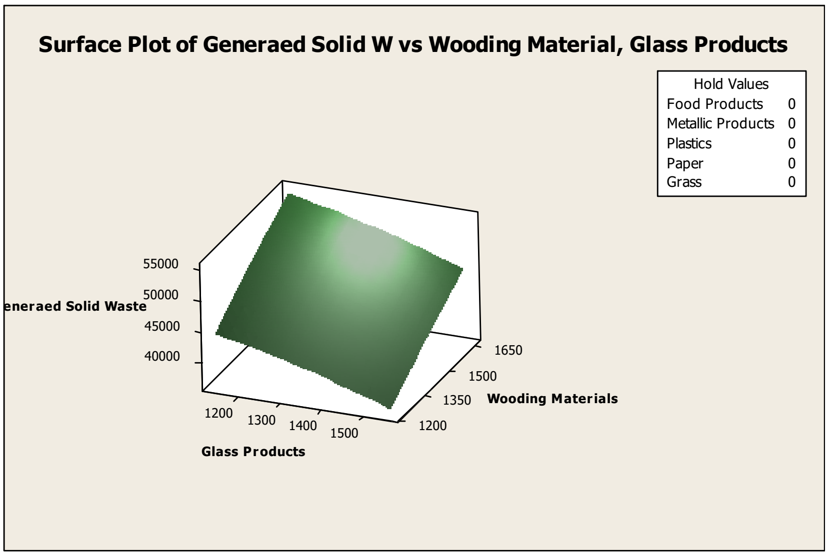

Figure 12: Surface Plot of Generated Solid Waste versus Wooding Material, Glass Products

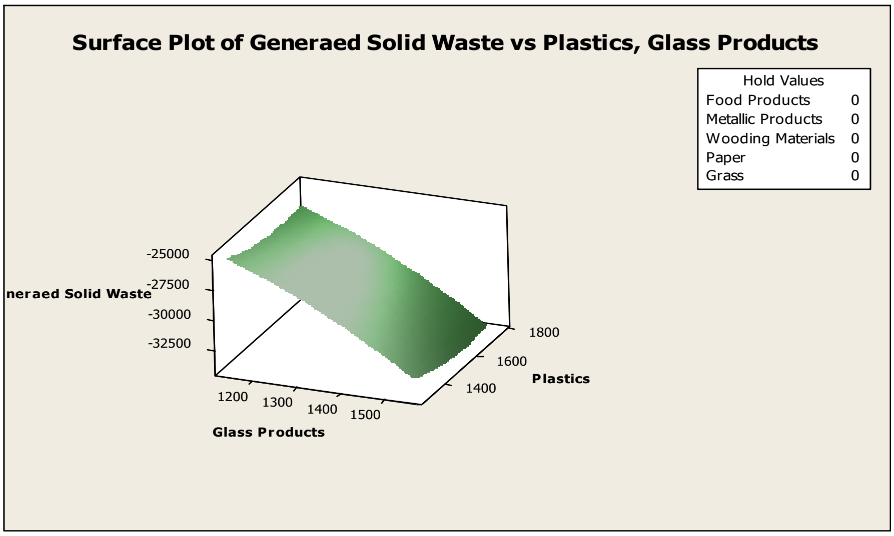

Figure 13: Surface Plot of Generated Solid Waste versus Plastics, Glass Products

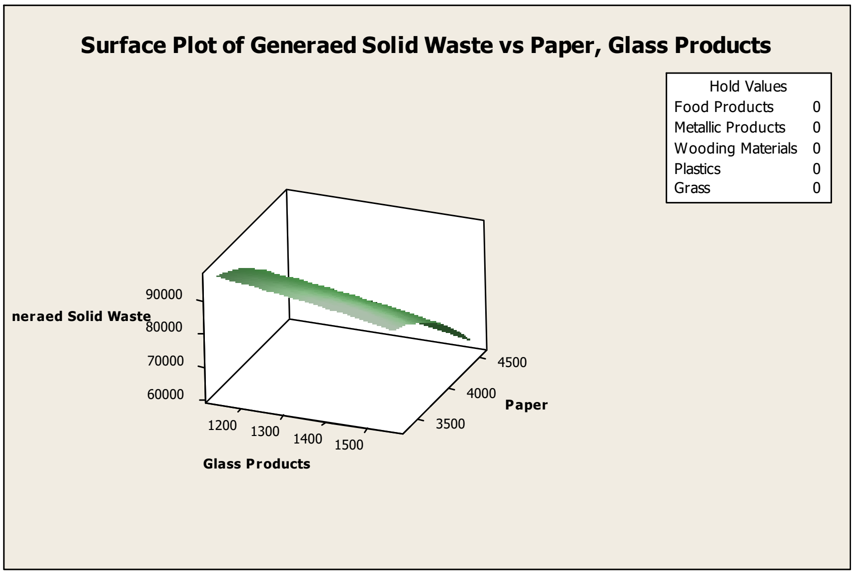

Figure 14: Surface Plot of Generated Solid Waste versus Paper, Glass Products

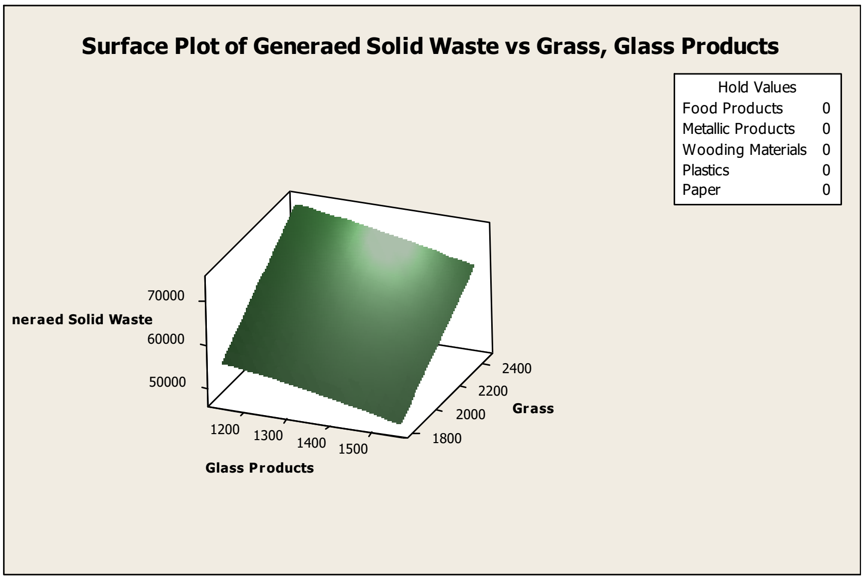

Figure 15: Surface Plot of Generated Solid Waste versus Grass, Glass Products

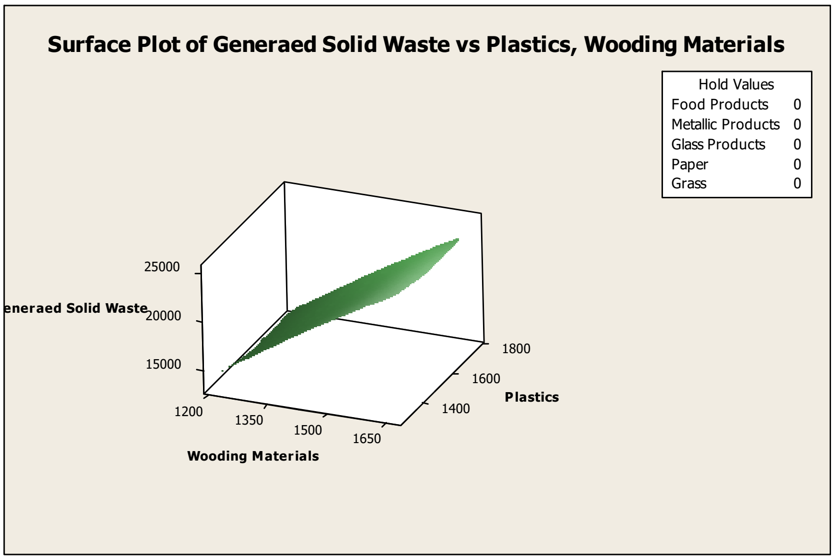

Figure 16: Surface Plot of Generated Solid Waste versus Plastics, Wooding Materials

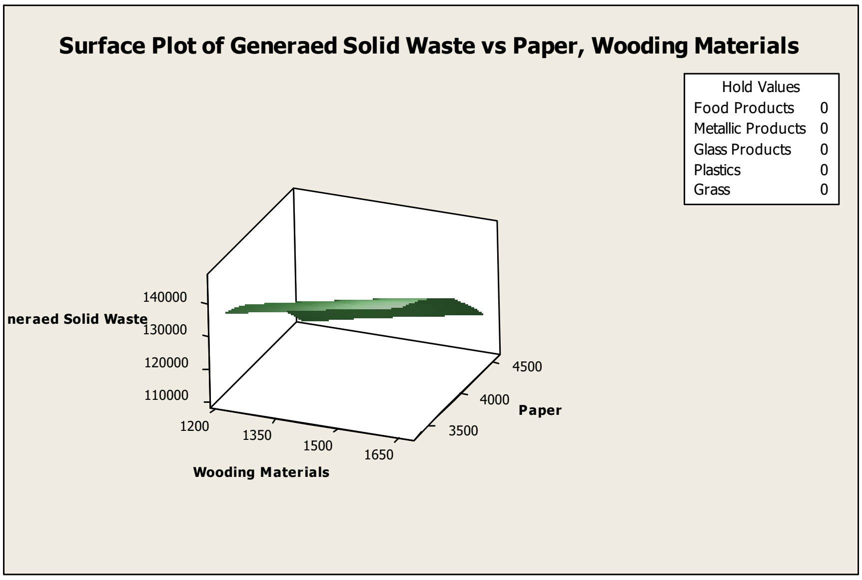

Figure 17: Surface Plot of Generated Solid Waste versus Paper, Wooding Materials

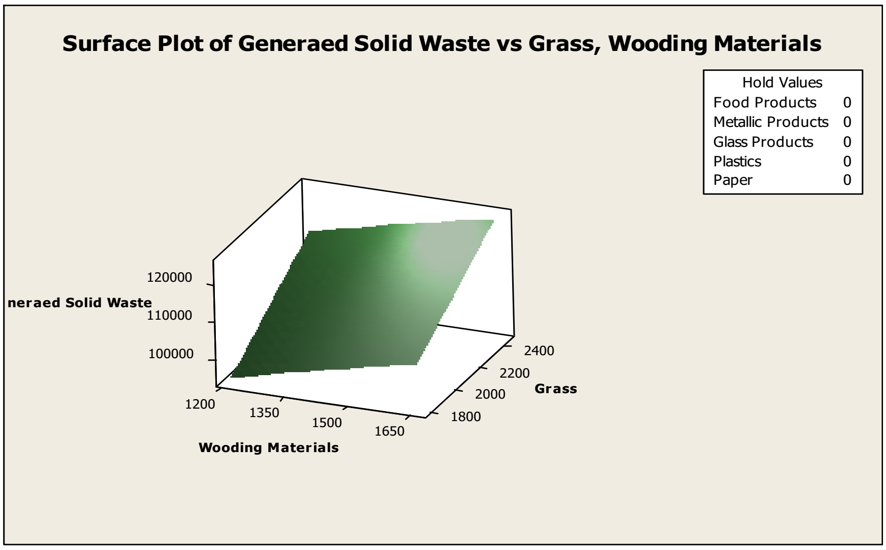

Figure 18: Surface Plot of Generated Solid Waste versus Grass, Wooding Materials

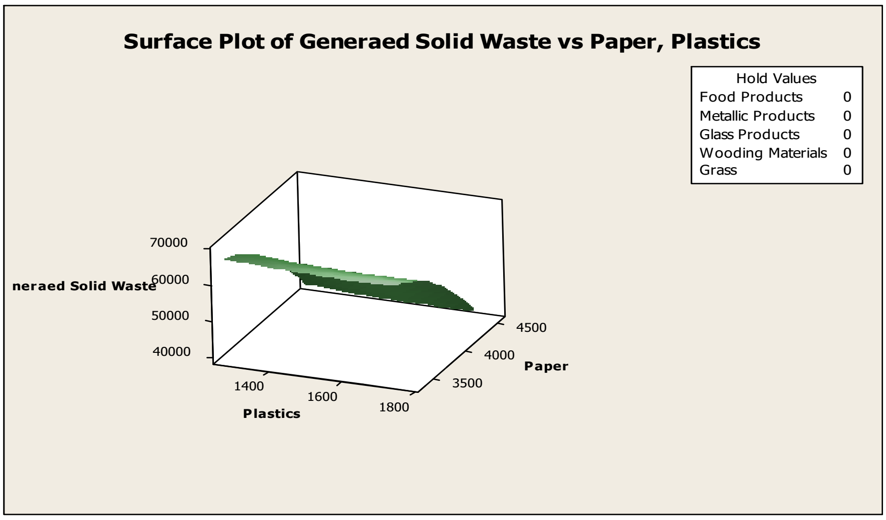

Figure 19: Surface Plot of Generated Solid Waste vs Paper, Plastics

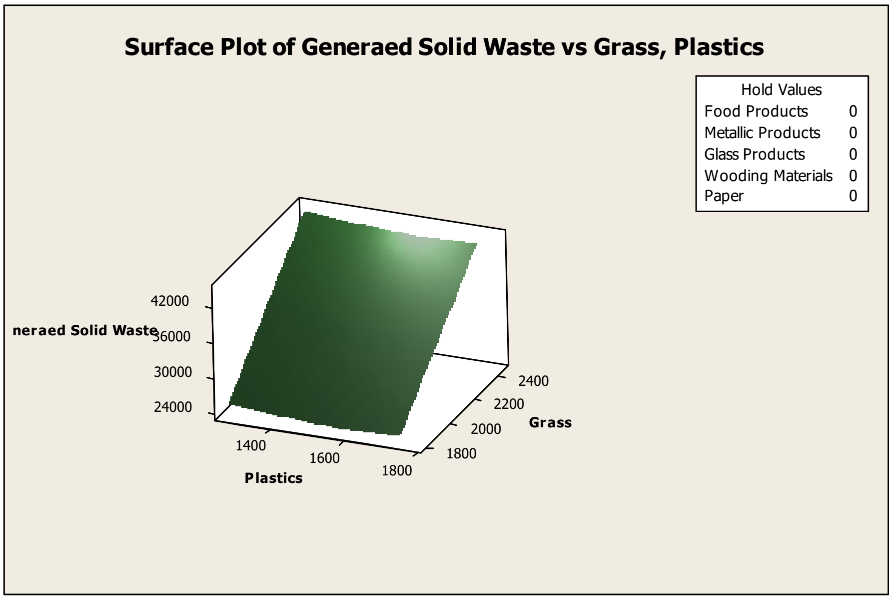

Figure 20: Surface Plot of Generated Solid Waste verse Grass, Plastics

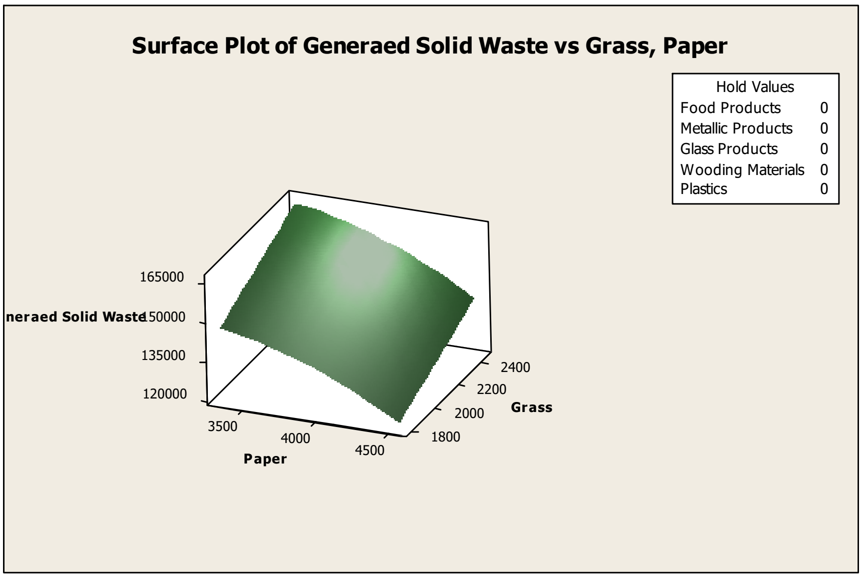

Figure 21: Surface Plot of Generated Solid Waste verse Grass, Paper

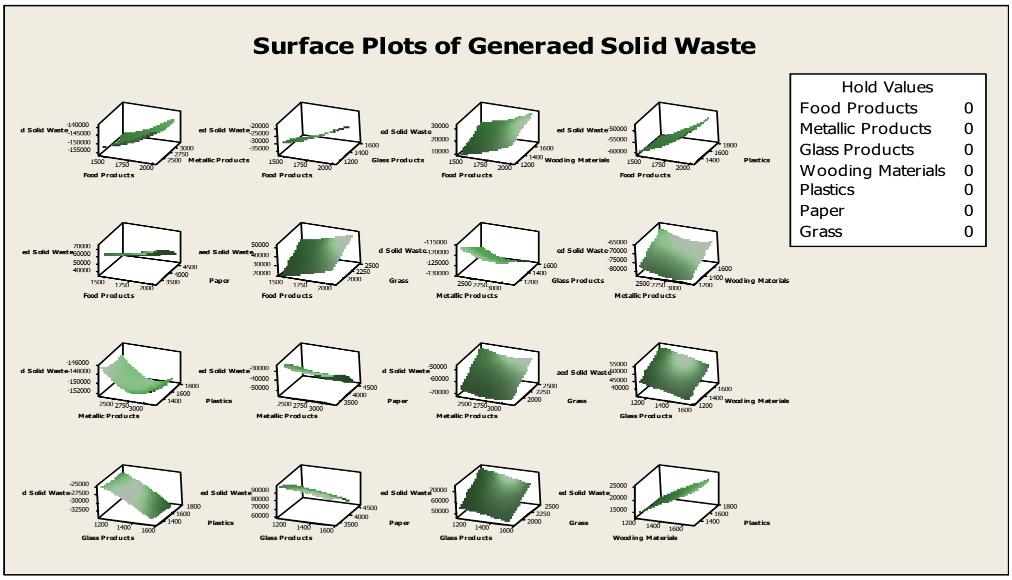

Figure 22: Surface Plots of Generated Solid Waste

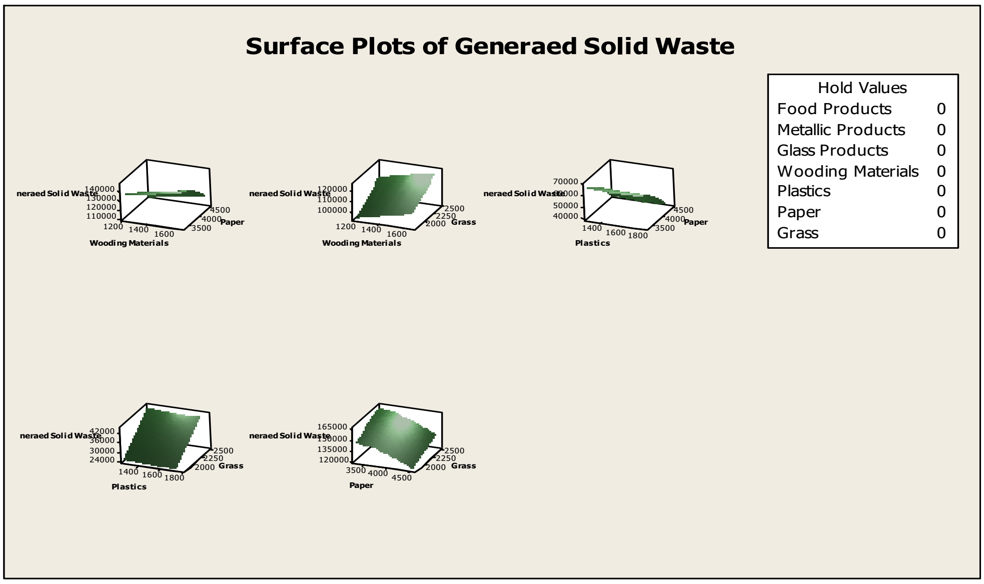

Figure 23: Surface Plots of Generated Solid Waste

Simplifying the Response Surface Regression Model;

Generated Solid Waste (in kg)= $\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 {X_1}^2 + \beta_9 {X_2}^2 + \beta_{10} {X_3}^2 + \beta_{11} {X_4}^2 + \beta_{12} {X_5}^2 + \beta_{13} {X_6}^2 + \beta_{14} {X_7}^2 + \beta_{15} X_1 X_2 + \beta_{16} X_1 X_3 + \beta_{17} X_1 X_4 + \beta_{18} X_1 X_5$

For purpose of analysis, let the following represent; Food Products= X_1, Metallic Products= X_2, Glass Products= X_3, Wooding Materials= X_4, Plastics= X_5, Paper= X_6, Grass= X_7, Constant= β_0, Coefficient = β.
Response Optimization

Parameters	Goal	Lower	Target	Upper	Weight	Import
Generated Solid	Maximum	1000	14000	14000	1	1

Table 3. Response Optimization Table for Local Solutions

S/N	FOOD PRODUCTS	METALLIC PRODUCTS	GLASS PRODUCTS	WOODING MATERIALS	PLASTIC S 10%	PAPER 26.6%	GRASS 14.3%
1	2001.2	2307.4	1556.5	1659.1	1744.6	3335.6	2445.9
2	1467.2	3147.1	1556.5	1659.1	1744.6	4549.7	2445.9
3	2001.2	2307.4	1556.5	1659.1	1744.6	4549.7	2445.9
4	1467.2	2307.4	1556.5	1659.1	1744.6	4549.7	2445.9
5	2001.2	3147.1	1141.1	1216.4	1279.1	4549.7	2445.9

6	1467.2	3147.1	1141.1	1216.4	1279.1	4549.7	2445.9
7	2001.2	2307.4	1141.1	1216.4	1279.1	4549.7	2445.9
8	1467.2	2307.4	1141.1	1216.4	1279.1	4549.7	2445.9
9	2001.2	3147.1	1556.5	1659.1	1744.6	3335.6	2445.9
10	1467.2	3147.1	1556.5	1659.1	1744.6	3335.6	2445.9
11	2001.2	2307.4	1556.5	1659.1	1744.6	3335.6	2445.9
12	1467.2	2307.4	1556.5	1659.1	1744.6	3335.6	2445.9
13	2001.2	3147.1	1141.1	1216.4	1279.1	3335.6	2445.9
14	1467.2	3147.1	1141.1	1216.4	1279.1	3335.6	2445.9
15	2001.2	2307.4	1141.1	1216.4	1279.1	3335.6	2445.9
16	1467.2	2307.4	1141.1	1216.4	1279.1	3335.6	2445.9
17	2001.2	3147.1	1556.5	1659.1	1744.6	3335.6	1793.2
18	2001.2	2307.4	1556.5	1659.1	1744.6	3335.6	1793.2
19	1734.2	2727.25	1348.8	1437.75	1511.85	3942.65	2119.55
20	2001.2	2307.4	1556.5	1659.10	1744.6	4549.70	1793.20
21	2001.2	2307.4	1141.1	1216.40	1279.1	3335.6	1793.20
22	2001.2	3147.1	1556.5	1659.10	1744.6	4549.70	1793.20
23	2001.2	3147.1	1141.1	1216.40	1279.1	3335.6	1793.20
24	1467.20	2307.4	1556.5	1659.10	1744.6	3335.6	1793.20
25	1467.20	3147.1	1556.5	1659.10	1744.6	3335.6	1793.20
26	2001.2	2307.4	1141.1	1216.40	1279.1	4549.70	1793.20
27	2001.2	3147.1	1141.1	1216.40	1279.1	4549.70	1793.20
28	1467.20	2307.40	1556.50	1659.10	1744.6	4549.70	1793.20
29	1467.20	2307.4	1141.1	1216.40	1279.1	3335.6	1793.20
30	1467.20	3147.1	1556.5	1659.10	1744.6	4549.70	1793.20
31	1467.20	3147.1	1141.1	1216.40	1279.1	3335.6	1793.20
32	1467.20	2307.4	1141.1	1216.40	1279.1	4549.70	1793.20
33	1467.20	3147.1	1141.1	1216.40	1279.1	4549.70	1793.20
34	2001.2	2307.4	1400.49	1537.32	1628.72	3335.6	2445.9
35	2001.2	3147.1	1400.61	1537.27	1628.65	3335.6	2445.9
36	2001.2	2307.4	1401.37	1537.01	1628.22	4549.64	2445.9
37	2001.2	3147.1	1401.50	1536.97	1628.15	4549.64	2445.9
38	1467.35	2307.4	1401.78	1536.87	1627.98	3335.6	2445.9
39	1467.34	3147.1	1401.91	1536.83	1627.91	3335.6	2445.9
40	2001.2	2307.4	1296.74	1338.52	1395.35	3335.6	2445.9
41	2001.2	3147.1	1296.61	1338.56	1395.42	3335.6	2445.9
42	1467.35	2307.4	1402.69	1536.57	1627.46	4549.63	2445.9
43	1467.35	3147.1	1402.82	1536.53	1627.38	4549.63	2445.9
44	2001.2	2307.4	1295.85	1338.82	1395.86	4549.63	2445.9
45	2001.2	3147.1	1295.72	1338.87	1395.93	4549.63	2445.9
46	1467.34	2307.4	1295.44	1338.96	1396.10	3335.6	2445.9
47	1467.34	3147.1	1295.30	1339.01	1396.17	3335.6	2445.9
48	2001.2	2307.4	1404.14	1536.11	1626.60	3335.6	1794.11
49	2001.2	3147.1	1404.27	1536.07	1626.52	3335.6	1794.11
50	1467.35	2307.4	1294.54	1339.27	1396.63	4549.63	2445.9
51	1467.35	3147.1	1294.39	1339.31	1396.71	4549.63	2445.9
52	2001.2	2307.4	1405.08	1535.83	1626.03	4549.68	1795.05
53	2001.2	3147.1	1405.22	1535.79	1625.94	4549.68	1795.98
54	1467.35	2307.4	1405.52	1535.71	1625.75	3335.6	1798.13
55	1467.35	3147.1	1405.66	1535.67	1625.66	3335.6	1799.15
56	2001.2	2307.4	1293.07	1339.72	1397.50	3335.6	1794.12
57	2001.2	3147.1	1292.93	1339.76	1397.59	3335.6	1794.12
58	1467.35	2307.4	1406.48	1535.45	1625.14	4549.68	1805.93
59	1467.35	3147.1	1406.62	1535.42	1625.05	4549.68	1807.21
60	2001.2	2307.4	1292.12	1340.00	1398.09	4549.68	1797.99
61	2001.2	3147.1	1291.98	1340.03	1398.18	4549.68	1799.01
62	1467.36	2307.4	1291.68	1340.12	1398.38	3335.6	1801.37
63	1467.36	3147.1	1291.54	1340.15	1398.47	3335.6	1802.50
64	1467.35	2307.4	1290.72	1340.36	1399.00	4549.68	1809.96
65	1467.36	3147.1	1290.58	1340.40	1399.10	4549.68	1811.37
66	2001.2	2307.4	1437.16	1485.60	1552.62	3335.6	2445.9
67	2001.2	3147.1	1437.05	1485.64	1552.74	3335.6	2445.9
68	2001.2	2307.4	1436.41	1485.85	1551.09	3342.78	2445.9
69	2001.2	3147.1	1436.30	1485.89	1551.18	3335.6	2445.9
70	2001.2	2307.4	1260.58	1390.05	1470.84	3335.6	2445.9
71	1467.31	2307.4	1436.06	1485.98	1553.87	3335.6	2445.9
72	2001.2	3147.1	1260.74	1389.98	1470.87	3335.6	2445.9
73	1467.32	3147.1	1435.95	1486.02	1554.01	3335.6	2445.9
74	2001.2	2307.4	1261.39	1389.76	1472.57	3335.6	2445.9
75	1467.35	2307.4	1433.86	1486.69	1552.58	4549.64	2445.9

76	2001.2	3147.1	1261.50	1389.72	1472.46	3335.6	2445.9
77	1467.32	3147.1	1433.72	1486.73	1552.66	4549.64	2445.9
78	1467.31	2307.4	1261.74	1389.64	1469.71	3335.6	2445.9
79	1467.40	3147.1	1261.85	1389.60	1469.57	3335.6	2445.9
80	1467.32	2307.4	1263.99	1388.92	1471.12	4549.64	2445.9
81	1467.34	3147.1	1264.13	1388.87	1471.04	4549.64	2445.9
82	2001.2	2307.4	1432.34	1487.22	1553.43	3335.6	1794.00
83	2001.2	3147.1	1432.20	1487.27	1553.51	3335.6	1794.00
84	2001.2	2307.4	1431.33	1487.58	1554.00	4549.68	1794.02
85	2001.2	3147.1	1431.18	1487.63	1554.08	4549.68	1794.02
86	2001.2	2307.4	1264.58	1388.94	1470.57	3335.6	1848.79
87	1467.35	2307.4	1430.85	1487.74	1554.27	3335.6	1794.02
88	2001.2	3147.1	1265.35	1388.72	1470.09	3335.6	1793.99
89	1467.34	3147.1	1430.70	1487.80	1554.35	3335.6	1794.02
90	2001.2	2307.4	1266.55	1388.02	1469.69	4549.68	1794.02
91	1467.33	2307.4	1429.79	1488.11	1554.86	4549.68	1794.04
92	2001.2	3147.1	1266.70	1387.97	1469.61	4549.68	1794.02
93	1467.35	3147.1	1429.63	1488.16	1554.95	4549.68	1794.04
94	1467.32	2307.4	1267.04	1387.85	1469.42	3335.6	1794.03
95	1467.37	3147.1	1267.19	1387.80	1469.34	3335.6	1794.03
96	1467.37	2307.4	1268.11	1387.49	1468.82	4549.68	1794.04
97	1467.43	3147.1	1268.26	1387.44	1468.73	4549.68	1794.04
98	2001.2	2307.4	1246.71	1374.92	1455.08	3335.6	2445.9
99	2001.2	3147.1	1246.51	1374.92	1454.69	3335.6	2445.9
100	2001.2	2307.4	1247.25	1374.47	1455.03	4016.46	2445.9
101	2001.2	3147.1	1247.38	1374.40	1454.98	4007.85	2445.9
102	1467.35	2307.4	1247.10	1374.52	1452.58	3335.6	2445.9
103	1467.26	3147.1	1247.80	1374.17	1454.11	3335.6	2445.9
104	2001.2	2307.4	1451.04	1500.51	1568.71	3335.6	2445.9
105	2001.2	3147.1	1451.33	1500.55	1568.96	3335.6	2445.9
106	1467.27	2307.4	1248.58	1373.75	1454.54	3929.28	2445.9
107	1467.27	3147.1	1248.96	1373.61	1454.33	4344.97	2445.9
108	2001.2	2307.4	1450.59	1501.00	1568.64	4036.67	2445.9
109	2001.2	3147.1	1450.46	1501.07	1568.69	4028.01	2445.9
110	1467.33	2307.4	1450.18	1501.23	1569.45	3335.6	2445.9
111	1467.26	3147.1	1450.06	1501.31	1569.51	3335.6	2445.9
112	2001.2	2307.4	1250.05	1373.05	1453.90	3335.6	1830.89
113	2001.2	3147.1	1250.45	1372.90	1453.68	3335.6	1807.46
114	1467.26	2307.4	1449.29	1501.73	1569.11	3949.62	2445.9
115	1467.29	3147.1	1449.15	1501.80	1569.17	3940.97	2445.9
116	2001.2	2307.4	1251.52	1372.43	1453.18	4549.69	1793.67
117	2001.2	3147.1	1251.73	1372.33	1453.09	4549.69	1793.67
118	1467.28	2307.4	1251.45	1372.48	1453.19	3335.6	1840.47
119	1467.26	3147.1	1251.59	1372.43	1453.11	3335.6	1841.58
120	2001.2	2307.4	1447.83	1502.45	1569.73	3335.6	1829.01
121	2001.2	3147.1	1447.05	1502.77	1570.13	3335.6	1793.66
122	1467.27	2307.4	1252.42	1372.15	1452.64	4549.69	1848.89
123	1467.28	3147.1	1252.56	1372.10	1452.56	4549.69	1850.27
124	2001.2	2307.4	1446.54	1502.99	1570.37	4549.69	1804.81
125	2001.2	3147.1	1446.74	1502.92	1570.26	4549.69	1835.88
126	1467.28	2307.4	1446.43	1503.04	1570.42	3335.6	1838.05
127	1467.27	3147.1	1446.29	1503.09	1570.49	3335.6	1839.09
128	1467.27	2307.4	1445.47	1503.39	1570.95	4549.69	1845.91
129	1467.27	3147.1	1445.32	1503.44	1571.03	4549.69	1847.20
130	2001.2	2307.4	1556.5	1659.1	1774.6	3335.6	2445.9

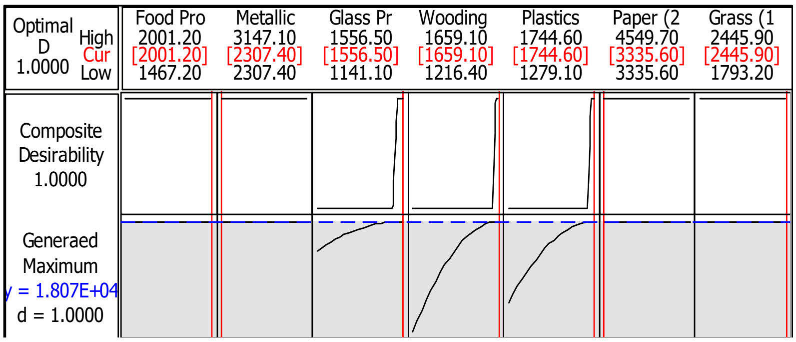

Figure 24. Optimization Plot

After several variations of local solutions, a global solution is developed. The current variables (indicated by the red lines) are the highest solid waste we can expect. The optimal structure succeeded in the determination of the highest and the lowest solid waste we can expect. The optimal desirability is an indication on how favourable the current variable will favour the solid waste generation model. We could assert the fact that by purpose of analysis, we found out that;

Optimal desirability = composite desirability = joined desirability

Where d = desirability = 1.0000.

The desirability is the maximum solid waste that can be generated on any month. A clear appreciation of what we have above will indicate three kinds of lines with different colours that play a great significance on what the model entails. The black line indicates different boundaries of decision making at the maximal and minimal points in the model. The red line indicates the current variables. An observation will show that depending on how far (right wards) the current variable is from the boundary lines will determine the optimal point for the several solid waste materials under assessment i.e the more right wards is favourable and the more left ward is not favourable, in other words, close to the minimum or maximum.

IV. CONCLUSION

The contribution made by reason of this report is that we have known the maximum waste we can generate and the number of waste handling equipment i.e disposal vehicles the agency can send for disposal and handling. It also accounts for extra addition of waste handling equipments. Continuous improvement is carried out after the optimization has been done and what we can do to improve the optimal. This continous improvement is done by using the shewhart quality control chart and subsequent quality assurance. There is also a neccesity of mass customisation for product improvement.

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