Assessment of Domestic Solid Waste Generation in PortHarcourt by Separator-Receptacle Technology

A. J. Akor , M.J. Ayotamuno , L.I. Aman , S.O. Enokela

Abstract; A manually operated domestic waste separator – receptacle designed and constructed in the Department of Agricultural and Environmental Engineering, River State University of Science and Technology PortHarcourt, Nigeria. The receptacle was administered to sixty (60) households at three (3) income/ population densities' zones in PortHarcourt in attempt to access the magnitude and quality of garbage/recyclables generated per household of six persons per day. The receptacle was found to have 24% average volume tolerance for three day collection interval without overspill. Analysis of the waste collected by this technology indicated 51.54% of garbage per household/day that can be composed for energy and manure, 48.46% of recyclable consisting of 11.45%, 12.34%, 9.47% and 15.40% for plastic, paper, glass and metal respectively. Cost involvement is low when compared with the scavenger or centralized sort plant. The centralized sort plant requires special equipment and additional man power to handle the pick-up of recyclables from the heterogeneous waste stream The source separation techniques of receptacle-separator produces high quality recyclable materials recovery. The waste stream is also homogeneous and small in volume that creates no difficulty in separation with less facility-level of recyclable removal. Decomposition of waste that causes unpleasant ordour and fly invasion are aborted. The technology appears to be economically viable because of the homogeneous nature of recyclable by source separation thereby creating opportunity for establishment of recycling industries.

Keywords; Domestic solid waste, receptacle-separator, garbage, recyclable, recycling industries

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1. Introduction

The global concern for environmental health is on the increase as a result of improper management of waste from domestic and industrial / institutional centers. Materials identified to have no more value to man otherwise known as waste are gathered together and disposed off in non- environmentally friendly and non acceptable manner. The effect becomes harmful to human, plants, animals and other natural resources over the years. Effective management of solid waste has been a major problem in developing countries because of the poor waste management system. In Nigeria, dumping of refuse at street corners (municipal solid wastes, MSW) is still the common general practice [1]. Even when they are dumped at dumpsite or land fill, there still exist the problem of leachate that contaminate the groundwater and other water bodies which affect human health. When there is combustion of MSW, significant atmospheric pollution becomes the problem

According to [2] and [3], management of waste by landfill is becoming expensive because of the cost of collection and disposition of waste. Recycling that should reduce the volume of disposed waste is being ignored as adequate technology for recycling are not enough for the increasing waste generated by the teaming population.

Waste recycling has actually attracted attention in recent time because of the advancement in Waste to Wealth (WTW) programmes. Research has shown that the success of the solid waste management through recycling waste into useful product depends largely on separation of solids waste into component using appropriate technology [4] and Wike, [5]. Various devices are already in place for separation of solid waste, however most of these equipment are cumbersome and are designed for commercial application. They involve centralized collection and separation of large volume of solid waste. The problem still remain that waste from individual or domestic household must be transported to the collection centers

which involve huge finance, waste management agencies and field staff. [6] reported that the collection of waste and storing them in a centralized location increases the pollution of the associated recycling plant as well as reducing the quality of the recycled product. The current recycling programme in the market requires special containers for separate pick up of recyclables in homes which often translate to high cost and it also inconveniences the residents by keeping different containers at homes. However, the involvement of household in waste reduction and management according to [7] is gaining popularity. [8] also noticed that source separation at household level have many favourable environmental impacts including energy saving and greenhouse gas reduction.

This paper is therefore aimed at making recycling of waste a productive venture. It is an attempt to introduce household solid waste separator - receptacle technology for sorting of refuse to constituent components at the source of generation thus making recyclable materials available and of standard quality.

2 Materials and methods

The separator – receptacle technology under consideration is a six – sided container made of plywood and aluminum foil and constructed at the Department of Agricultural and Environmental Engineering, River State University of Science and Technology PortHarcourt. Nigeria. Four separate openings are provided in the front into four cavities with handle affixably mounted thereon which allows the doors to be grasped and pivoted open outwardly. The fifth opening runs from the top to the bottom behind the four cavities. Each of these cavities is provided with disposables bag position therein to separately receive and hold waste component for actual discarding. The inner walls of the receptacle are made of aluminum foil fig "1a & 1b".

Fig.1a & 1b. Side and front view of the Separator –Receptacle.

Aluminum foil and plywood became the materials for the construction because of their cost effectiveness, structural integrity, water tightness and their everlasting durability if well protected and not willfully damaged.The domestic solid waste is known for having more of garbages with some percentage of moisture contents with low density, therefore should be easily handled by above material to avoid deterioration of components. The plywood used is of $16mm^2$ thick..It is somewhat weather proof and made of odd number of sheets with strong water resistant adhesive to prevent warping and mechanical wear. In addition, preservative chemicals (chlorinated phenol and sodium PCP) were used for treatment against defect by insect, chemical action and fire.

The volume of the receptacle was chosen to be 0.064m³/day based on household waste generation rate 0.46kg/c, day of six person per a household and a collection frequency of two times per week. The designed bulk density of 155.1 kg/m³ with each receptacle having the capacity 0.0173m³/day created 24% excess volume that could account for any sudden change in population density. The removable waste receiving bags is in form of plastic with light weight, non magnetic, do not rut or rust but durable to withstand tear, bust, hence polythyne.

The receptacle was administered to twenty household each at three categorized zones in Portharcourt. These zones are;

[A]   Low income/high population density (Bundu Area)

[B]   Middle income/middle population density (D line area)

[C]   High income /Low population density (GRA area)

This gives a total of sixty households representing the income categories/population densities that make Portharcourt. The ratio of per day generation to the number of persons per household gives the generation rate. Mathematically the generation rate Q is defined as

$$Q = \frac{M}{P_r} - - - - - - 1$$

Where ; M is the amount of solid waste generated per day by a house hold

P_r is the number of persons per household

The volume of each waste component V_c were computed using the equation

$$V_c = \frac{M_c}{\rho_c} - - - - - - 2$$

Where; M_C is the mass of solid waste components

ρ_C is the density of solid waste component

The bulk density ρ_d of the domestic solid waste was calculated using

$$\rho_d = \frac{M_{TC}}{V_{TC}} - - - - - 3$$

Where; M_{TC} is the total mass of solids waste and V_{TC} is the total volume of solid waste

The receptacle was placed behind the back of the residence of each household for a period of one month with adequate incentives given to the source sorter. Different solids waste components generated daily were source sorted and dropped in their respective cavity as identified on the receptacle. The polyethene bags containing the recyclables were picked up at three days interval and constituent weighed using weighing balance. The process was repeated for the period of investigation and simple analysis of sum, mean and percentages were carried out to determine the total weight and volume of waste generated per household and the volume of components/ recyclables generated per household.

3   Results and discussion

Table 1 shows the volume of the various waste components for the respective category by income and population densities.

Table 1. Average volume of waste components generated per household/day in the respective zone.

Components	Volume (m³)/ Zones		
	[A]	[B]	[C]
Garbages	0.0269	0.0220	0.0212
Glass	0.0032	0.0046	0.0054
Paper	0.0039	0.0064	0.0068

Plastic	0.0030	0.0064	0.0059
Metal	0.0044	0.0080	0.0086

The results from the table show a variation in volume of the waste recyclables in all the zones. The volume of garbages generated by the low income / high population density is higher than that generated by the other two categories. Conversely the middle and high income category generated more of glasses, plastics paper and metal than the low income category which attested to their income and consumption pattern.

Table 2 gives the average amount of solid waste components generated per household in PortHarcourt/day

Table 2; Average amount of garbage/recyclable generated per household /day

Component	weight (kg)	Volume (m³)	Fraction (%)
Garbages	4.640	0.0234	51.54
Plastics	0.312	0.0052	11.45
Paper	0.504	0.0056	12.34
Glass	0.860	0.0043	9.47
Metal	0.621	0.0069	15.20

The results above revealed that garbage alone constitute 51.54% of the domestic solid waste generated in PortHarcourt while the recyclable constitute 48.46%. Comparing these results with the report of [9] which attested to 30% recyclable material recovery of the scavenger method, it is evidently clear that the source separation by receptacle has added 18.46% growth rate.

A comparative analysis was also carried out to establish the variation that exist between the fraction of constituent generated by receptacle technology and centralized sorting plant and the result is as presented in table 3.

Table 3; Representative fraction of components by receptacle and centralized sorting

Components	fractions (%)	
	S.S	CSP
Garbage	51.54	30.01
Plastic	11.45	10.20
Paper	12.34	7.46
Glass	9.47	9.47
Metals	15.20	11.32

SS – source separation (receptacle)

CSP – central sorting point (scavenger)

From the result above it is clear that the fraction of solid waste components recovered at source separation are more than those recovered by centralized separation plant except for glass that maintain the same fraction by both methods. This could be as the result that glasses do not deteriorates quickly with time. Physical appreciation of the relationship Fig. "2" shows that residual wastes of plastics, paper and glasses are found below 10% in the centralizes method of separation. However, residual wastes do not deteriorate below 10% in the source receptacle-separator method. This means that at source separation of solid waste, every domestic solid waste component is well defined and can easily be recovered for recycling and reuse or composed. It also means that source separation can give maximum value of recyclables over the centralized separation. In other world's source separation can give maximum reduction in volume of waste to be disposed and as well prolong landfill life span than centralized separation.
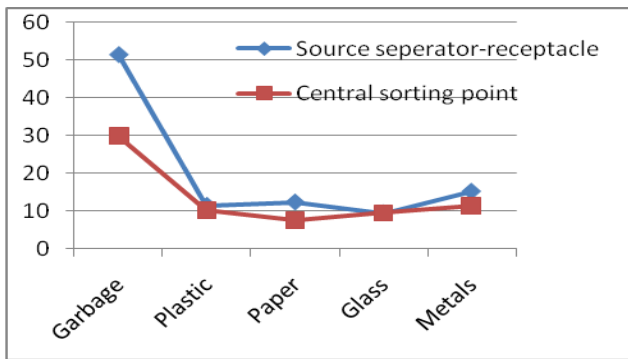
Fig.1 Physical appreciation of SS and CSP

4   Conclusion

Source separation of domestic waste by receptacle is associated with low cost because energy cost, waste treatment cost, labour cost, rent, sophisticated equipment cost and transfer cost. The only costs involved are those for receptacle and incentives given to household waste separator. Beside, the source separation techniques of receptacle produces high quality recyclable materials recovery. The waste stream is also homogeneous and small in volume that creates no difficulty in separation with less facility-level of recyclable removal. Decomposition of waste that causes unpleasant odour and fly invasion are aborted. However the centralized requires special equipment and or additional man power to handle the pick-up of recyclables from the heterogeneous waste stream. The picking up and dumping of waste into their respective cavities in the receptacle is simple and timeless because of their homogeneity at the point of generation and need no separation. Linkages and foul ordours are always aborted from receptacle because of the polyethene bag that receives the component in the cavities. The aluminum coverage of the internal walls retains and prevents water that may leak out of the garbage. From the forgoing, the receptacle technology is economically viable for establishment of recycling plant in Portharcourt because it has been reported by [10] that 40% of artisan in Onitsha, Nigeria and small scale industries receive 48% of their raw materials from

scavengers' methods. In addition the 51.54 % of garbage waste is highly economical for the establishment of microbiological processing plant for extraction of biogas when compared with the 31% biodegradable recovery in USA as reported by [11]. The 51% can be recycled by composting for agricultural production. The following recommendations are important for the major stakeholders in the Port Harcourt area and indeed the Rivers State Government of Nigeria:

1. A standard $0.0604m^3$ (60.4liters) manually operated household solid waste separator- receptacle with cavities not less five should be provided for occupants of offices and households for source separation of solid wastes. This will help solve the various problems of inefficiency associated with the system of multiple waste bins in a house and the centralized separation.

2. The Rivers State Environmental Authority (RSESA) should insist on the compulsory use of a household solid waste separator-receptacle by every household in order to encourage source separation of waste to meet up the National and Global mandate for waste recycling, reuse and reduction. This will reduce the cost of solid waste management and help limit the contamination of air ,soil and water by leachate and emission of pollutants from the mass burning or land filling of solid wastes

3. Direct incentives should be paid in cash to households/waste separators for the recyclable items they bring to the site of collection in order to give value to useful waste materials and to foster participation in source separation of wastes.

4. The Rivers State Government of Nigeria should encourage the establishment of recycling industries within the state to ensure the marketing and recycling of the recovered materials in order to put to an end the " throw away mentality" or burning of valuable waste materials within the mixed waste streams.

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