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SOLID WASTE SEGREGATION AS A STRATEGY FOR IMPROVED WASTE MANAGEMENT IN PORT HARCOURT

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ABSTRACT
The diverse composition of municipal solid waste complicates its management significantly. Waste segregation, essential for effective solid waste management, has yet to be embraced by Nigerian society. Failure to properly segregate waste can lead to diseases such as diarrhea. This research aimed to evaluate the effectiveness of solid waste segregation as a means to enhance waste management in Port Harcourt. A quasi-experimental design was utilized, and a multistage sampling method was employed to select 30 households. A self-administered questionnaire with a semi-structured format was utilized, consisting of demographic information, a 14-point knowledge scale, and a 14-point practice scale. The knowledge and practice results were classified into three categories: poor (≤4), fair (4-8), and good (above 8). Unlabeled jute sack bags were distributed to households for a week to gather solid waste. The waste collected was categorized and weighed before the intervention took place. Afterward, households received labeled, color-coded jute sack bags (Black for biodegradable and White for non-biodegradable waste), and training on how to use them was provided over a span of 2 weeks. Following the intervention, the questionnaire was re-administered to the chosen respondents. Waste generated from households was gathered and weighed over a week following the intervention on solid waste segregation. Non-degradable waste was sorted, analyzed, and its individual components were recorded and weighed. The collected data underwent analysis using descriptive statistics and a t-test with a significance level of p=0.05. The average age of the respondents was 28.6±2.6 years. The educational backgrounds of the respondents included non-formal education (23.3%), primary education (26.7%), secondary education (20.0%), and tertiary education (30.0%). The respondents' knowledge score before the intervention was 2.7±0.2, while their practice score was 2.2±0.1. The results of this intervention indicate that waste segregation at the source is a feasible and sustainable method for improving solid waste management in the country. These findings will enhance the planning, development, implementation, and assessment of solid waste management within the community, state, and Nigeria. It is strongly recommended that there be an increase in community-based public awareness initiatives, that the government provide bags as incentives to encourage source segregation of waste, and that buy-back recycling centers be established by the government.

Keywords:
Solid Waste Segregation, Waste Management, Waste Reduction, Waste Sorting, Environmental Sustainability

Introduction

Effective solid waste management practices are a crucial part of the environmental infrastructure in communities. These practices include all activities that take place from when waste is produced to when it is finally disposed of. In most urban areas of Africa, the responsibility for solid waste management falls primarily to Municipal Councils, while in many rural regions, waste is managed and disposed of at the household level (Frank, 2006). Solid Waste Management (SWM) is a significant environmental concern, especially for municipalities in numerous developing countries that face various environmental challenges. Alamgir, Donald, Roehl, and Ahsan (2005) emphasize that both urban population growth and economic advancement are vital factors in generating Municipal Solid Waste (MSW). The rapid and unplanned growth of cities, combined with the prevailing attitude of "out of sight, out of mind" regarding waste,

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contributes to an increase in solid waste generation and exacerbates environmental issues, leading to chaotic waste disposal in many municipalities. SWM is often a primary challenge for local governments and towns in various nations, and Nigeria is no different (ADB, 2012).

Waste segregation involves categorizing waste into dry and wet types. Dry waste consists of solid materials like wood products, metals, and glass, among others. Wet waste generally refers to organic or liquid waste typically produced by food establishments, and it is heavier due to its moisture content. The amount of waste being generated is on the rise, while a significant portion is disposed of at improperly situated and managed dumpsites, leading to serious environmental and health repercussions. Additionally, Mtey (2005) and Vincent (2000) indicate that between one-third and one-half of the solid waste produced in many cities across low and middle-income nations goes uncollected. This waste often ends up as illegal dumping on streets, in open areas, and wetlands, adversely affecting local flora and fauna. The Ministry of Infrastructure further states that improving solid waste management is essential through a national policy and regulatory framework to address these environmental challenges.

Port Harcourt's waste still consists of approximately 70 percent organic, biodegradable material, while in rural areas, this proportion exceeds 95 percent. Waste sorting, composting, and recycling efforts were initiated only recently, and as of 2015, Nigeria began investing in environmentally friendly landfills. The operational dumpsite manages around 400 tons of unsorted solid waste daily, totaling 140,000 tons annually (MININFRA, 2013). Common environmental issues associated with such rudimentary dumpsites include persistent fires, methane leaks, landslides, and contaminations threatening rivers and groundwater (Hogan, 2004). The prevailing view is that inadequate waste management primarily stems from the failure of current institutions to effectively tackle waste-related challenges (Yekeen, 2010). Any efforts to enhance the capabilities of urban institutions must be both appealing and supportive of environmental protection. To aid in capacity building and evaluation, which seeks to identify existing capabilities and those required to fulfill tasks, understanding and assessing capacity must involve all levels, both formal and informal (NUDB, 2008; Yekeen, 2010).

Material and Method

Nigeria's Niger Delta encompasses Port Harcourt, located at approximately 4.8157° N latitude and 7.0499° E longitude. The city is near the Gulf of Guinea, where the Imo and Bonny Rivers converge. To the east, it is bordered by the Atlantic Ocean, while the northern side is flanked by the hinterlands of Rivers State, and the west is dotted with wetlands and rivers. Ogunwale et al. (2022) highlight the city's strategic position as an important port and industrial hub. The population of Port Harcourt is rapidly increasing due to urbanization and migration. Current estimates suggest that the population stands at 1,865,000. According to Ezeh and Udo (2021), Port Harcourt has one of the highest population densities in Nigeria, which places considerable pressure on the city's infrastructure and services, particularly in waste management. Port Harcourt has a tropical rainforest climate, characterized by consistently high temperatures and substantial rainfall throughout the year. Nnamdi and Obinna (2022) note that this warm and humid climate is typical for the Niger Delta region. The average yearly temperature ranges from 24.6°C to 31°C. Omojola and Oladipo (2023) mention that sustained high temperatures contribute to a generally warm climate.

This research utilized a quasi-experimental design. The primary goals included assessing knowledge, attitudes, and behaviors regarding solid waste segregation, categorizing and weighing the discarded waste, and supplying training along with color-coded waste collection bags. A stratified random sampling method was adopted to select 30 households from AMAC. The study population consisted of 574 households in AMAC. Participants were chosen based on mutual consent. The following criteria were considered for selecting the community included in the study: it is a semi-urban area, it features a mix of high- and low-density populations, and it is located within the state capital. The sample size was determined using the statistical hypothesis testing or power analysis formula detailed in "Sampling: Design and Analysis" by Sharon L. Lohr (2010).

$$n= [Z_\alpha (2P(1-P))^{1/2} + Z_\beta (p_1 (1-p_1) + p_2 (1-p_2))^{1/2}]^2/(p_1-p_2)^2$$

An approximate formula is given below

$$n= (Z_\alpha + Z_\beta)^2 \{p_1 (1-p_1) + p_2 (1-p_2)\}/ (p_1- p_2)^2$$

p_1 = proportion with event in group 1=0.5, p_2 = proportion with event in group 2=0.5

p = average of p_1 and p_2

Z_α is standard normal deviate corresponding to level of significance (usually 5%)

Z_β is standard deviate corresponding to power of 1-β

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Using 90 power= 1.28

$$N = \frac{(1.9+1.28)^2 \; x \; 0.5\;(1-0.5)+0.5\;(1-0.5)}{(0.5-0.5)^2} \quad \square N \rightarrow \alpha \; 5.25$$

nr =An attrition or non-response rate (nr) of 10% for household survey as suggested by WHO/UNAIDS (2009) was further considered.

(Nx1/1-nr) 5.25 x 1/1-0.1 = **5.83**

To achieve greater accuracy, the sample size was increased to 15, resulting in a total of 30 individuals across both locations. The research followed the sampling technique suggested by the Global Adult Tobacco Survey (GATS, 2010). AMAC was divided into two categories: the housing estate (low-density area - LD) with 40 households and the actual communal settlement (high-density area - HD) consisting of 534 households. A total of 30 households were chosen for the research study.

The survey was structured into five sections, labeled A, B, C, and D. Section A included questions aimed at capturing the socio-demographic details of the participants, while section B featured questions designed to evaluate the knowledge of solid waste segregation at the source. Section C encompassed inquiries regarding the participants' attitudes toward segregation at the source. Section D of the semi-structured questionnaire assessed the actual practices of solid waste segregation at the source among the respondents. The questionnaire was designed to measure both baseline and post-intervention knowledge, attitudes, and practices related to waste segregation. The development of the questionnaire was informed by a review of pertinent literature and the identification of relevant variables associated with solid waste segregation at the source. A self-administered questionnaire was chosen to minimize interviewer bias and to reduce costs.

Knowledge, Attitude, and Practices were evaluated using scales of 14, 10, and 14 points, respectively. Knowledge and Practice scores were categorized as poor, fair, and good with scores of 0≤4, ≥4-8, and ≥8. Similarly, Attitude scores were classified as poor, fair, and good with ranges of 0≤4, ≥4-7, and ≥7. During the development of the instruments, experts from Environmental Health, Epidemiology, Health Promotion, and Education were consulted.

To improve the face and content validity of the tool, it was presented to experts in Environmental Health, Epidemiology, and Health Promotion and Education within the Public Health faculty for their input. Necessary adjustments were made after the evaluation by these specialists and were subsequently reviewed by my Research supervisor. The questionnaire was translated into the Izon language and then translated back into English. This procedure was carried out to ensure that the instrument preserved its original meaning.

To evaluate its reliability, the instrument was initially tested with 15 households in Port Harcourt, a community that is different yet shares similar characteristics with the targeted group. The questionnaires that were pretested were cleaned, coded, and later entered into the Statistical Package for Social Sciences, SPSS (version 16). The reliability was assessed using Cronbach's alpha coefficient analysis, which measures internal consistency based on the average inter-item correlation. The reliability coefficient calculated was 0.92, indicating that the instrument was highly reliable.

The questionnaires were compiled and revised by the researcher along with the help of field assistants. They were reviewed for completeness and given serial numbers for easy identification. Each questionnaire's responses were manually coded using a coding guide that the researcher developed after carefully analyzing all the responses. A template was created in SPSS (version 16) for entering the coded data. The data from each questionnaire was inputted into SPSS 16 software. Descriptive statistics and a t-test were used to analyze the data, with a significance level set at p=0.05. The findings were displayed using tables, pie charts, and bar graphs..

Result and Discussion

Socio-Demographic Characteristics of Respondents

A total of 30 individuals from the community were interviewed, with ages varying from 15 to 45 years. The average age of the respondents in the community is 28.6±2.6 years. The socio-demographic characteristics of the respondents from the community are presented in Table 4.1.

Knowledge of Respondents on Solid Waste Segregation

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The average knowledge score among the 30 respondents interviewed before the intervention was 2.7±0.2. A percentage of 73.3% reflects a deficiency in knowledge, while 26.7% indicates a reasonable level of knowledge. Tables 4.2, 4.5, and figure 4.1 illustrate the respondents' knowledge levels regarding solid waste segregation.

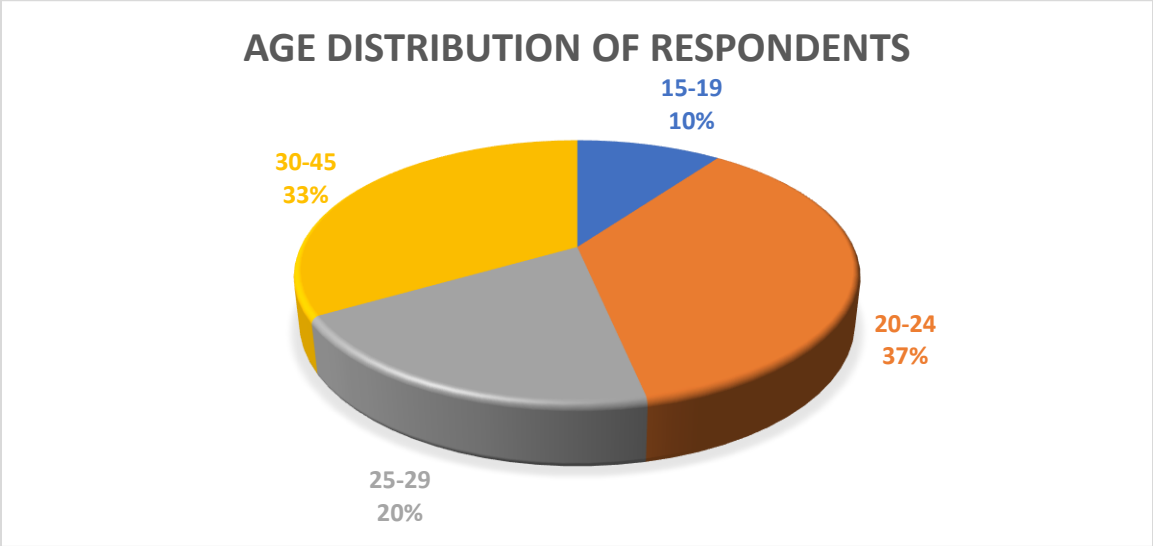
Attitude of Respondents to Solid Waste Segregation

Out of the 30 community members interviewed, 86.7% exhibited a poor attitude, while only 13.3% displayed a fair attitude. The attitude levels of the respondents towards solid waste segregation at the source are illustrated in Tables 4.3, 4.6, and Figure 4.1.

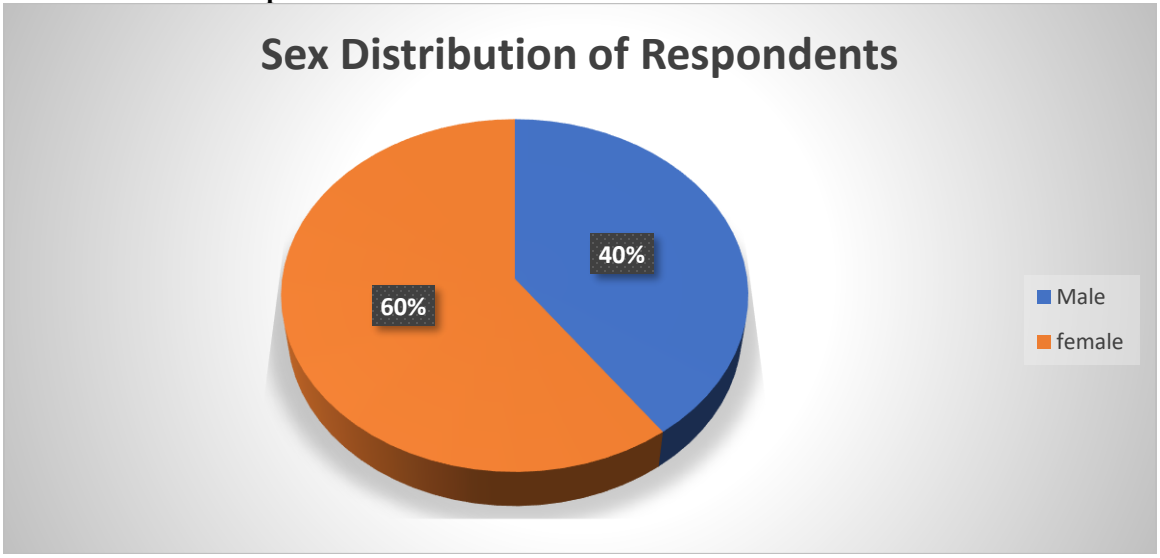
Practice of Solid Waste Segregation

The average practice score for solid waste segregation among the 30 respondents interviewed was 2.2±0.1. Of this total, 70.0% of the respondents exhibited poor practice, while 30.0% demonstrated fair practice, as illustrated in tables 4.4, 4.7, and figures 4.1, respectively.

Age Distribution of Respondents



Sex Distribution of Respondents



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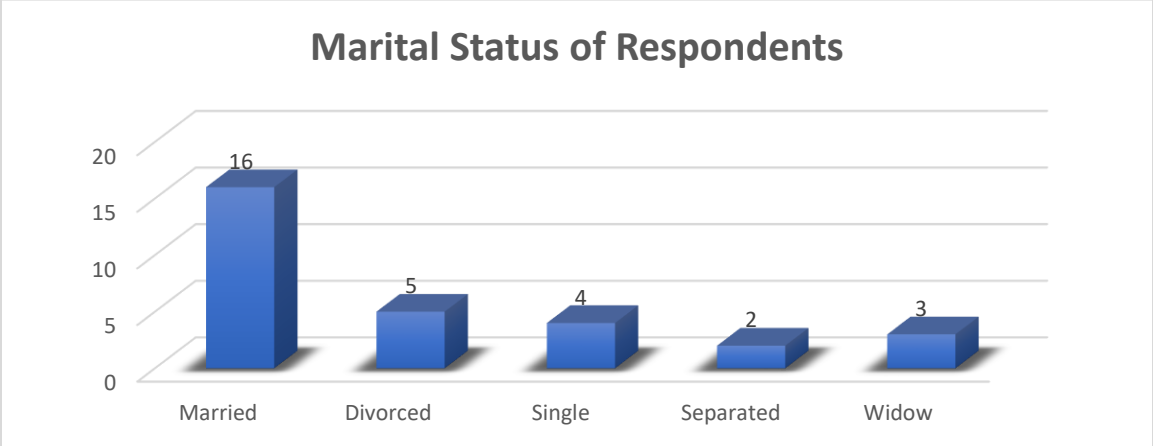
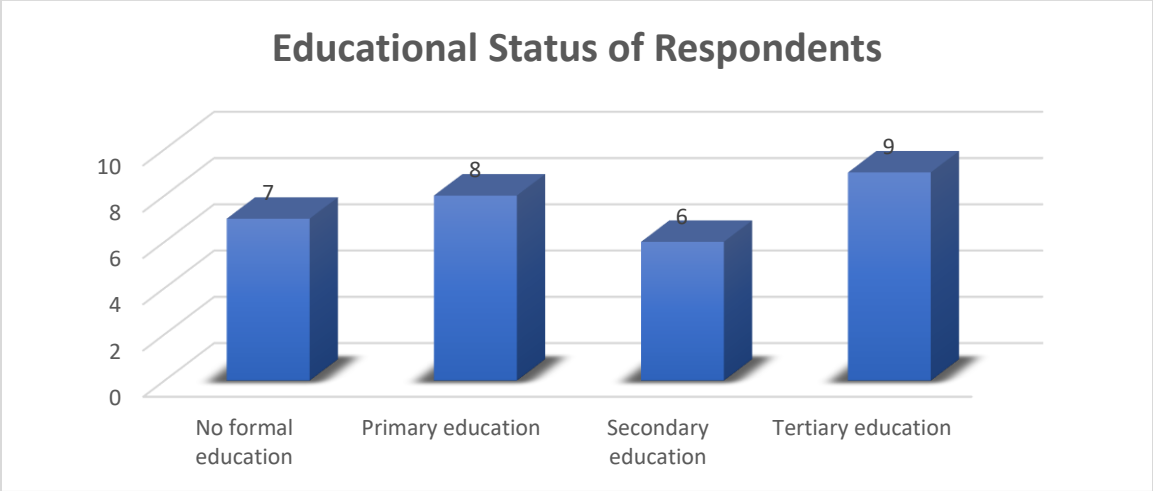
Marital Status of Respondents



Educational Status of Respondents



Occupation Status of Respondents

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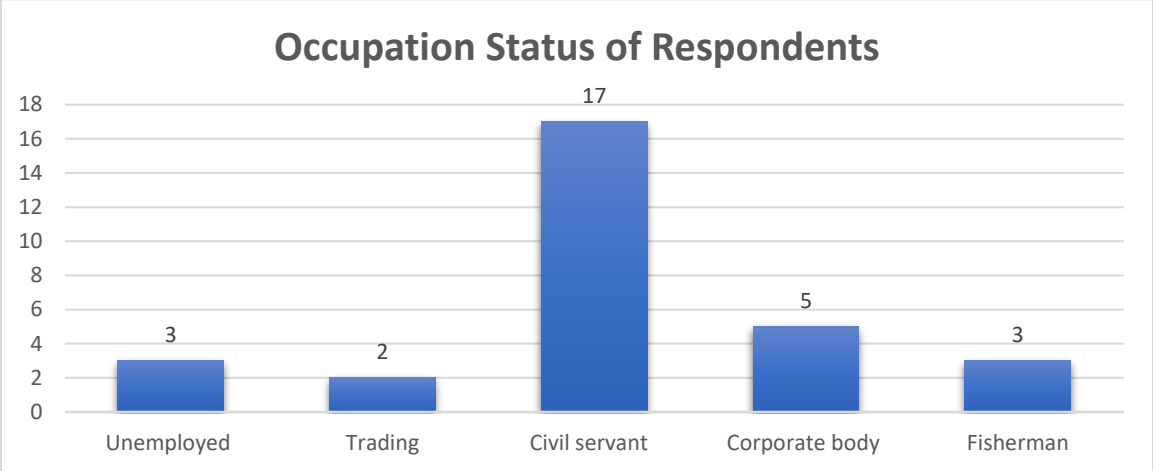

Table 4.1: Socio-demographic characteristics of respondents

Variable	Total
Age:	
15-19	3 (10.0%)
20-24	11 (36.7%)
25-29	6 (20.0%)
30-45	10 (33.3%)
Mean ± SD	28.6±2.6
Sex:	
Male	12 (40.0%)
female	18 (60.0%)
Marital Status:	
Married	16 (53.3%)
Divorced	5 (16.7%)
Single	4 (13.3%)
Separated	2 (6.7%)
Widow	3 (10.0%)
Educational status:	
No formal education	7 (23.3%)
Primary education	8 (26.7%)
Secondary education	6 (20.0%)
Tertiary education	9 (30.0%)
Occupation:	
Unemployed	3 (10.0%)
Trading	2 (6.7%)
Civil servant	17 (56.7%)
Corporate body	5 (16.7%)
Fisherman	3 (10.0%)

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Table 4.2: Respondents knowledge on solid waste segregation

Variable		At Pre-intervention	
			Total (%)
Do you know any form of solid waste management:			
good	1 (50%)	6 (21.4%)	7 (23.3%)
poor	1 (50%)	14 (50.0%)	15 (50.0%)
Fair		8 (28.6%)	
Do you think solid waste can be converted into useful material:			
good	2 (100%)	5 (17.9%)	7 (23.3%)
poor		20 (71.4%)	20 (66.7%)
Fair		3 (10.7%)	10 (10.0%)
Do you know that solid waste can be separated at the source of generation:			
good		2 (7.1%)	2 (6.7%)
poor	2 (100%)	19 (69.9%)	21 (70.0%)
Fair		7 (25.0%)	7 (23.0%)
Do you know that waste can be reused, recycled and recovered:			
good	1 (50%)	5 (17.9%)	6 (20.0%
poor	1 (50%)	18 (64.3%)	19 (63.0%)
fair		5 (17.9%)	5 (16.7%)
Do you think waste segregation at source is beneficial to health:			
good		5 (17.9%)	5 (16.7%)
poor	2 (100%)	13 (46.4%)	15 (50.0%)
fair		10 (35.7%)	10 (33.3%)
Do you know if there are useful materials in solid waste:			
good	2 (100%)	8 (28.6%)	10 (33.3%)
poor		17 (60.7%)	17 (56.7%)
Fair		3 (10.7%)	3 (10.0%)
Do you think it's ideal to put all your waste in a single waste bin:			
good	2 (100%)	8 (28.6%)	10 (33.3%)
poor		18 (64.3%)	18 (60.0%)
fair		2 (7.1%)	2 (6.7%)

Note; LD= Low Density and HD= High Density.

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Table 4.3: Respondents attitude to waste segregation

Variable	At pre- intervention		
	LD	HD	Total (%)
Solid waste segregation at the source is necessary in AMAC			
good	0 (0%)	6 (21.4%)	6 (20.0%)
fair	0 (0%)	8 (28.6%)	8 (26.7%)
bad	2 (100%)	14 (50.0%)	16 (53.3%)
Training of households on solid waste segregation is necessary in AMAC			
good	0 (0%)	2 (7.1%)	2 (6.7%)
fair	1 (50%)	3 (10.7%)	4 (13.3%)
bad	1 (50%)	23 (82.1%)	24 (80.0%)
Solid waste segregation at the source enhances waste minimization and resource maximization			
good	1 (50%)	5 (17.9%)	6 (20.0%)
fair	0 (0%)	10 (35.7%)	10 (33.3%)
bad	1 (50%)	13 (46.4%)	14 (46.4%)
Solid waste management should be left for the waste management authority an government alone			
Good	0 (0%)	11 (39.3%)	11 (36.7%)
fair	0 (0%)	5 (17.9%)	5 (16.7%)
Bad	2 (100%)	12 (42.9%)	14 (46.7%)
Solid waste segregation enhances a clean and healthy environment			
good	0 (0%)	7 (25.0%)	7 (23.3%)
fair	1 (50%)	5 (17.9%)	6 (20.0%)
bad	1 (50%)	16 (42.9%)	17 (56.7%)

Note; LD= Low Density and HD= High Density.

Table 4.4: Respondents practice of waste segregation

Variable	At Pre-intervention		
	LD	HD	Total (%)
Do you separate valuables in waste Good	1 (50%)	3 (10.7%)	4 (13.3%)
poor	1 (50%)	25 (89.3%)	26 (86.7%)

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Fair	0 (%)	0 (0%)	0 (0%)
Do you use separate containers or bags for the collection/storage of different category of valuables good	0 (0%)	5 (17.9%)	5 (16.7%)
poor	2 (100%)	19 (67.9%)	21 (70.0%)
Fair	0 (0%)	4 (14.3%)	4 (13.3%)
Do you separate valuables into different categories good	0 (0%)	6 (21.4%)	6 (20.0%)
poor	2 (100%)	16 (57.1%)	18 (60.0%)
Fair	0 (0%)	6 (21.4%)	6 (20.0%)
Do you sell some of your waste items good	0 (0%)	6 (21.4%)	6 (20.0%)
poor	2 (100%)	19 (67.9%)	21 (70.0%)
Fair	0 (0%)	3 (10.7%)	3 (10.0%)
Do you keep plastics, bottles, and tin cans in separate place after using their contents good	2 (100%)	6 (21.4%)	8 (26.7%)
Poor	0 (0%)	19 (67.9%)	19 (63.3%)
Fair	0 (0%)	3 (10.7%)	3 (10.0%)
Does your neighbour do what is asked in question above good	2 (100%)	8 (28.6%)	10 (33.3%)
Poor	0 (0%)	14 (50.0%)	14 (46.7%)
Fair	0 (0%)	6 (21.4%)	6 (20.0%)
Have you exchanged waste materials for any valuable good	2 (100%)	8 (28.6%)	10 (33.3%)
poor	0 (0%)	10 (35.7%)	10 (33.3%)
Fair	0 (0%)	10 (35.7%)	10 (33.3%)

Note; LD= Low Density and HD= High Density.

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Table 4.5: Respondents level of knowledge of solid waste segregation

	Level of knowledge			χ^2	P-value
	Poor (%)	Fair (%)	Good (%)		
Location at Preintervention	22 (73.3%)	8 (26.7%)	0 (0%)	5.893†	0.064

†FT = Fisher's exact test (4 cells (66.6%) has expected count less than 5)
Relationship was not significant

Discussion of Result

The majority of community responders were women aged 15 to 45, with an average age of 28.6±2.6 years, as indicated in Table 4.1. This may be attributed to the fact that women often take on the role of primary caregivers in their households, and even if they are employed, many return home to fulfill family responsibilities such as cleaning. According to Margret (2011), there is a strong link between gender and the separation of solid waste; she suggests that women are more inclined to separate solid waste compared to men. This tendency is likely because it is women within the home who understand and determine what is deemed useful and what is considered waste. Research conducted in Pakistan, Bangladesh, and Ho Chi Minh City also shows that women partake in source separation more than men do within the household (Beall, 2007; Du, 2005). Similarly, Ekere et al. (2009) reported results in Uganda that aligned with these findings regarding the segregation of agricultural residues.

Participants exhibited a limited understanding of waste separation at the point of origin prior to the intervention, as indicated in Table 4.5, which shows that 73.3% had poor knowledge while 26.7% had fair knowledge. This could have been linked to their differing educational backgrounds; however, this does not appear to be the case since respondents with both tertiary and secondary education displayed minimal awareness of solid waste segregation at the source. This implies that a person's educational attainment does not inherently provide knowledge about solid waste segregation at the generation source. According to Sridhar et al. (2009), awareness regarding the segregation of solid waste can only be cultivated through ongoing and well-structured educational programs delivered by trained professionals in solid waste management. WHO (1999) and Cookey (2005) state that effective waste segregation implementation relies on thorough training for personnel from various institutions regarding what healthcare waste entails, its categorization, the significance of segregation, the types of waste involved, the different colored containers or bags assigned to specific wastes, their designated locations, and the intended use for each type of segregated waste. Nonetheless, following the intervention, the knowledge of respondents improved, as demonstrated in Table 4.16, where 64.3% exhibited good knowledge and 7.1% had poor knowledge.

After the intervention, the various elements of dry waste (non-biodegradable) that were sorted included polythene, metals, paper, plastics, glass (bottles), clothing, wood, shoes, human hair, and tetra packs. According to Sridhar et al. (2010), an average person in Nigeria produces around 0.43 kg of solid waste daily, with organic materials, plastics, polythene, and scrap metals accounting for approximately 60 to 80 percent of total waste generated. The results of this research indicate an immediate need to develop policies and create programs that promote solid waste segregation. This change would significantly enhance our current waste management practices. It is also crucial to prioritize public awareness and community involvement. The community should be effectively engaged in the planning, development, implementation, and assessment of any solid waste management initiatives. Promoting household composting is essential. Environmentally friendly composting methods should be adopted and practiced within the community to help alleviate the amount of organic waste and provide fertilizer for gardens. A thorough and appropriate legal framework should be established when formulating policies and programs related to solid waste management.

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Authorities across all tiers must show the determination to enforce effective waste segregation methods right from the point of generation.

Conclusion and Recommendation

The outcomes of this intervention indicate that implementing waste segregation at the source is a feasible and sustainable method for enhancing solid waste management in Port Harcourt. However, collaboration among all stakeholders is crucial, particularly in terms of advocacy, raising public awareness, establishing buy-back recycling centers, fostering community involvement, and creating public-private partnership frameworks. The insights gained from this study will contribute to the planning, development, execution, and assessment of solid waste management in the community, particularly in Port Harcourt.

It is strongly advised that:

1. Enhanced public awareness initiatives at the community level be implemented.
2. The government provide bags as an incentive for encouraging waste separation at the source.
3. Buy-back recycling centers should be established by the government.
4. Prior to the adoption of any solid waste management policies, research on the current status of solid waste generation and practices should be conducted.
5. Promotion of waste segregation at the point of generation should be encouraged.
6. Community involvement should be actively promoted.
7. Home-based composting of waste should be encouraged.
8. Sufficient legislation and enforcement mechanisms should be provided.

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