Environment Protection Engineering

Vol. 22 1996 No. 3–4

C.D. OKEREKE*

REFUSE CHARACTERIZATION AND MANAGEMENT IN A DEVELOPING ECONOMY: OWERRI TOWN CASE STUDY

Solid wastes were collected daily for 1 week of each of the months of September to March from randomly selected households in 12 different areas of the Owerri town. These daily household solid wastes were weighed and sorted to determine refuse production rate per capita, characteristic of waste composition and the percentage contents of each constituent of the household refuse. The current refuse disposal arrangements in the study area were examined. Statistical techniques were used in the analysis.

The results show that the average garbage generation rate per capita in low income, middle level and high income families are 53.16 grams per capita per day, 83.77 grams per capita per day and 89.90 grams per capita per day, respectively. The biodegradable materials represent 62% of household refuse. An average of 82.81% (σ_{n-1} = 8.17%) of them is combustible. This information is required in refuse disposal planning and designs.

1. INTRODUCTION

Wastes are undesirable substances that are generated or voided by man during the day to day activities in the household, office, or market square. Waste may be water-borne or of solid nature. The water-borne wastes involve sewage and sullage or unwanted solution or suspension, whereas solid wastes (refuse) include rags, papers, metals, glass, empty tins, plastics, ash and garbage of organic matter origin such as vegetable waste and food rejects capable of causing environmental nuisance. Some of the rejects can be desirable by individuals or household for ruminants or acceptable by the scavengers for reuse. For example, egg shells and bones can be used by manufacturers of adhesive, tooth paste, ceramics dishes or plates and abrasive.

Refuse collection and disposal do not pose any problem in rural villages, because the population is sparse and the magnitude of wastes produced by households are of small organic nature, ash and fine earth. According to OKEREKE [1], the average rate of

*School of Engineering, Federal University of Technology, Owerri, Nigeria.

solid waste generation in villages is 20 grams per capita per day. The rural dwellers often burn the combustible matter and tip the ash on the garden behind the yard. They also spread the degradable matter and ash from kitchen on their backyard orchards or garden as manure without any risk of environmental pollution. In the cities such as Owerri, refuse collection and disposal pose a great concern because of the magnitude in which wastes are generated daily with the attendant environmental hazard.

In this paper, the waste generating capacities of households and the management practices prevalent in Owerri municipality are examined with a view to evaluate the requisite conditions for planning and designing effective municipal refuse management scheme.

2. STUDY AREA

Owerri lies between latitude 5°15′N and longitude 6°40′E to 7°15′E in the Rain Forest Zone of the country. It has population density of about 1000 persons per ha. The sample locations (figure 1) have families of high, middle and low income levels, usually typified by the nature of accommodation which ranges from bungalows with generous spaces inside and outside for the high income people, block of flats or twin flats of 4 to 2 rooms for the middle level families to single room apartment with detached kitchen, toilet and bathroom for the low income people.

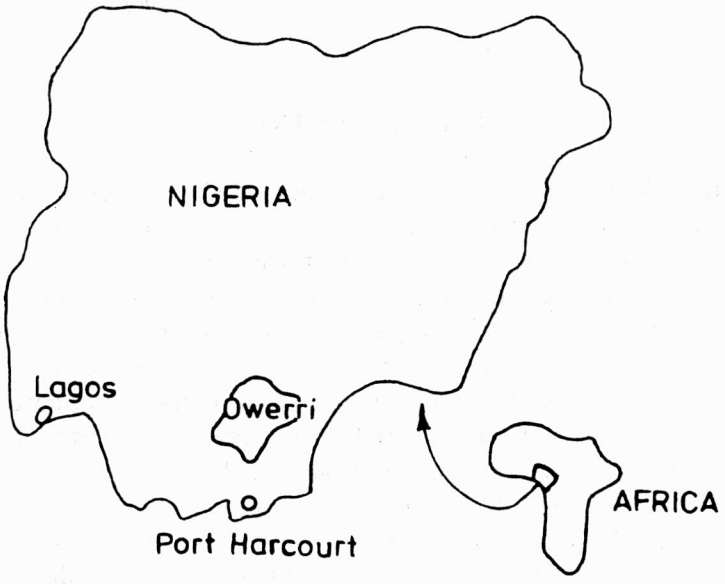

Figure. 1a

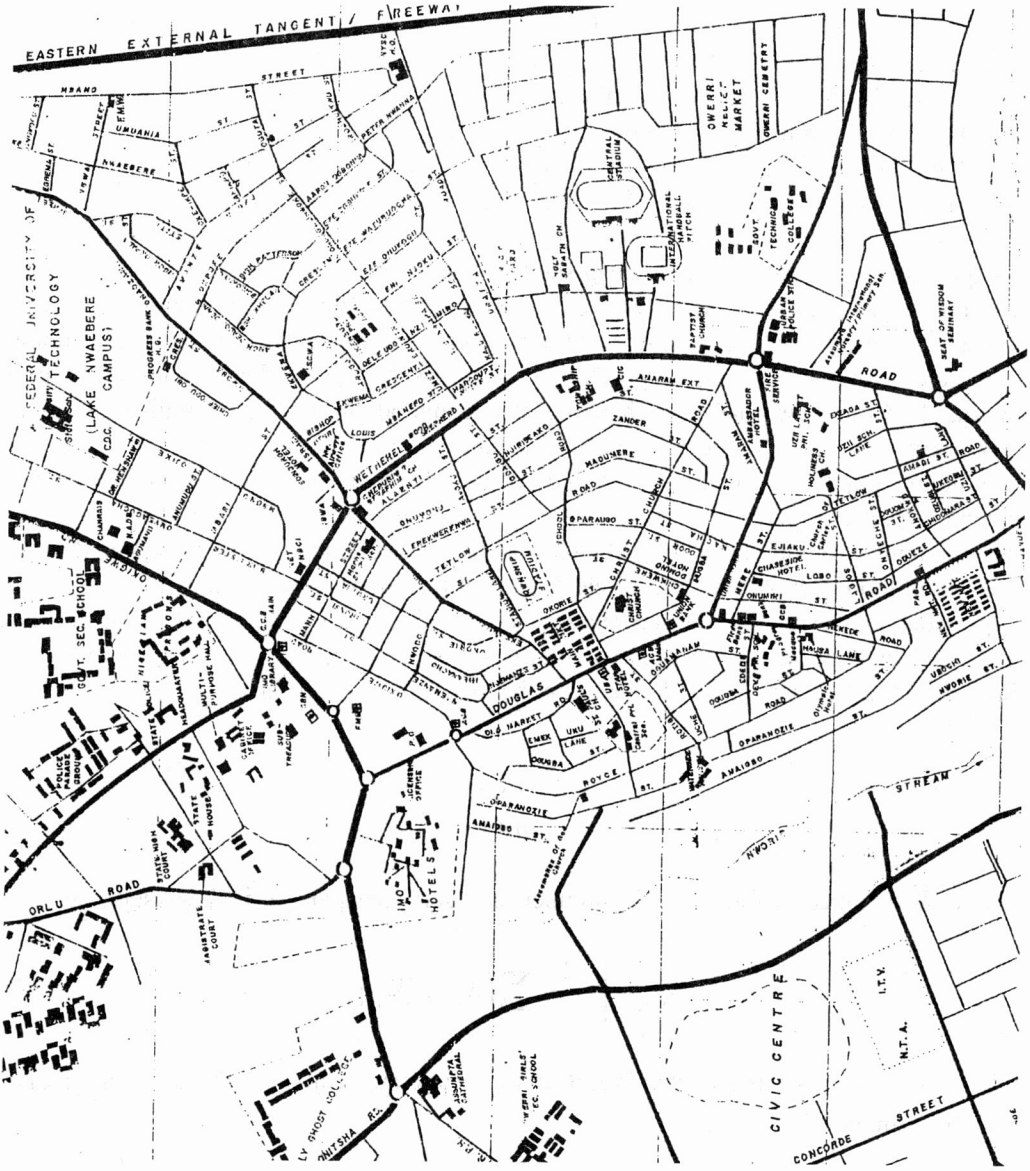

Figure 1b

3. RESEARCH METHODOLOGY

In order to determine the household refuse characteristics and the per capita solid waste generating capacity of householders of Owerri town, 12 areas were randomly

marked for sampling. These areas (figure 1) are along Njemanze and Okorie Streets, residences along Douglas Road, Royce Road, Mere Street, Erekwerenwa Street, Dele-Udo, Umez-Eronini Street at Ikenegbu Layout, Federal University of Technology, Owerri temporary campus at Lake Nwaebere staff quarters, Mbano-Amanze Njoku Aladinma Housing Estate, Orji and Amakohia. The refuse (garbage) produced daily from the selected households in the areas were collected from the bins and the bulk weighed before sorting the various components that made up the refuse. The typical composition of the solid waste are egg shells, plantain and yam peelings, ash, fine earth, vegetable matter, paper, empty metal cans, rags, plastics, polythene materials, glass and bones. The weight of each component was obtained gravimetrically and accordingly recorded by the income grouping. The income classification of the families was based on standard of living (nature of housing or accommodation). Those families in single room and crowded housing are the low income, whereas those in flats and single or stand-alone duplex or bungalow with generous garden and lawn are the middle and high income groups, respectively. The process of measuring daily per capita refuse generating capacities of individual households and the characterization were repeated from household to household within the selected areas for one week of each of the months of September to March in 1988 and 1994. The data obtained was analysed using the formulae for evaluation of statistical mean and standard deviation (equations (1) and (2)). Student's t-test was also used to compare the means at 5% significance level.

Thus,

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i \tag{1}$$

where $\bar{X}$ is a mean value, n is the number of observations and X_i is the observation;

$$\sigma_{n-1} = \left[\frac{1}{n-1}\sum_{i=1}^{n}\left(X_i - \bar{X}\right)^2\right]^{1/2} \tag{2}$$

where σ_{n-1} is the statistical standard deviation from the mean, X_i is the observation and n is the number of observations;

$$t = \left|\bar{X} - \bar{X}_2\right| \left\{\left[\sum\left(X_1 - \bar{X}_1\right)^2 + \sum\left(X^2 - \bar{X}_2^2\right)/n(n-1)\right]\right\}^{-1/2} \tag{3}$$

where t is the significance of the difference of means measured by ratio of the difference to its standard deviation [3], $\bar{X}_1$, $\bar{X}_2$ are the means being compared by the null hypothesis, $X_1 - \bar{X}_1$, $X_2 - \bar{X}_2$ are the residuals of both statistical samples and n is the number of observations. If the calculated t is greater than the standard value [3] at the specified 5% level of significance, we reject the null hypothesis and conclude that the

difference is significant. The modes of waste collection and disposal were obtained from oral interviews and survey conducted in the same study area. The refuse management system was assessed, and this information is used in the discussion that follows.

4. RESULTS AND DISCUSSION

In table 1, the average characteristics of domestic wastes in the study area is presented. It depends largely on the standard of living and eating habits of the people. People in the lower social cadre produce wastes of mostly vegetable matter (biomatter) ranging from yam and cassava peelings to vegetable stems or remains such as *Telfairia occidentalis*.

Table 1

Average percentage composition
of household refuse in Owerri municipality

Characteristics	Percentage of total waste
Plantain peelings	29.07
Yam peelings	20.29
Egg shell	1.55
Vegetable matter	10.02
Polythene	0.04
Plastics	13.71
Paper	0.63
Metal cans	12.36
Rags	2.52
Glass	2.54
Bones	1.48
Ash and fine earth	5.79

In low income families, waste matter of carbohydrate constitution and vegetable trash represents 80.10% of the garbage produced by a household. 4.52% of the wastes are in the form of fruit seeds or fibre and 3.15% represent wastes from protein food source (beans trash). The rest 11.77% occur as ash or fine sand and silt particles. The mean rate at which they generate refuse is 53.16 grams per capita per day (standard deviation, $\sigma_{n-1} = 4.68$ grams per capita per day). The combustible materials constitute about 88.23% of the total refuse produced. By burning the combustible materials, a total of 98% volume reduction is achieved. In other words, the volatilization of waste matter leaves only 2% of total refuse as ash to be disposed by land tipping or bagging for application as fertilizer or soil conditioner.

The middle income people produce 62.91% solid waste materials of carbohydrate origin that are biodegradable. The nonbiodegradable materials constitute 33.62% of

total refuse, egg shells and bones (mainly of calcium constitution) make up almost the remaining 3.47%. 85.1% of their refuse is combustible. The middle income household refuse is 83.77 grams per capita per day (σ_{n-1} = 18.15 grams per capita per day).

In the high income population, the solid waste matter of vegetable and carbohydrate nature comprises 60.02% of the refuse from their household. The nonbiodegradable refuse including rags comprises 36.28% of waste production. The egg shells and bones, which are largely calcium compounds, make up 3.69%, while 0.01% occur as ash or fine earth particulate. Combustible materials constitute 83.25% of the total wastes. The mean per capita refuse generating rate among this grade of people (families) is 89.90 grams per capita per day (σ_{n-1} = 11.53 grams per capita per day). The day to day (Monday through Sunday) household refuse production trend among the low, middle and high income groupings is shown in table 2. The peak values occur on Saturday of the week.

Table 2

Daily weight of refuse per person in 3 classes of families

Week day	High income people $\overline{X}$	σ_{n-1}	Middle income people $\overline{X}$	σ_{n-1}	Low income people $\overline{X}$	σ_{n-1}
Monday	81.37	7.86	78.97	24.19	41.33	7.26
Tuesday	77.00	2.23	68.78	17.29	40.89	2.91
Wednesday	108.20	22.50	101.83	17.92	63.22	8.18
Thursday	82.00	16.75	84.53	28.30	34.11	14.44
Friday	94.00	21.72	70.81	16.34	36.33	8.01
Saturday	112.23	23.64	104.56	17.77	111.67	31.29
Sunday	74.60	22.74	76.94	10.70	44.55	5.05
Average per person per day	89.90	11.53	83.77	18.15	53.16	4.68

All units are in grams per capita per day. Density is 0.5–0.6 kg/dm^3 (mean density – 0.3 kg/dm^3).
σ_{n-1} – standard deviation from the mean, $\overline{X}$, for n observations.

From t-test at 5% level of significance, there is indeed no difference between the standard of generating waste among the middle class and high income people. Therefore for the purposes of waste collection or management planning and design, both classes of people or families should be grouped together.

5. SOLID WASTE MANAGEMENT MANNER IN OWERRI

The current solid waste collection scheme in Owerri town, in which some households are able to empty their refuse bins into a slowly moving refuse van or trailer that only runs at 10 km/h along selected streets once a week, serves limited number of the city population. The scheme costs government of Imo State about N500,000.00 per month for overhead charges. This arrangement of refuse collection in residential areas (with a day to day waste generation trend shown in table 2) does not cover the interest of majority of the urban population. Therefore, refuse is often dumped indiscriminately on the various streets because there are no designated points or silo-bins anywhere in the vicinity for centralised waste dumping by households. At an average rate of 75.61 grams per capita per day of solid waste accumulation, in less than one week, some of the streets are overtaken by mountains of refuse that impede drainage and traffic flow (figure 2).

Fig. 2. Mountain of refuse on Douglas Road in Owerri City that impedes drainage and traffic flow

A solid waste collection arrangement should involve two separate bins for the biodegradable and nonbiodegradable materials kept by each household. A third bin for collection of egg shells and bones is necessary but may not be economically practicable. The bin for garbage of organic nature should be twice bigger than that for nonbiodegradable solid waste but the container for egg shells and bones should be ten times less than the latter in capacity. The separation of refuse and their collection in that manner makes solid waste management easy and reuse feasible. In essence, during the house to house or point to point waste collection, there should be two parallel trailers or trucks to collect the household solid wastes for onward transportation to the designated central deposition points. At these points further treatment by burning or crushing (size reduction) takes place prior to disposal by land tipping or sales for agriculture in the case of

the degradables and direct collection of varieties of nondegradables (glass, etc.) for reuse by interested peasant carpenters, metal workers, cottage factories and industries.

One way of reducing the magnitude of nondegradable wastes in the household bins is generally let the industries or factories introduce a 'return-bottle or container' scheme as have been done by the breweries and bottling companies. If for example, the cans used by the canning industries and plastic containers used for cosmetics or beauty cream or lotion for saloons are returned to the manufacturer through the retailers of such goods after using the content only, the quantity of nonbiodegradable will significantly be reduced by 99.57%. In other words, only probably damaged or broken glasses, plastics and cans will be found in the bins. Consequently, the frequencies of trucking to collect nondegradable waste for disposal or for recycling will be reduced thereby reducing cost of solid waste management. The level of cost reduction derivable from equation (4) depends on the magnitude of waste volume reduction achieved by this practice.

6. WASTE COLLECTION MODEL

Figure 3 shows the process model for waste collection and disposal management. The routes of activity may be simultaneous or according to the operator's schedule. To make collection easier, special trailers should be made and used in block of flats housing areas and market square instead of ordinary central bin and these central trailers can be rolled to the disposal (treatment and disposal) points for evacuation once a week. Thereafter the trailer is rolled back to position by tractor and keyed back to a standpost for security. The capacity of the trailers and prime mover should be designed based on the 112 grams per capita per day of solid waste production rate and number of users not exceeding 2000 persons (i.e., 5 cm^3 capacity). The schedule of waste collection should be worked out street/lane by street/lane on designated day of the week to cover all the locations in the urban area every week. House to house refuse collection is only feasible in low density housing areas.

To reduce the volume of garbage for handling, garbage grinders could be installed along the process route.

To sustain the waste collection and disposal services by the constituted sanitation authority, households or waste generators charged sanitation rate should be established based on the formula:

$$C_a = C_r + C_v \tag{4}$$

where C_a is the total charge per m^3 of waste to be collected, C_r is the cost of conveyance of waste and C_v is the volumetric charge derived from cost of the primary treatment and disposal.

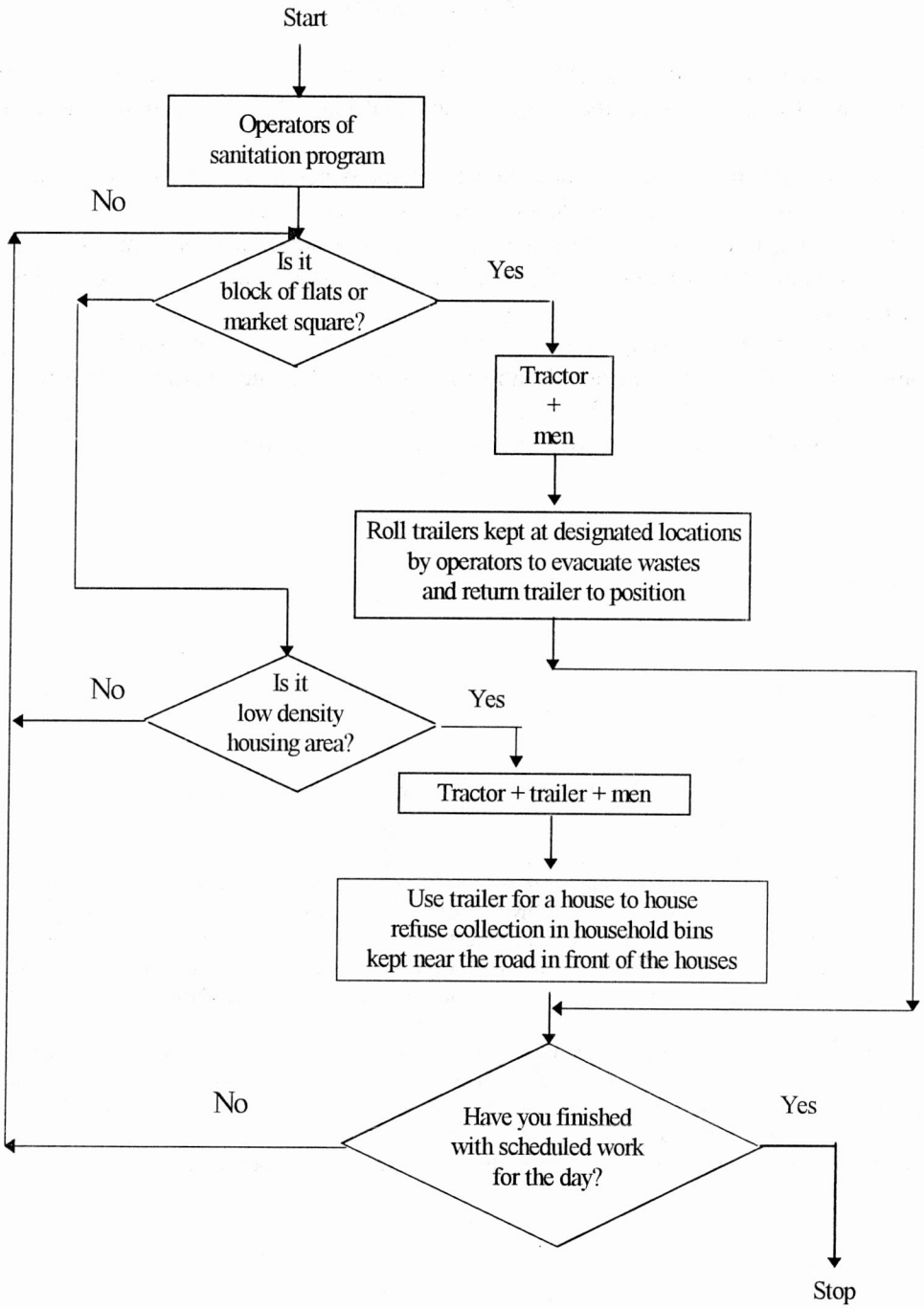

Fig. 3. Process pathway model in refuse handling

7. CONCLUSIONS

Solid waste disposal is basically an engineering problem that requires the expertise of a team of engineers with the requisite technical know-how by training and experience.

The success of any refuse management scheme depends on the quality of the team (operators), initial data input in planning and design and funds.

In working out refuse disposal arrangement, consideration should be given to the overall area and the distribution of collection points within the vicinity of groupings of households.

The information arising from this study that 82.81% of the household refuse is combustible, 62% is biodegradable and the weight is on the average between 53.16 grams per capita per day to 89.9 grams per capita per day are important in refuse disposal designs for the Owerri town or places with similar refuse characteristics.

REFERENCES

[1] OKEREKE C.D., ASERE A.A., NDUBIZU C.C., *Environmental pollution and fire hazard management in developing economy*, NSE proc. of annual seminar held at Federal University of Technology, Owerri, 13–14 October, 1988, pp. 102–103.

[2] Ministry of Lands, Survey and Urban Planning, 1987 November, Map of Owerri main Town.

[3] KENNEDY J.B., NEVILLE A.M., *Basic statistical methods for engineers and scientists*, Harper Int. Ed., London, 1976.

CHARAKTERYSTYKA ODPADKÓW I ZARZĄDZANIE NIMI W KRAJACH ROZWIJAJĄCYCH SIĘ – PRZYPADEK MIASTA OWERRI

Odpady stałe zbierano codziennie przez okres jednego tygodnia od września do marca z losowo wybranych gospodarstw domowych w 12 różnych miejscach miasta Owerri. Te dzienne porcje odpadów ważono i sortowano, aby w ten sposób określić tempo ich wytwarzania w przeliczeniu na jednego mieszkańca, scharakteryzować skład i podać udział procentowy każdego odpadu. Zbadano też bieżące działania podjęte w celu usuwania odpadów. W analizie otrzymanych wyników zastosowano metody statystyczne.

Otrzymane wyniki pokazują, że średnie tempo wytwarzania odpadków na jednego mieszkańca wynosi 53,16 g w przypadku rodzin o niskich dochodach, 83,77 g w przypadku rodzin o średnich dochodach i 89,90 g w przypadku rodzin o wysokich dochodach, Materiały, które ulegają rozkładowi biologicznemu, stanowiły 62% odpadów, średnio 82,81% (σ_{n-1} = 8,17%) odpadów można było spalić. Te informacje są potrzebne, aby planować i projektować metody usuwania odpadów.