Hypothetical Assessment of Solid Waste Planning and Management in Enugu Metropolis

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Abstract- ***The study carried out a hypothetical assessment of solid waste planning and management in Enugu metropolis. The objective is to assess the issues of adequate disposal vehicles to efficient disposal service delivery, changes in government policies to its effect on solid waste planning and management, and whether lack of public awareness on proper environmental education is responsible for poor sanitation in Enugu. The methodology involve a purposive sampling techniques based on three (3) selected local government areas that made up the Enugu metropolis. A sample size of three hundred (300) respondents was selected from population of 722664 based on 2006 census figure for the three local government areas that made up Enugu metropolis. The five point likert scale was used to assess the opinion of respondents based on the three objectives set out for the assessment. The result of the analysis shows that inadequate disposal vehicles, frequent changes in solid waste planning and management policy, and lack of public awareness on proper environmental education for inefficient solid waste management in the area. The work recommends that integrated solid waste management of waste generated, source reduction of solid waste through effective legislation, procurement of more compression vehicles to ease collection and disposal, and proper education on efficient waste management for the economic benefits of the inhabitants will improve the general sanitation of Enugu metropolis.***

Indexed Terms- ***Solid waste, Integrated, Management, Sustainable, Environmental, Planning.***

I. INTRODUCTION

Management of solid waste and associated wastes are paramount to achieving a healthy and sustainable environmental sources of solid wastes which are from dead wild animal, leaves from trees arising from transpiration effects, house refuse, garbage, rubbish, street refuse, ashes, demolition debris, construction refuse, junk automobile, old furniture, and wastes from slaughter houses, schools, manufacturing plants, hospitals, agricultural, markets, etc.

Nwofe (2017) opined that management of waste requires careful approach and planning through the method of collection, storage, transportation, processing, treatment and its final disposal so that it will not lead to negative consequences like environmental degradation, health issues and emission of harmful gases into the atmosphere. It is difficult to achieve in practice sustainable waste management systems in most developing countries either as a result of poverty, illiteracy, lack of awareness, government insensitivity, lack of waste management data, lack of credible policy on sustainable waste management, lack of advanced technological skills, lack of trained manpower in waste management, and other associated issues. People are not aware of the need to preserve their environment through careful management of waste or by utilizing more civilized approaches to other human activities that could lead to a safe and sustainable environment. The management of the quantity of Municipal Solid Waste (MSW), which is an indicator of an urban lifestyle, has been a nagging problem all over the Enugu community as a result of increase in population, rise in the living standard, etc. These have increased Solid waste generation rate in Enugu and have made solid waste composition more complex and heterogeneous. This problem is worse in public places such as Schools, Markets, Mechanics sites etc. in which Municipal Solid Waste Management is highly neglected (Chime, 2009).

Agbaeze, Onwuka&Agbo (2014) stated that, in many areas dumpsites are not adequate, indiscriminate and unhygienic waste dumps existed, and solid waste collection in some dumpsites were not regular due to inadequate disposal vehicles, plant and machinery to

tackle the waste management. Public enlightenment was more on payments of Enugu State Waste Management Authority (ESWAMA) sanitation fees than protection of environment and human lives, population control measures and sustainable environmental hygiene measures. There is one disposal and no data base for solid waste characteristics and generation. Some used vehicle tyres and construction wastes are packed on some dumpsites along the road sides for years with progressive increase in quantity without hope on when they will be collected and disposed. There are policy changes on waste management with change in government administration of Enugu state that hamper the development of a comprehensive master plan for solid waste management in Enugu. Inadequate capacity of waste handlers to have access to required equipment results to low collection efficiency.

Spontaneous increase in volume and composition of solid waste as a result of urbanization and industrialization is growing problem in Enugu. Solid waste survey and characterization are special tools in bringing to light the generation rate and composition of solid waste (Sincero and Sincere, 2006). Management methods such as reduction, recovery, recycling, and reuse are very important tools for creating wealth from waste. Oyinlola (1999) stated that it is not essentially every composition of solid waste that can be further utilized as resources for wealth creation. Therefore, solid waste components in Enugu must be well classified to make the compositions readily differentiable to intended stakeholders.

Majority of the inhabitants in the area do not know what is expected of them as regards solid waste management. Out of the need to get rid of the solid waste from their domains and relieve themselves of its nuisance, the inhabitants dump the refuse behind their houses and indiscriminately in nearby open dumps. Some of the solid waste is dumped in the water channels, gullies, river side and any available spaces. In most cases, the refuse accumulates, encroaching on roads and streets. Open burning has become the practice of reducing the volume of solid waste in some location leading to air pollution in Enugu. In fact, solid waste disposal/management is said to be the highest environmental problem because at the moment, there is no effective existing solid waste management/disposal technology for the area.

1.1 Aim and Objectives

The aim of the study was to carry out hypothetical assessment of solid waste planning and management in Enugu metropolis with the objectives of

i. To educate the public on the health implication of ineffective waste disposal
ii. To reduce the volume of waste in circulation by educating the public on the better way of managing waste
iii. Create awareness on the need to provide more compression vehicles in solid waste collection and disposal.
iv. Adequate or proper legislation to back up the handling and source reduction of solid waste management in Enugu,

1.2 Hypothesis of the Study

Hypothesis 1

Ho/Ha:

The Enugu State Waste Management Authority (ESWAMA) have or do not have adequate or enough disposal vehicles which affect their inability for efficient service delivery.

Hypothesis 2

Ho/Ha:

Changes in government policies do or do not affect solid waste planning and management in Enugu metropolis.

Hypothesis 3

Ho/Ha:

Lack of public awareness on proper environmental education is or is not responsible for poor sanitation in Enugu metropolis.

II. LITERATURE REVIEW

The scope of solid waste management includes planning, administrative, financial, engineering, and legal functions. Solutions might include complex inter-disciplinary relations among fields, such as public health, city and regional planning, political science, geography, sociology, economics, communication and conservation, demography, engineering, and material sciences (Atuegbu, 2007).There is a distinction in Solid waste management practices for residential and industrial producers, for urban and rural areas, and for developed and developing nations. The job of Local government authorities is administration of non-hazardous waste in metropolitan areas. However, the

management of hazardous waste materials is typically the responsibility of those who generate it, as subject to local, national, and even international authorities (Pichtel, 2005).

Amalu and Ajake (2014) stated that the city of Enugu in Nigeria is confronted with urban solid waste management which is considered to be one of the most serious environmental problems. The economic recession in Nigeria which has resulted in high levels of unemployment is estimated at 80 percent of the population (NBS, 2020). This has led to the growth of home industries in Enugu and around the city centre and high density suburbs such as Abakpa, Emene, Amaechi Awkunanaw, Enugu Ngwo etc. Solid waste generation in these suburbs is very high given their spatial extent and population. This is putting much pressure on the waste disposal system in place and as a result a lot of waste is left uncollected creating a health hazard.

The available sites identification and methods of waste disposal is one of the major challenges facing many urban authorities today. This is exacerbated by the NIMBY (not in my backyard) syndrome whereby no one wants the dumpsite in his or her backyard, but all the same want the waste removed and dumped somewhere else (Nzeadibe and Anyadike, 2012). Landfills represent the dominant alternative for municipal solid waste disposal in most parts of the world. In many emerging economies, municipal solid waste disposal by sanitary landfill is regarded as the most cost-effective method to protect human health and the environment. In South Africa, almost all collected municipal solid waste is land-filled. Similarly, over 80% of municipal solid waste generated in China is landfilled. Landfilling provides the cheapest and most convenient method of waste disposal today when operated efficiently.

III. PROPERTIES AND COMPOSITION OF SOLID WASTE

(a) Physical Properties

These include information of individual components making up the waste, particle size analysis, moisture content and density of the solid waste.

(i) Waste composition (components)

This refers to the individual components such as food waste, glass, plastics etc. that typically make up municipal solid waste and their range of distribution. Compositional differences are due to economic, cultural, climatic and geographical differences among cities and regions (Rao, 2006).

(ii) Particle size distribution

This involves the analysis of the components that typically make up the municipal solid waste. It could be either by measuring the longest dimension or the ability of pass through a sieve. Particles size distribution of refuse affects two issues in solid waste management planning. The need for compaction of soil covers in landfill and for size reduction by shredding, prior to compositing, biogas generation or incineration (Ramachandra, 2006).

(iii) Moisture Contents

The moisture content could be found using either the wet mass method of measurement or the dry-mass method and it is expressed in percentage. Moisture content is often not reported for the compositional samples taken.

(iv) Waste density

Waste density information is of particular importance to the planner. It varies with geographical location, season of the year and length of time in storage. Waste density information coupled with waste generation rate expressed by weight allows the load capacity (in volume) of the collection equipment to be estimated. Where the bulk volume is high, the density tends to be low and vice-versa.

(b) Chemical Properties

Information on chemical composition of municipal solid waste is important in evaluating alternative processing and energy options. It is good to take note of the following properties.

(i) Proximate analysis which include; moisture loss at 150°C for 1 hour, volatile matter which results in additional moisture loss and ignition at 950°C, ash residue after burning and fixed carbon.

ii. Determination of fusing point of ash

iii. Ultimate analysis - percentage of carbon, hydrogen, oxygen, nitrate, sulphur and ash.

iv. Heating (energy) value.

(c) Biological composition

This refers simply to the effect of both micro and macro organisms present in the waste and the effects of dehydro-oxidation on the waste. This helps in the

treatment of waste against the contamination of ground water.

IV. STUDY AREA AND METHODOLOGY

a. Study Area:

The following, plate 1 to 4 shows some of the dumpsites in Enugu metropolis.

Plate 1: Dumpsite at Ogbete Crescent Enugu.

Plate 2: Dumpsite at Coal Camp Enugu.

Plate 3:: Dumpsite at Bishop Ayogu / Robinson street Uwani Enugu.

Plate 4: Dumpsite opposite University of Nigeria Enugu campus

3.2 Methodology of Analysis

For this study a purposive sampling techniques was adopted using survey design method to select three (3) local government areas out of the 17 local government areas (LGAs) in Enugu state. The 3 selected LGAs were selected based on level of urbanization. They are Enugu East, Enugu North and Enugu South local governmentareas. A sample size of 300 respondents was determined from the population of 722664 drawn from both male and female population of the three LGAs as published by National Population Commission (NPC Census, 2006). The analysis of methodology was focused to ascertain from respondents the issues on:

i. Inadequate environmental policies and legislation
ii. Low level of environmental awareness and public enlightenments
iii. Poor funding because of the capital intensive nature of waste management
iv. Inadequate technology and inadequate facilities
v. Polities and corruption
vi. Unplanned developments and population increase.

3.3 Method of Data Analysis for Questionnaire Responses

In analyzing the data, the mean scores were used to answer the research questions which guided the study. A cut-off mean score of 3.25 and above was regarded as constituting a problem, while a mean score of less than 3.25 was regarded as not constituting a problem. In calculating the mean, the five point rating scale was given the following values;

(i) Strongly Agree (SA) 5 values
(ii) Agree (AG) 4 values

(iii) Undecided (UD) 3 values
(iv) Disagree (DA) 2 values
(v) Strongly Disagree (SD) 1 value.

The formula for the mean, $\bar{X} = \frac{\Sigma fx}{N}$ were used to calculate the average score, where
Σ = summation or sum of
f = frequency of observation
X = individual
N = number of sample

Pearson Product Moment Correlation Coefficient (PMCC) denoted by (r) was used to determine the strength of the correlation between the two variables X which represents responses from sample of sixty (60) respondents selected from the six sample locations and Y which represents the responses from sample of forty (40) respondents from workers of Enugu State Waste Management Authority (ESWAMA). The PMCC or r has values $-1 \leq r \leq +1$. As the value approaches +1, the stronger the correlation. The simple linear correlation have positive correlation shows that both x and y increase or decrease together while negative correlation is when X increases as Y decreases i.e. change in opposite direction. The value of r = 1 shows a perfect positive correlation.

Decision Rule: the mean score of above 3.25 from the respondents indicates that the problem exists from the responses while below 3.25 shows the problems are regarded as disagreed.

The results obtained from questionnaire no. 1 were presented as follows.

V. RESULTS AND DISCUSSION

Hypothesis One: The Enugu State Waste Management Authority (ESWAMA) has inadequate disposal vehicles and this result in their inability for efficient service delivery.

Table 1: The Agency has not provided enough waste disposal vehicles for efficient delivery.

S/N	Options	Frequency	Ratio Values	Percentage (%)
1	Strongly agree	117	0.39	39.0%
2	Agree	72	0.24	24.0
3	Undecided	54	0.18	18.0
4	Disagree	42	0.14	14.0
5	Strongly disagree	15	0.05	5.0
	Total	300		100

Source: Field survey report 2019.

Formula for 'Z 'test statistics

$$Z = \frac{PQ}{\sqrt{nPQ}} \qquad (4.1)$$

Where,
P = proportion of positive response (Strongly Agree, and Agree).
Q = proportion of the negative responses (Undecided, Disagree and stronglydisagree)
n= sample size
b= level of significance is 0.05
c= critical value at 0.05 level of significance, the "Z" score take value between -1.96 to +1.96.
d= Decision Rule: If the computed "Z" value is between -1.96 to 1.96 of our critical value, we reject the null hypothesis.
e= computation of the "Z" value
From the Table 4.5 above, p=189 (63%), Q=111 (37%) n= 300.
P= 39% +24% = 63 %, Q = 18% + 14 % + 5% = 37%

$$Z = \frac{0.63\ x\ 0.37}{\sqrt{300x0.63\ x\ 0.37}} = \frac{0.2331}{\sqrt{8.3624}} = 0.02787$$

Decision
Since our computed "Z" value of 0.0279 falls between -1.96 and 1.96 of our critical value, we reject the null hypothesis. Since we rejected the Null hypothesis we therefore accept the Alternative hypothesis which states that the "Enugu State Waste Management Authority (ESWAMA) have inadequate disposable vehicles which affects their inability for efficient service delivery".

A further test can be used to determine the relationship between the ratings and number of responses that ESWAMA has inadequate disposal vehicles which results in their inability for efficient service delivery

using the Pearman (r) Product Moment Coefficient of Correlation.

Table 2: Rating and number of responses that ESWAMA have inadequate disposal vehicles for efficient service delivery.

S/N	Ratings (X)	Frequency of responses (Y)	XY	X^2	Y^2
1	5	117	585	25	13689
2	4	72	288	16	5184
3	3	54	162	9	2916
4	2	42	84	4	1764
5	1	15	15	1	225
Total	15	300	1134	55	23778

$$\bar{X} = \frac{15}{5} = 3, \qquad \bar{Y} = \frac{300}{5} = 60$$

Using the formula,

$$Pearson\ (r) = \frac{n\sum XY - \sum X . \sum Y}{\sqrt{[n\sum X^2 - (\sum X)^2][n\sum Y^2 - (\sum Y)^2]}}$$

Or,

$$Pearson\ (r) = \frac{\sum XY - n\bar{X}\bar{Y}}{\sqrt{[\sum X^2 - n\bar{X}^2][\sum Y^2 - (\bar{Y}^2)]}}$$

where n, is the total number of ratings

X is the ratings

Y is the number or frequency of responses for various rating

r is the coefficient of correlation

Substituting the values generated in Table 4.6, we have

$$r = \frac{5(1134) - (15)(300)}{\sqrt{[5(55) - (15)^2][5(23778) - (300)^2]}}$$

$$r = \frac{5670 - 4500}{\sqrt{50 \times 28890}} = \frac{1170}{\sqrt{1444500}} = \frac{1170}{1201.8}$$

$$= 0.9735$$

= 0.9735

Or

$$r = \frac{1134 - 5(3)(60)}{\sqrt{[55 - 5(3)^2][23778 - 5(60)^2]}} = \frac{234}{\sqrt{57780}}$$

$$= 0.9735$$

This result of coefficient of correlation (r) = 0.9735 shows a very strong positive linear relationship between the result of the ratings and number of responses that ESWAMA has inadequate disposal vehicles which affects their inability for efficient service delivery.

Using another measure, the coefficient of determination which is the square of coefficient of correlation, we have

$r^2 = (0.9735)^2 = 0.9477$ or 94.8 percent

The computed coefficient of determination (r^2 = 0.948) shows that 94.8% of the total variation in the number of frequency of responses is explained by the variations in the ratings for the questionnaire response while 5.2% of the variations in frequency of responses is attributable to the influence of other factors not explained by the regression function. This is referred to as coefficient of non determination$(1 - r^2) = 0.052$.

Hypothesis Two

Changes in Government Policies affect Solid Waste Planning and Management in Enugu Metropolis.

Table 3: Distribution of Respondents on Changes in Government policies.

S/N	Options	Frequency	Ratio Values	Percentage (%)
1	Strongly agree	112	0.373	37.3
2	Agree	76	0.253	25.3
3	Undecided	24	0.08	8.0
4	Disagree	63	0.210	21.0
5	Strongly disagree	25	0.084	8.4
	Total	300	1.00	100.0

Source: Field Survey Report (2019).

Formula for 'Z 'test statistics,

P = 0.373 + 0.253 = 0.626

Q = 0.08 + 0.210 + 0.084 = 0.374

$$Z = \frac{PQ}{\sqrt{nPQ}}$$

From Table 4.7, $P = 188\ (62.6\%), Q = 111\ (37.4\%) n = 300$

$$Z = \frac{0.626\ x\ 0.374}{\sqrt{300x0.626\ x\ 0.374}} = \frac{0.234124}{\sqrt{8.3807}}$$

$$= 0.02794 \approx 0.028$$

Decision

Since our computed "Z" value of 0.028 falls between -1.96 and 1.96 of our critical value, we reject the Null hypothesis. We therefore accept the Alternative hypothesis which states that "Changes in government policies affect solid waste planning and management in Enugu".

Using another Measure,
The coefficient of correlation can also be determined to ascertain the relationship between the ratings and frequency of responses in the hypothesis on how the changes in government policies affect solid waste planning and management in Enugu metropolis.

Table 4: Rating and number of responses that changes in government policies affect solid waste planning and management in Enugu metropolis.

S/N	Ratings (X)	Frequency of responses (Y)	XY	X^2	Y^2
1	5	112	560	25	12, 544
2	4	76	304	16	5776
3	3	24	72	9	576
4	2	65	126	4	3969
5	1	25	25	1	625
Total	15	300	1087	55	23, 490

$$\bar{X} = \frac{\sum X}{n} = \frac{15}{5} = 3, \quad \bar{Y} = \frac{\sum Y}{n} = \frac{300}{5} = 60$$

Using the formula,

$$Coefficent\ of\ correlation\ (r) = \frac{\sum XY - n\bar{X}\bar{Y}}{\sqrt{[\sum X^2 - n\bar{X}^2][\sum Y^2 - (\bar{Y}^2)]}}$$

$$r = \frac{1087 - 5(3)(60)}{\sqrt{[55 - 5(3)^2][23490 - 5(60)^2]}}$$

$$r = \frac{187}{\sqrt{10 \times 5490}} = \frac{187}{\sqrt{54900}} = 0.7981$$

The coefficient of correlation (r) = 0.7981 shows a good positive linear relationship between the result of the ratings and frequency of their respective responses in the questionnaire.

Using another measure, the coefficient of determination (r^2) which is the square of coefficient of correlation, we have,
$r^2 = (0.7981)^2 = 0.63696 \approx 0.637$ or 63.7%

The computed coefficient of determination (r^2 = 0.637) shows that 63.7 percent of the total variation in the frequency of responses is explained by the variations in the ratings for the questionnaire responses while the coefficient of non determination ($1 - r^2$) = 0.363 or 36.3.% of the variation in frequency of responses is attributable to the influence of other factors not explained by the regression function. This test supports the acceptance of the alternative hypothesis as stated above.

Hypothesis Three
Lack of Public Awareness on Proper Environmental Education is Responsible for Poor Sanitation Habits in Enugu Metropolis.

Table 5: Distribution of respondents on lack of public awareness Environmental Education

S/N	Options	Frequency	Ratio Values	Percentage (%)
1	Strongly agree	120	0.40	40.0
2	Agree	62	0.207	20.7
3	Undecided	18	0.06	6.0
4	Disagree	72	0.24	24.0
5	Strongly disagree	28	0.093	9.3
	Total	300	1.00	100.0

Source: Field Survey Report (2019).

Formula for "Z" test statistics: $Z = \frac{PQ}{\sqrt{nPQ}}$

Where; P = proportion of positive responses (Strongly agree and Agree)

Q = proportion of the negative responses (undecided, disagree and strongly disagree)

n = sample size

b = Level of significance is 0.05

c = critical value at 0.05 level of significance, the "Z" score take values between -1.96 to 1.96 of our critical value, we reject the null hypothesis and accept the alternative hypothesis.

e = computation of the "Z" value

From Table 4.9, $P = (182)\ 60.7\%, Q = (118)\ 39.3\%\ and\ n = 300$

$$Z = \frac{0.607\ x\ 0.393}{\sqrt{300x0.607\ x\ 0.393}} = 0.028199$$

Decision: Since our computed "Z" value of 0.0282 falls between -1.96 and 1.96 of our critical value we reject the Null hypothesis and therefore accept the Alternative hypothesis which states that, lack of public awareness on proper environmental education is responsible for poor sanitation in Enugu Metropolis.

Also, in order to determine the relationship between the ratings and frequency of responses on lack of public awareness on proper environmental education is responsible for poor sanitation habits in Enugu metropolis, we compute the coefficient of correlation (r) using the information in Table 6 below.

Table 6: Ratings of lack of public awareness on proper environmental education is responsible for poor sanitation habits in Enugu urban

S/N	Ratings (X)	Frequency of responses (Y)	XY	X^2	Y^2
1	5	120	600	25	14400
2	4	62	248	16	3844
3	3	18	54	9	324
4	2	72	144	4	5184
5	1	28	28	1	784
Total	15	300	1074	55	24, 490

$$\bar{X} = \frac{\sum X}{n} = \frac{15}{5} = 3, \quad \bar{Y} = \frac{\sum Y}{n} = \frac{300}{5} = 60$$

Using the formula,

$$Coefficent\ of\ correlation\ (r) = \frac{\sum XY - n\bar{X}\bar{Y}}{\sqrt{[\sum X^2 - n\bar{X}^2][\sum Y^2 - n(\bar{Y}^2)]}}$$

$$r = \frac{1074 - 5(3)(60)}{\sqrt{[55 - 5(3)^2][24{,}536 - 5(60)^2]}}$$

$$r = \frac{174}{\sqrt{10 \times 6536}} = \frac{174}{\sqrt{65360}} = 0.681$$

The coefficient of correlation (r) = 0.681 shows a good positive linear relationship between the result of the ratings and frequency of responses in the tested hypothesis three since it is above 0.5.

The coefficient of determination (r^2) = $(0.681)^2$ = 0.4538 or 46.38 percent

The computed coefficient of determination (r^2) shows that only 46.4 percent of the total variation in the frequency of responses is explained by the variations in the ratings for the questionnaire response while the coefficient of non determination ($1 - r^2$) = 1 – 0.464 = 0.536 or 53.6.percent of the variation in frequency of responses is attributable to the influence of other factors not explained by the regression function.

VI. CONCLUSION AND RECOMMENDATION

There are two different waste management options that must be combined intelligently in a way as to reduce the environmental, and social impact of wastes are improving the aesthetic of the city and living conditions of residents within the area. The combined option of integrated solid waste management and system approach should be used for the assessment of the competing options. Source reduction backed by effective legislation will encourage companies to use materials that are less hazardous for packaging their products thereby reducing waste and encourage recycling of packages for manufactured products. It is in this regards that this study here suggest the following recommendations;

i. In order to enhance environmental education program and public participation as it affects solid waste management, it should be provided not only through the radio, television and print media but also through grassroots enlightenment campaigns via the chiefs, community leaders.
ii. To champion the course of effective solid waste management, the involvement, participation and cooperation of local communities and the government is of utmost importance.
iii. There should be serious commitment on the part of Enugu State Government to sponsor more research projects into the reduction of solid waste at source, collection and efficient disposal.
iv. Solid waste management should be integrated in the curricula of primary, secondary and tertiary schools as a way of general enlightenment.
v. There is need for access road to the entire street around the metropolis to be constructed and put in good condition to aid accessibility of the waste

collection trucks to all the streets and compound in the area.

vi. The procurement of more Compaction vehicles will ease the problem of collection to disposal location.

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