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EVALUATING THE EFFICIENCY OF SOLID WASTE COLLECTION SERVICES IN OWERRI MUNICIPALITY, NIGERIA

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ABSTRACT
The concentration of people and activities in most Nigerian towns has led to the problem of solid waste management. This study tried to evaluate the level of efficiency in solid waste collection services in Owerri Municipality. Data were collected through extensive field measurements on different activities relating to solid waste collection services for a monitoring period of 60 weeks. Data were analyzed using a structural time-based model and logistic regression models. Results showed that the quantity and weight of waste collected increased by more than 3 times during sanitation days. A cumulative mean of 12min was spent on each pick-up operation. The unit cost of waste collection was significantly associated with time required per trip of collection (OR=1.32; 95% CI, 1.06-16.4). Age of members of the collection crew was strongly associated with pick-up time (0.84). The overall result showed that efficiency in waste collection in the town was 61%. This moderate value resulted from some operational dysfunctions observed on the part of the two waste collection companies that currently operate in Owerri Municipality. Some suggestions were proffered on how to improve on waste collection services in the town.

KEYWORDS*:* Collection, Dumpsite, Efficiency, Haul, Off-site, On-site, Solid Waste.

INTRODUCTION

Urbanization is one of the most pervasive phenomenal issues occurring in the Sub-Saharan Africa in general and in Nigeria in particular. The rate of urban growth in Nigeria is one of the highest in the world, exceeding 6.5% per annum (NEEDS Document, 2004). This growth has created diverse problems in urban areas (water scarcity, erratic power supply, traffic congestion, etc) but the most intractable of all still remains solid waste management (Nkwocha and Emeribe, 2008; Obianigwe 1999). It is not uncommon to find streets, roads, undeveloped plots and drains littered with solid waste (Nkwocha and Okeoma, 2009). Open dumping is commonplace wherever land is available without regard to safety, health hazards and aesthetic degradation (Olayemi et al 2010; Botkins and Kelly 1998). It often contributes to flood disasters and road accidents (Akaegbu, 2008, David and Master 2004). This implies that of all the waste management functions in Nigeria, the most daunting remains waste collection: the process of gathering waste from places of generation and storage, and transporting them to where they are stored, treated or disposed of (Oluwande and Filani 2002). Clean and healthy living conditions in towns, cities and villages cannot be achieved without reliable and regular waste collection and disposal (Rushbrook and Pugh 1999). Ever since the democratic dispensation in Nigeria in 1999, much improvements have been recorded in many towns and cities in waste collection services, especially in modernizing collection equipment, quality of personnel, but most importantly in contractual engagements with private companies primarily to reduce costs as waste collection accounts roughly three-fourth of the total costs of waste management services (Masters 2006, Versilind and Morgan 2004). For example, Port Harcourt city has engaged the services of five waste contractors, Enugu four, Aba four, Calabar three and Owerri two. The story remains the same for other major towns and cities such as Lagos, Kano and Ibadan. The fundamental question is how have these contractors faired in solid waste collection given the volume of resources allocated to them annually to perform their functions? How efficient are they in rendering waste collection services? The fact remains that little or no effort has been made to study and evaluate the level of efficiency of these companies in waste collection services. An evaluation of waste collection efficiency encompasses an important component in the diversity of responses to the concerns raised by poor solid waste management in Nigerian towns. Efficiency in solid waste collection can be defined as a systematic co-ordination of various time-related factors affecting waste collection so as to ensure an effective evacuation and transportation of stockpiled waste to the final disposal site at minimum costs. Realistically no waste collection system achieves 100% efficiency in its operations but certainly through rational planning high results can be achieved. This case study is geared towards evaluating and understanding the efficiency of solid waste collection in Owerri Municipality with the aim of exposing the major constraints and mostly of developing a sustainable waste collection culture in order to maintain a durable urban cleanliness in this growing urban metropolis in the South Eastern Nigeria.

METHODOLOGY

i Population and Solid Waste Generation

This study was carried out in Owerri Municipal, the regional capital of Imo State. It is located in the South-Eastern Igbo speaking area of Nigeria between Latitude 5^0N to $6^0$30'N and Longitude 6^0E to $7^0$34'E. Like most towns in Nigeria, it experiences two distinct climatic seasons; namely dry (October to March) and wet (April to September) seasons. A period of cold, dry, dusty winds known as "Harmattan" occurs from December to February

annually. Owerri has a mean temperature range between 24^0C to 34^0C with a relative humidity of 70% in dry months and 90% in wet months. With a projected 2010 population of 610,211 people (NPC, 2007) unevenly distributed over a total land area of 50;885km^2, its residents are mainly traders, civil servants, artisans and blue collar workers in small-scale industries (bakeries, food processing, medical laboratories, printing etc). A well developed network of major roads, access roads and streets also exist in the town. This assemblage of infrastructure makes Owerri the hub of economic and industrial activities generating different types of solid wastes. With the upsurge in the number of institutions (two universities, a federal polytechnic, a federal college of education and others), volume of activities, and in fact, the increasing trend in migration from surrounding rural communities towards Owerri, there has been a tremendous increase in the volume of solid waste generated within the area. The unsightly accumulation of these wastes generally reduced the aesthetic value of the urban environment, destroyed the landscape and to some extent, polluted the Otamiri and Nworie Rivers that passed through the town, which serve as sources of water supply to many rural communities down stream. It also increased the breeding conditions of some disease vectors and pathogens which invariably increase the morbidity (malaria, dysentery, diarrhea) and mortality (Oguoma et al 2010) as well as the cost of medical expenditure among the local residents (Nkwocha et al 2011; Ukpong 2006). Since the inauguration of the present administration, the government has been moving towards the realization of the targets set for the '**New Face of Imo Project**', the highlight of which is the '**Clean and Green Initiative'**. This current policy is *geared towards ridding the roads and streets of all refuse and producing a clean and green urban environment* (Ohakim 2007). The institution of an efficient waste collection system in the town is central to this current policy of the State government. The result of this study therefore remains an important document for evaluating the workability and level of service of the Clean and Green Initiative.

ii. Solid Waste Collection Services

The Fourth Schedule of the 1999 Constitution of the Federal Republic of Nigeria (Amended 2010) provides that the issue of refuse collection and disposal should remain the responsibility of the Local Government Councils (LGCs). Due to the dual status of Owerri as both the Imo state capital as well as the headquarters of Owerri Municipal Council, the cost of solid waste management is shared by these two levels of government even though the state government takes charge of policy formulation. For example, to ascertain the quantity of waste generated in the town, a Load Count Analysis (LCA) was conducted by Society Nigeria Limited in July 2008 under the auspices of the Imo State government. The results indicated that about 1520 tonnes of solid wastes were generated each day in the town. Since October 2009, waste collection is carried out by concession from the State Government through two companies, namely, Society Nigeria Limited and CODUC Nigeria Limited, under the Imo State Law of Nigeria, No. 3, 2008 (ENTRACO Law). This law is the foundation of the Clean and Green Policy of the State government, which is geared towards "*reclaiming the state from filth and upgrading its sanitary conditions with the aim of producing* a *healthy environment"*.

These two companies use the stationary container system in which the collection crews carry waste storage bins placed at strategic places within the town and empty them into collection vehicles either manually or mechanically. The containers are then returned to their original positions before proceeding to other locations, until the vehicle is filled up, from where they leave to the three disposal sites located at the outskirts of the town for discharge (maximum distance of 6km). These companies dispose of 55 Yellow and Green metallic receptacles of 5000kg and 800kg provided by the Niger Delta Development Commission (NDDC) and the Imo State Environmental Transformation Committee (ENTRACO). In some areas, wastes are dumped at open but designated sites, from where they are collected. The two companies receive a monthly allocation of N15million for rendering solid waste collection services in the town.

iii.Data Collection

Data for this study were generated from a lot of sources. The first sets of data were those on waste collection operations. For effective collection of these data, ten sanitary inspectors employed by Owerri Municipal Council were hired and given a two-day training in general interviewing techniques, specific study protocols and questionnaire and refusal aversion techniques. Each interviewer was asked to submit information obtained from the field in a chart prepared for the purpose on daily basis. An important component of the chart was the time-varying information concerning activities relating to various collection activities such as pick up time, haul time, off-route time, number of hours worked per day, haulage time spent by each truck per day, number of collection crews, quantity of waste hauled, area of the town covered per week, etc., all through the study period. All these records helped to capture major activities and time they occurred. Each of these data collectors was assigned a unique identification code and data chart submitted was only identified by the assigned code. All the data submitted were carefully sorted out, serialized and analyzed. Data on quantity of waste collected, pick-up time, haul-time, off-route time etc., were all fitted into a model for evaluation of waste collection efficiency in the area. A questionnaire survey was equally carried out among supervisors and members of waste collection crews in the waste collection companies to obtain additional information concerning waste collection (age of vehicles, total number of personnel, cost of collection per trip etc). A time-chart was prepared for respondents to fill complementary information on the following: zone and point of waste collection, month, week, days, shifts (morning/afternoon) respectively. Spaces were also provided for subjects to indicate the company's name, crew-leader's name, signature and date. Data for the study were collected on daily basis during the waste collection time (8am to 3pm) for a period of 60 weeks (April 2009 to May 2010) covering both dry and rainy seasons.

iv. Evaluation of Efficiency in Waste Collection

This evaluation was carried out by the application of a structural time-based model proposed by Tchobanoglous et al (1993) which is used for predicting the level of efficiency in solid waste collection for a stationery container system of waste collection. According to this model, the time required per trip of waste collection is given by the equation:

$$Thc_s = \frac{(Phc_s) + s + h}{1 - w} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where

Phc_s = Pick-up time/time spent during the next container after the empty container has been deposited, plus the time spent picking up loaded container, plus the time required to redeposit the container after its contents have been emptied (hrs/trip)

S = on-site time per trip (hrs/trip)

H = haul time per trip (hrs/trip)

w = off-route factor (expressed as a fraction)

The total haul time (h) is related to the round trip haul distance (x) (km/trip) by the equation

$h = a + bx$ ……(2)

Where

h=total haul time hrs/trip

a=empirical haul time constant, h/mi

b=empirical haul time constant, h/mi

x=average round-trip haul distant, mi/trip

For stationary container system, the pick-up time per trip is expressed by

$Phcs = pc + uc + dbc$ …… (3)

Where

pc = time required to pick up filled container (hrs/trip)

uc=time required to unload empty container (hr/trip)

dbc=time required to drive between container

Another important relationship is:

$Nd = h(1-w) - (t_1 + t_2)/ Thcs$ …..…… (4)

Where

Nd = number of trips per day (trips/day)

Thcs=time required per trip

w=off-route factor (expressed as a fraction)

t_1=time to drive from dispatch station to first container location to be served by the day, h.

t_2=time to drive from the last container location to be served for the day to the dispatch station, h.

The time required per trip may also be estimated from the relationship:

$$Dw = \frac{tw - Thcs}{h} \quad \ldots\ldots\ldots\ldots (5)$$

Where

tw= number of trips per week

Also the number of trips can be estimated as

$$tw = \frac{Vw}{(cf)} \quad \ldots\ldots\ldots (6)$$

Where

Vw=the weekly waste generation (m^3/kg)

c=the average container size (m^3/kg)

f=weighted average container utilization factor

Efficiency in waste collection "EWC" may then be estimated as

$$EWC = \frac{Phcs + h + s + W_O . Thcs}{Thcs} \quad \ldots\ldots\ldots (7)$$

Where

W_O=allowable off-route activity time

If the sum of Phcs + h + s is eliminated using equation ……(1), we then have

$$EWC = \frac{(1 - w) . Thcs + W_O . Thcs}{Thcs}$$

$$= 1 - w + w_o$$

This implies that if the off-route factor (w) is equal to the allowable off-route factor (w_o) i.e. [$w = w_o$], then the collection system is 100% efficient.

In addition of this model, logistic regression models were used to assess the relationships between waste collection variables such as haulage time, pick up time, time for off-route activities, collection costs, etc. We began with a model adjusted only for average haulage time per trip and average cost per trip. Other variables were then added for confounding: total daily off-route time, total daily on-site time, size of collection equipment, age of drivers (>50yrs). These analyses were performed using SPSS for Windows version 17.0 (SPSS, Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

The two waste collection companies, CODUC Nigeria Limited and Society Nigeria Limited employed 68 and 35 persons respectively for waste collection from Mondays to Fridays. However, during clean-up exercises which usually take place every last Saturday of the month, the staff strengths in the two companies are increased to 99 and 64 persons respectively as indicated in Table 1.

TABLE 1: Personnel involved in the Waste Collection Process in Owerri Municipal

Company	Waste Collection Day	Market value in ₦	Number of Units			Total
		Manager	Supervisor	Labour	Drivers	
CONDUC SOCIETY	Other day	4	5	40	19	68
	Sanitation day	4	5	60	30	99
	Other day	2	2	25	6	35
	Sanitation day	2	2	52	8	64

Source: Field Survey, 2010

From Mondays to Fridays, CODUC Nigeria Ltd, collected wastes at 90 points, but this number increased to 200 points on Saturdays and Sundays in the two zones where it operates as indicated in Table 2.

TABLE 2: Number of waste collection zones and points

	Number of waste collection points					
Company	Oma Zone A		Oma Zone B		Oma Zone C	
CODUC Nigeria Limited	47 Points	107 Points	43 Points	93 Points	Nil	Nil
Society Nigeria Limited	Nil	Nil	Nil	Nil	50 Points	200 Points
Total	Mon – Fri = 90; Sat – Sun = 200				50	200

NB: OMA Owerri Municipal Administrative zones.
Source: Field Survey, 2010

On the other hand, Society Nigeria Ltd which operates only in a zone (OMA Zone C), collected waste on 50 points from Mondays to Fridays, but this number increased to 200 points during Saturdays and Sundays. Table 3 shows the total distribution of collection equipment in the two companies; 2 compactors, 6 pail-loaders, 3 green lifter trucks, 6 NDDC skip trucks, between 15 to 65 open tippers, depending on the period of collection during the week.

TABLE 3: Type, Capacity, Market Price and Number of Units of Collection Equipment Used

Equipment	Capacity in tones	Market value in ₦	Number of Units		Total
			CONDUC	Society	
Compactor	15		1	1	2
Pail-loader	3	200m	2-4	1-2	3 - 6
Green Lifter Truck	8	175m	2	1	3
NDDC Skip Truck	5	30m	4	2	6
Open Tippers	5	50m	10-40	5-25	15-65

Source: Field Survey, 2010

The quantity of waste collected per day varied according to the period of the week. Table 4 shows that during the work days, (Mondays to Fridays) CODUC Nigeria Ltd collected an average of 760 tonnes/day and 2945 tonnes/day on sanitation days. The Society Nigeria Ltd on its part, collected an average of 430 tonnes/day during the week and 1860 tonnes/day on sanitation days.

TABLE 4: Quantity of Waste Collected/Day

Company	Collection Day	Average Weight By Equipment (in tonnes)				Total (tonnes)
		Compactor	Green Lifter Truck	NDDC Skip Truck	Pail-loader	
	Other day	-	160	200	400	760
CONDUC	Sanitation day	225	320	400	2,000	2,945
SOCIETY	Other day	-	80	100	250	430
	Sanitation day	150	160	300	1,250	1,860

Source: Field Survey, 2010

TABLE 5: Result of ANOVA Analysis

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	72272.865	5	14454.573	59.947	.000[a]
	Residual	9162.727	54	241.124		
	Total	81435.592	59			

a. Predictors: (Constant), S, H, W, THCS, PHYCS
b. Dependent Variable: CST

TABLE 6: Results of Regression Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Co linearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	416.346	111.620		3.730	.001		
	PHYCS	-1.472	.934	-.206	-1.576	.123	.173	5.794
	THCS	6.029	.474	1.512	12.718	.000	.209	4.776
	H	-.530	2.309	-.014	-.230	.820	.779	1.284
	W	.992	1.389	.052	.715	.479	.551	1.816
	S	-15.422	2.883	-.600	-5.350	.000	.235	4.249

a. Dependent Variable: CST

TABLE 7: Result of ANOVA Analysis

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.663	5	.333	2.116	.085[a]
	Residual	5.973	54	.157		
	Total	7.636	59			

a. Predictors: (Constant), S, H, W, THCS, PHYCS

b. Dependent Variable: AGE

This shows that the total weight of waste collected by CODUC per day is multiplied by 3.8 times on sanitation days while that of Society Nigeria Ltd increased by 4.33 times. Results of the modeled data computed with an allowable off-route time of 60 mins per work day, (with the number of personnel already indicated) showed certain variations such that at-site time per trip of operation was 3.2 mins for hoist trucks, 7.6 mins for open tippers, and 6.0 mins for manually loaded trucks. It was also found out that a cumulative mean of 12.6 mins was spent on each pick-up operation and 34.7 mins on off-route activities. The off-route activities on Saturdays were longest, sometimes as high as 42 mins while the lowest values for off-route activities were recorded on Sundays (22mins). This may be attributed to the increase in number of collection points during the weekends, especially on sanitation days; while the extremely low values on Sundays were due to the hurry of collection crews to finish and return home. The pick-up time (Phcs) for hoist trucks such as the NDDC skip trucks and the Green Lifter trucks was shortest throughout the collection process (10.3mins). This may be attributed to the on-site activities involved (sweeping and packing of litter, hooking the receptacle into the truck, and then hoisting the receptacle). Haul-time (h) per trip was greatest on Mondays (27.3mins) because of traffic congestion on major roads (Douglas, Wetheral, Tetlow, Royce roads) taken by truck drivers resulting from school-runs by many parents, civil servants returning from villages, and businesses re-opening after week-end activities, etc. The lowest haul-time value was recorded on Sundays with little or no traffic congestion while residents were at home resting (21 mins). Results of the regression model showed that cost of waste collection was significantly associated with time required per trip of collection (OR=1.32; 95% CI; 1.06-16.4). When this observation was excluded from the regression analysis, no statistically significant relationship was observed. In the same vane, age of the collection crew was strongly associated with pick-up time (0.84), although the former did not contribute measurably to other variables analyzed. Also, average cost of collection per trip was statistically significantly associated with average haul time. When this was included in the regression model, there was a statistically significant relationship (p=0.86). This observation appears to be valid and was consistent with other major findings. With the exception of these results, none of the waste collection variables analyzed was statistically significantly associated with the cost of waste collection. Results from the structural time-related model showed that efficiency in waste collection in Owerri Municipality was estimated at 61%. This value implied that out of the total quantity of waste generated in Owerri, only 61% of them were collected which was slightly above average within the 60-week study period. The remaining 39% of them were therefore left to accumulate in various parts of the town. This result corroborates the claim by environmental specialists that Owerri has lost the high level of cleanliness it was noted for in the 1980s (Mbamala 2009, Ohakim 2007). This moderate value may also be suggestive of the technical cum operational dysfunctions observed on the part of the two waste collection companies that operate in the town (poor schedule, use of over-aged drivers, poor maintenance of equipments, etc). However, despite these short-comings, some neighborhoods such as Ikenegbu, Aladinma, and Works Layout occupied by the rich and middle class in the town experienced quantum improvements in waste collection services. In these areas, most of the major roads and streets (Wetheral, Mbaise, Royce, Concorde, etc.) were observed to be generally clean throughout the period of study. This high level of cleanliness resulted from daily sweepings of the roads by numerous uniformed road-sweepers (185 in number) who participate actively in the Clean and Green Programme of the present administration.

Other neighborhoods such as New Market Layout, Old Owerri and peripheral districts (Orji, Amakohia, Federal Housing Egbu, Prefab, etc.) occupied by the working class and poor masses recorded low levels of waste collection and cleanliness, creating a sort of "apartheid" within the municipality. A comparative analysis of cost per trip recorded during the study period and the pre-concessional period (2006 – 2009) revealed that there was great reduction in the cost of collection. While the average cost per trip was estimated at ₦1250.00 during the pre-concessional period, it was greatly reduced to ₦625 per trip, a reduction of about 90%. This also corroborates the classical argument that liberalization of solid waste management functions to private companies leads to better services and therefore helps to improve the level of urban cleanliness (Nkwocha and Okeoma 2009; Hisashi 2005; Leton and Nweke 2004). The littering of waste by overloaded and overflowing waste collection vehicles which characterized the pre-concessional period were greatly reduced. Street collection of wastes was improved by the active role of informal waste collectors who used wheel-barrows and carts in areas with narrow streets and difficult accessibility. Collected wastes are then sent to designated collection points where they are now picked by the collection crews. There were seasonal variations in time spent on waste collection services. While an average of 12.6 mins was spent at each pick-up operation, it was about 13.2 mins in rainy season and about 12 mins in dry season. The slight difference was attributed to gain in weight by waste components due to rains and the inconveniences of collecting them (accelerated putrefaction of waste and odour production). The average cost of collection was therefore slightly higher in the rainy season than in the dry season, an observation that corroborates earlier studies in some Nigerian town (Ogbonna et al 2002, Ekere 2003, Ayatomuno 2004).

Based on these findings, there is need to increase the level of efficiency in solid waste collection in the town. Firstly, waste collection in Owerri Municipality should be properly and fully de-regulated. This entails the engagement of more waste collection companies rendering services in the area. The actual number of companies should, in fact, be increased to at least six to enable regular collection of refuse within and around the municipality. These companies should be compelled to operate with modern but locally adapted collection equipment such as new tippers, compactors, pail-loaders, cleaners, etc. Competent waste managers, young supervisors, drivers and other skilled personnel should be employed by the existing and new companies in order to plan, organize and implement waste collection strategies to attain fixed objectives. Private investors should be lured by the State government to explore innumerable opportunities existing in the collection, treatment and disposal of waste in the town. This will certainly help to reduce the volume of waste that has to be disposed of annually. However, it is not enough to collect waste as almost all refuse collected are presently sent to the existing three open dumpsites that are poorly managed. This underscores the need for constructing a conventional regional sanitary landfill that will serve Owerri and its environs. Also, there is need to initiate integrated solid waste management strategies (recycling, composting, etc.) in the town as this will help, not only in reducing the quantity of waste that will be sent to the sanitary landfill, but will also help in salvaging recyclable materials that are highly needed by small cottage industries springing up in the area. Waste collection companies operating in the municipality should pay particular attention to the supervision of waste collection crews and field staff so as to minimize the amount of man-hours lost to unproductive off-route activities. These companies should carefully study the local traffic patterns to know the peak-periods on major collection routes in order to reduce the haul-time during the day. A better alternative will be to change the time of collection and haulage of waste to early hours of the day (3am- 6am). Finally, a specific allowable off-route time (w_o) should be fixed for the waste collection crews for each of the companies at least for records purposes.

CONCLUSION

This study has tried to evaluate the level of efficiency in solid waste collection in Owerri Municipality. It relied on extensive field data, a structural time-based model and logistic regression models in the evaluation exercise. Few other studies have used such an extensive network of field measurements to evaluate the state of waste collection in the area. Although the period of data collection was relatively short, there is evidence suggesting that the duration of the study captured the essential data, especially on spatial, temporal and seasonal variations on solid waste collection in the area. The spatial patterns of data collected were stable over time. Results showed that the level of efficiency in waste collection in Owerri Municipality was slightly above average (61%), and therefore not very high. This may be attributable to some observed dysfunctional factors which led to discriminatory collection services in different neighborhoods of the municipality. The nature of the roads and the time of collection are of particular concern. It is not possible to rule out the residual influence from some unmeasured factors such as cost of equipments, age of equipment, salaries of workers, etc. Studies combining these factors are a priority for future research. Based on these findings, the study proffered some solutions which if considered will help in improving the level of waste collection and urban cleanliness in the area. Despite the shortcomings experienced in the study, results obtained will serve as useful adjuncts not only to informed decision on how to improve waste collection services in Owerri Municipality, but will also justify the need for further studies on the growing problem of solid waste collection in Nigerian towns and cities.

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