

Assessment of Population Perception Impact on Value-Added Solid Waste Disposal in Developing Countries, a Case Study of Port Harcourt City, Nigeria

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1. Introduction

1.1 Background

Waste materials are solid, liquid, gaseous or radioactive substances that have lost value to the user. Waste materials are often produced by human activities and waste management is the collection, transportation, processing, recycling or disposal, sequestration and monitoring of waste materials; a step undertaken to reduce their effect on health and the environment or aesthetics. Waste management is also carried out to recover resources from waste materials. Waste management is executed via different methods and fields of expertise for each form of waste material. Just as the manufacture, distribution and uses of products result in the emission of greenhouse gases (GHGs) that promote global warming and climate change, improper disposal of the waste materials generated from manufactured products could also promote climate change through the emission of GHGs. Increase in waste material generation is attributed to accelerated population growth, industrialization and urbanization.

Across board, the majority of municipal solid wastes consists of biodegradable organic substances, plastics, glass, metals, textiles and rubber materials but the composition and volume of the wastes vary from one region to the other and also from one country to another. There are also differences between the waste composition of high and low-income countries. In developing countries, waste generation rates are put at 0.66 kg/capita/day in urban areas and 0.44 kg/capita/day in rural areas as opposed to 0.7-1.8 kg/capita/day in developed countries (Cointreau, 1982). Wastes materials in developing countries are characterized by increased putrescible /organic matter contents in comparison to the

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developed countries; waste stream is over 50% organic materials; residential and market wastes are characterized by 78 to 90% compostable materials (Hoornweg et al., 1999; Cointreau, 1982; Ogwueleka, 2009; Otti, 2011). Furthermore, waste densities and moisture are much higher in developing countries. For instance, the density of solid waste in Nigeria is reported to be 250 kg/m³ to 370 kg/m³ higher than solid waste densities found in developed countries (Cointreau et al., 1984). Ogwueleka (2009), reported urban waste generation in Nigeria in the range of 12,000 to 255,556 tons per month (Fig.1); with Lagos, the commercial nerve centre of the country, generating the highest.

Focusing on Nigeria, waste management challenges in Port-Harcourt city, used as a case study in this project, is not different from any other major cities in developing countries (Zurbrugg, 2003; Imam et al., 2008; Ugwueleka, 2009;). As part of proactive measures to preserve the environment and protect the inhabitants from hazardous wastes, the Nigerian government and several states therein have established various governmental authorities and agencies that would ensure efficient and effective mode of waste management. The following are a list of solid waste management stakeholders and major actors at both the Federal and State levels:

- National Environmental Standards and Regulations Enforcement Agency
- Federal Ministry of Environment
- State Ministries of Environment
- State Environmental Protection Agencies

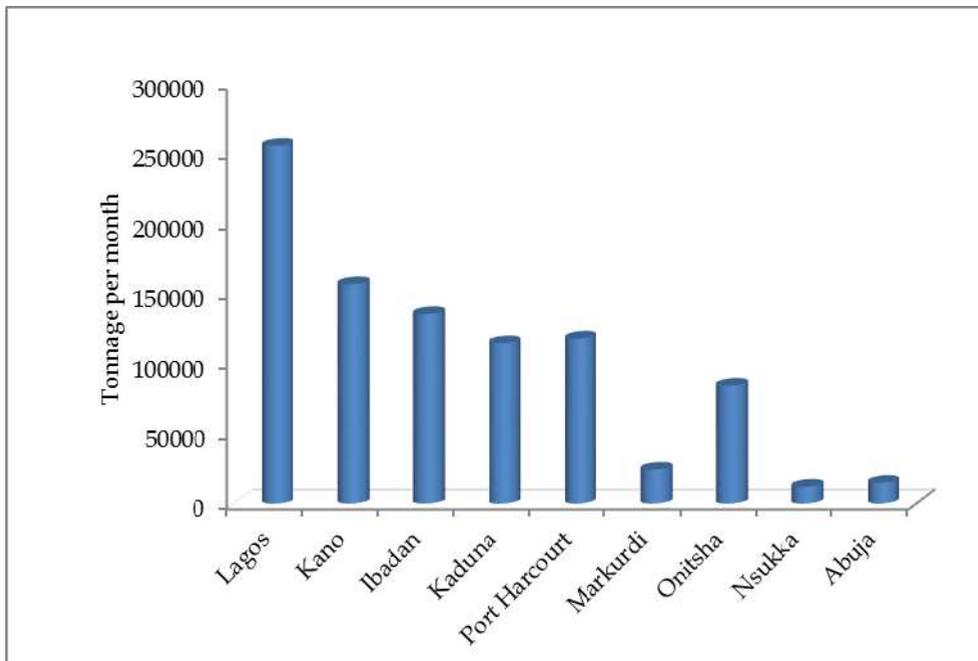


Fig. 1. Urban waste generation in Nigeria

In addition, as highlighted by ELRI (2009); various statutory regulations guiding solid waste management in Nigeria include:

- The Federal Environmental Protection Act of 1988,
- Environmental Impact Assessment Act, 1992. The purpose of the EIA Act is to, among other things, establish the magnitude of impact and mitigation measures before a decision taken by any person, authority corporate body or unincorporated body including the Government of the Federation, State or Local Government intending to undertake or authorize the undertaking of any activity that may likely or to a significant extent affect the environment. Such activities include the disposal of solid wastes in the environment,
- The National Environmental Standards and Regulations Enforcement Agency Act 2007 (NESREA ACT), which became the major statutory regulation or instrument guiding environmental matters in Nigeria. It specially makes provision for solid waste management and its administration and prescribes sanction for offences or acts which run contrary to proper and adequate waste disposal procedures and practices.
- National Environmental (Sanitation and Waste Control) Regulations, 2009. This regulation, among other things, makes adequate provisions for waste control and environmental sanitation including punishments in cases of malfeasance,
- The Harmful Waste (Special Criminal Provisions) Act prohibits the carrying, depositing and dumping of harmful waste on any land, territorial waters, contagious zone, exclusive economic zone of Nigeria or its inland water ways and prescribes severe penalties for any person found guilty of any crime relating thereto,
- The National Environmental Protection (NEP) (Pollution Abatement in Industries and Facilities Generating Waste) Regulations on the release of toxic substances and stipulates monitoring of pollution to ensure permissible limits are not exceeded; unusual and accidental discharges; contingency plans; generator's liabilities; strategies of waste reduction and safety for workers,
- The Management of Solid Hazardous Wastes Regulations. These regulate the collection, treatment and disposal of solid and hazardous wastes for municipal and industrial sources and give the comprehensive list of chemicals and chemical wastes by toxicity categories,
- The National Oil Spill Detection and Response agency, 2005 (NOSDRA ACT). This statutory regulation makes adequate regulations on wastes emanating from oil production and exploration and its potential consequences to the environment,
- The National Effluents Limitations Regulation. This instrument makes it mandatory that industrial facilities install anti-pollution equipment, make provision for further effluent treatment, prescribe maximum limit of effluent parameters allowed for discharge, and spell out penalties for contravention,
- The National Guidelines and Standards for Environmental Pollution Control in Nigeria. This was launched on March 12th 1991 and represents the basic instrument for monitoring and controlling industrial and urban pollution.

The highlighted regulations reveal that the country has the policy platform to tackle the challenges of waste management; however, waste material disposal/management in the country is still a burning issue to environmentalists. The situation is similar to that in other developing countries. The solution to waste material management or simply put, effective waste material disposal in developing countries will not be achieved if the fundamental issues regarding waste management are not aggressively addressed.

1.2 Justification

Despite the numerous existing laws and regulations, waste material disposal and management is still a great challenge facing environmental protection agencies in developing countries. This is not just a challenge to environmental sustainability but a social handicap. It is obvious that developing countries are still battling with the fundamentals of waste management. In contrast, waste management in many industrialized countries such as Germany, United Kingdom, and United States of America is governed by strict environmental guidelines and enforcement. There is no doubt that improved technology is an advantage for the developed countries but the pertinent question is: would developing countries fare better if high-tech facilities are donated to them right now? For a successful implementation of a given technology, rules and regulation must be implemented.

Using Nigeria as an example of the developing countries, a wide variety of approaches has been strategized in an attempt to tackle this environmental challenge. Some of these efforts include:

- workshops for stakeholders and academic conferences, which often end up at the level of a communiqué and or published articles, without practical impact,
- waste collection by municipal or related waste management authorities in the urban areas. In this case, residents lump different types of waste materials (food wastes, plastics, nylons, electronics, papers, glass, metal scraps etc) together at designated open dumps in the neighbourhood from where trucks convey them to an approved waste dumpsites and
- attempts by some state governments to delve into waste to wealth initiatives, involving Public-Private Partnership (PPP).

These efforts have, however, not yet solved the environmental problems posed by waste materials. The last approach is deemed to be the most viable option due to accruing benefits of dynamism, access to finance, knowledge of technologies, managerial efficiency and entrepreneurial spirit. It is, therefore, time to take a closer look and identify the rudimental causative factors to inappropriate waste management in developing countries. This is a step in the direction to finding a viable solution to this social menace.

Until recently, Port Harcourt was known as the "garden city of Nigeria" because of its neatness and the overwhelming presence of parks and gardens all over the metropolis. However, according to Ayotamuno et al., (2004), the presence of piles of refuse dotting the entire city has turned Port Harcourt to a "garbage city". The situation is such that traffic flow is often obstructed, while there is likelihood that leachates from such dumps, after mixing with rain water, have the potential to contaminate ground water (Ayotamuno et al., 2004; Adekunle et al., 2007). It is believed that PPP in waste management strategy will become more efficient if there is a concerted effort in mass mobilization/re-orientation to positively change the attitude of citizens in waste material handling and disposal. Organic waste materials can be effectively treated and disposed for land applications in the fields of environment and agriculture, paving way for a sustainable Public-Private-Partnership in solid waste management in most developing countries and Nigeria in particular (Adekunle et al., 2011).

1.3 Objectives

This chapter assesses (i) the level of population awareness, attitude and willingness to participate in value-added waste disposal for environmental sustainability in developing countries, using Port Harcourt city, Nigeria as a case study and (ii) possible factors contributing to lack of willingness to participate in value-added waste disposal.

2. Materials and methods

2.1 Study area

The Federal Republic of Nigeria comprises 36 states and the Federal Capital Territory, Abuja. Port Harcourt (Fig.2), is the capital of Rivers state, one of the 36 states, with geographical coordinates of 4° 27' 2" North and 6° 59' 55" East. Port Harcourt features a tropical monsoon climate with lengthy and heavy rainy seasons and very short dry seasons. Only the months of December and January truly qualify as dry season months. The harmattan, which climatically influences many cities in West Africa, is less pronounced in Port Harcourt. Port Harcourt's heaviest precipitation occurs during September with an average of 370 mm of rain. December on average is the driest month of the year; with an average rainfall of 20 mm. Temperature is relatively constant, showing little variation throughout the course of the year. Average temperatures are typically between 25 - 28°C (Wikipedia, 2011).

Port Harcourt is one of the major cities in Nigeria and the second largest port in the country after Lagos. It is a major industrial centre as it has a large number of multinational firms as well as other industrial concerns, particularly business related to the petroleum industry. It is the chief oil-refining city in Nigeria. Due to its economic vibrancy and population growth, waste material handling/disposal becomes an important environmental sustainability factor.

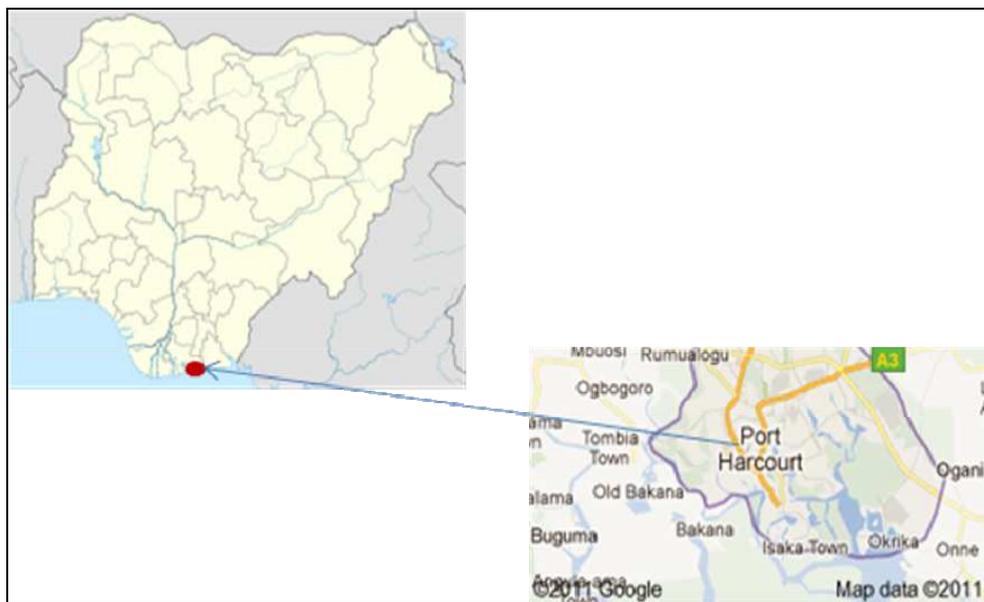


Fig. 2. Map of Nigeria showing Port Harcourt city

Qualitative research survey with the use of structured questionnaire was employed for this work. The respondents comprised of seven hundred, randomly selected, adults within the age range of 18 to 60 years; spread across the highly and non- highly educated, low to high income earners, males and females. All respondents lived in Port Harcourt at the time of study.

2.2 Research method

The questionnaire consisted of 30 research questions, which were grouped under 6 segments. An overview of the research question is presented as follows:

- i. socio-demographic characteristics of participants - age, gender, marital status, educational level and household size
- ii. socio-economic characteristics of participants - employment status, income level, housing tenure, housing type and period of tenement
- iii. awareness and participation in general solid waste management - knowledge and awareness on solid waste management, source of waste management information, waste handling method, type of waste sorting, type of waste collection system, time of waste collection and collection frequency
- iv. awareness and participation in organic solid waste management - knowledge and awareness on organic solid waste management, source of information, organic solid waste management style, composting as organic solid management approach, type of composting practiced, knowledge and awareness on environmental impact of waste materials
- v. financial implication of waste management to the respondents - consideration of waste materials as raw materials, ever been paid money for waste materials generated for transformation to a beneficial end use, ever paid money to municipal authority for waste disposal, possibility of being motivated if paid some token for effective waste disposal? Disposition if asked to pay for waste disposal
- vi. Willingness to participate in community based composting for value-added waste treatment and disposal - willingness to participate in community based composting, willingness to sort wastes at source for easy waste management and disposal, consideration of effective waste disposal as a necessity for environmental sustainability?

2.3 Data analysis

Primary data collected from the 700 respondents were grouped according to the variables. Frequencies were computed to obtain counts on variables' values, which were translated to percentage values. Results were then presented as bar-charts, pie-charts and Tables.

3. Results

3.1 Socio-demographic characteristics of respondents

Results on the socio-demographic characteristics of the 700 respondents (Fig.3) showed that 9% were within 18 to 21 years, 81% fell within 22 to 50 years of age; and 10% were above 50 years. The total study population (60% males and 40% females), comprised largely (70%) of married people while singles made up the 28% and the minority (2%) were either divorced (1%) or widowed (1%). Results, presented in Fig.4, showed that the majority (70%) of the respondents was educated, with a minimum of first degree in diverse disciplines; 25% had a minimum of secondary school certificate or the equivalent and only 4% were primary school graduates. Household sizes varied between 1 and 10 people. Specifically, 36% of the respondents had household size of 3 to 4 persons, 35% had 1 to 2 persons, 19% had 5 to 7 persons and 5% had more than 10 persons constituting the house.

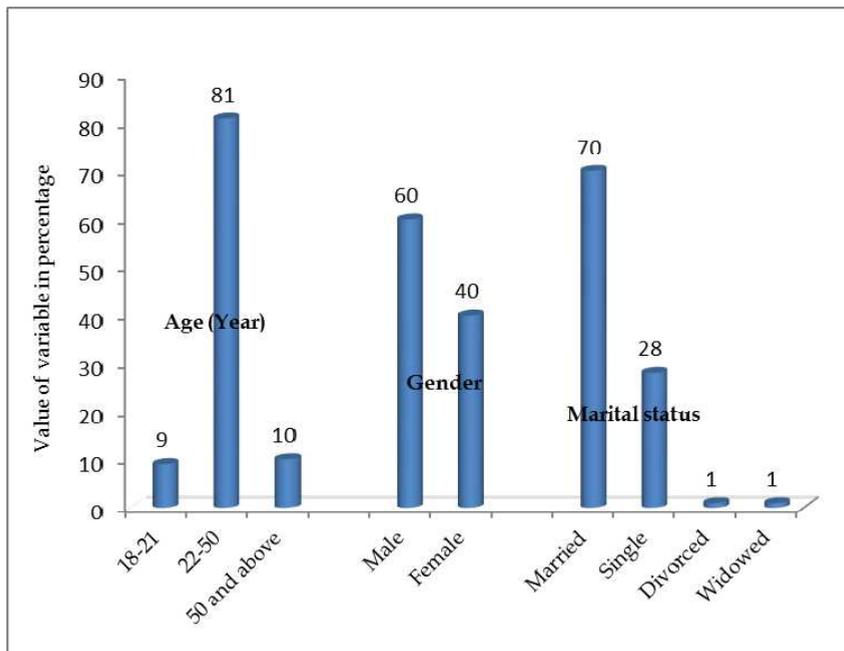


Fig. 3. Distribution of respondents according to age, gender and marital status

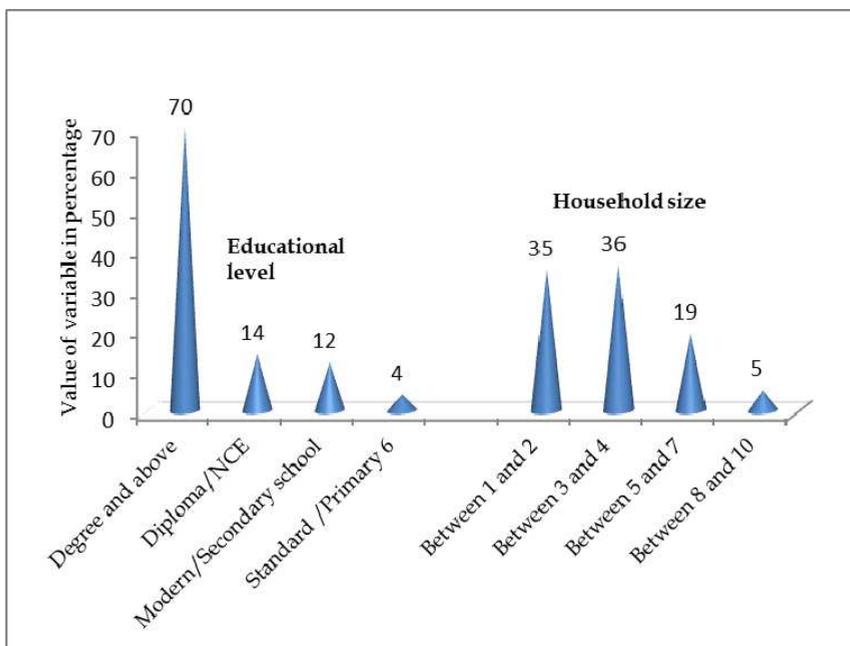


Fig. 4. Educational level and household size of respondents

3.2 Socio-economic characteristics of respondents

Results on socio-economic characteristics of the respondents are presented under the following variables: (i) employment status, (ii) income level, (iii) housing tenure, (iv) housing type and (v) period of tenement. Employment status and income level of respondents are presented in Fig.5 while information on housing regiment of respondents showing housing tenure, type and period of tenement are given in Fig.6. More than half (59%) of the participants were gainfully employed by either the Government or private sector. Only 22% were self employed while 11% were unemployed. However, 8% of them were engaged in jobs that could not be categorized under the previously mentioned job groups. Fifty-seven percent of the population perceived themselves as medium income earners as against 35% and 8% that claimed to be low income and high income earners respectively. The trend in income status was identified in the order: medium income earners > low income earners > high income earners.

Regarding housing regiment (Fig.6), 66% of the respondents were tenants, living in rented apartments and 34% of the total population lived in their own houses; 86% lived in residential areas, 14% dwelt in non-residential (4% for institutional and 10% for commercial). Period of tenement in their houses varied between 1 and 10 years for 48% of the people, less than 1 year for 29% and between 11 and 20 years for just 7% of the participants. However, 16% could not recall how long they had resided in their houses.

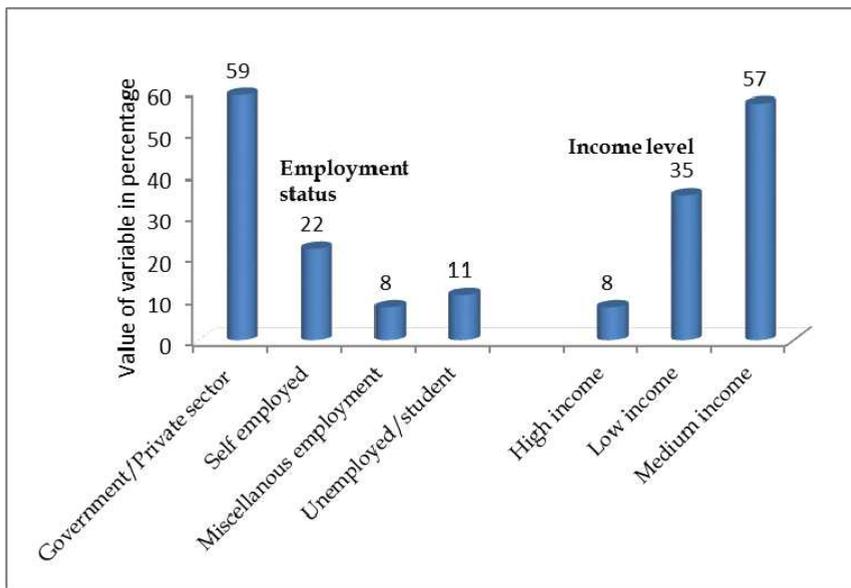


Fig. 5. Employment status and income level of respondents

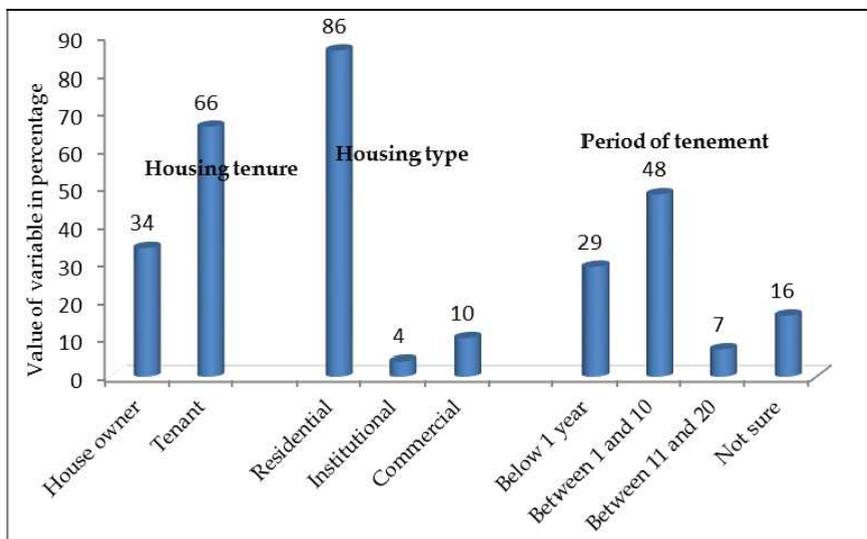


Fig. 6. Information on housing regiment of respondents showing housing tenure, type and period of tenement

3.3 Awareness and participation in general waste management

Results on awareness and participation in general waste management are presented under the following concepts (i) knowledge and awareness on waste management, (ii) sources of waste management information, (iii) waste material handling (iv) type of waste sorting: into recyclables, non-recyclables and biodegradables (v) type of waste collection systems, (vi) time of waste collection and (vii) frequency of collection. Data showed that 76% of the target population was very much aware of the negative impacts of improper waste material disposal on the environment (Fig.7).

Results, presented in Fig.8, showed that up to 85% of the people were aware of the theoretical concept of general solid waste management. Major sources of information were identified as (i) media, (ii) school and (iii) neighborhood for 46%, 13% and 4% of the respondents, respectively. Some participants (3%) claimed to have been informed by friends, 3% attributed their knowledge to other sources of information such as offices and internet facilities while up to 20% of the participants claimed ignorance. Regarding information on waste material handling at source (Fig.9), results showed that no participant really sorted waste materials at source; rather, an overwhelming majority (81%) mixed or mingled their wastes together in a given waste bin and 19% practiced indiscriminate disposal. By this, they disposed of their waste materials at convenience, without discretion on environmental impact of such an action. This, cumulatively, gave a total of 100% of the study population involved in non-segregation of waste at source.

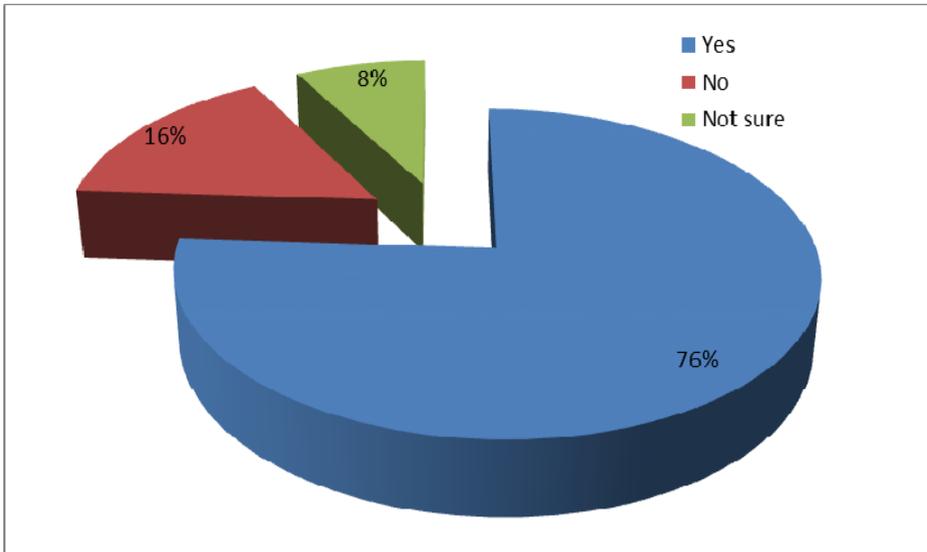


Fig. 7. Distribution of respondents regarding awareness on adverse environmental impact of improper disposal of waste materials

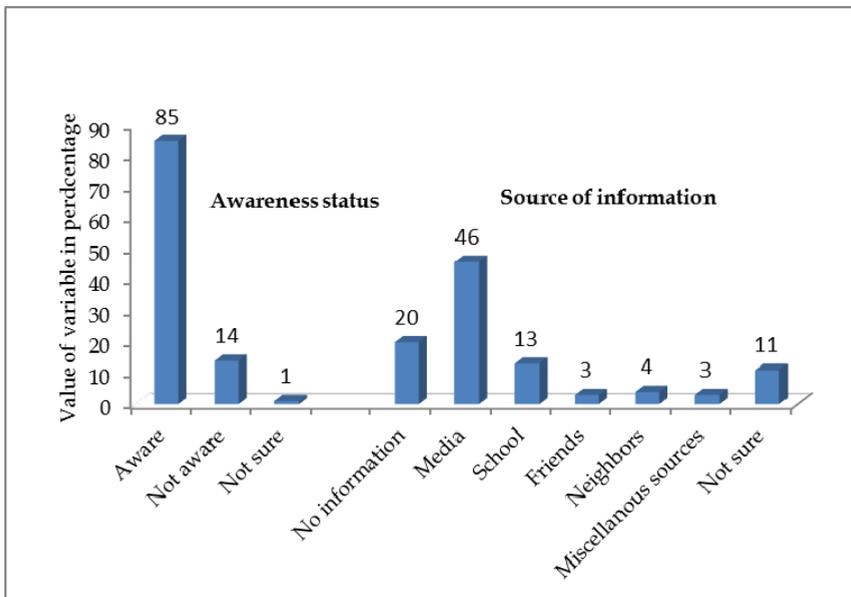


Fig. 8. Awareness status on general waste management and corresponding source of information

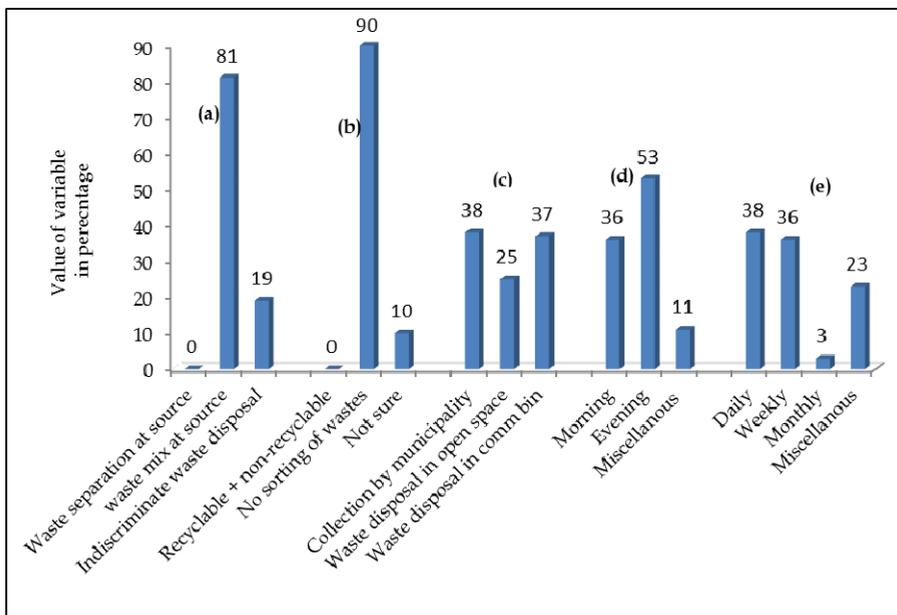


Fig. 9. Waste disposal strategy via handling (a), sorting (b), waste collection technique (c) time of disposal (d) and frequency of disposal (e)

Sequel to perceived lack of proper understanding on the concept by the respondents and benefits of waste segregation at source, a more detailed probe carried out on this subject revealed that none of the participants separated their waste materials into recyclables and non-recyclables materials at source. With this, 90% of the populace confirmed that they did not practice waste separation at source. Ten percent of the people could not categorize their method but they were definite that their method did not fall under waste separation at source. Figure 9 showed that collection of waste materials for disposal by municipal authority was reported by 38% of the participants while waste material disposal in open space (illegal waste dumpsite) was acknowledged by 25% of them and 37% of the participants disposed their wastes in community bins.

3.4 Awareness and participation in organic waste management

The results on the awareness and participation in organic waste management, shown in Fig.10, revealed that 67% of the study population acknowledged theoretical information on organic solid waste management. The remaining 33% were not very knowledgeable on this subject matter. Source of information decreased in the following order: media (44%) > school (13%) > information from friends (3%) > information from the neighborhood (1%). Thirty-nine percent of the participants could not trace their source of information. On organic waste management strategy, 92% of the populace disposed wastes into the collection bin, while the minority (5%) disposed biodegradables into the garden/farm

(Fig.10). None of the respondents practiced composting as effective disposal method for biodegradable organic waste materials.

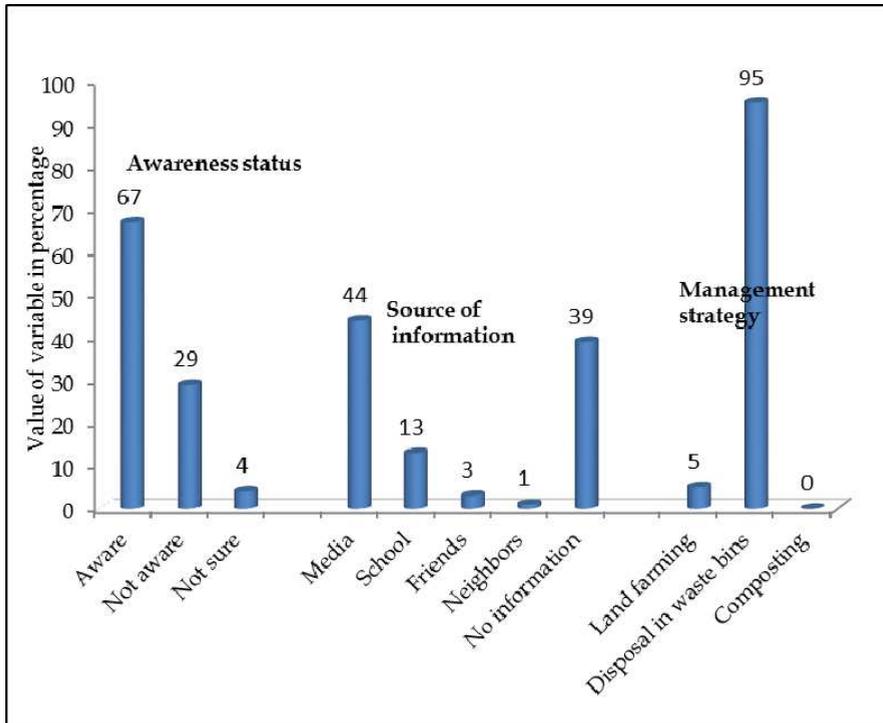


Fig. 10. Distribution of respondents in relation to awareness on organic solid management, source of information and management strategy

3.5 Knowledge and awareness of composting technology as a value-added disposal technique for organic wastes

Results on the survey of theoretical knowledge of the respondents on composting techniques (Fig.11) showed that 40% of the study population was not aware of composting technology. Data showed that the most common composting technology known to respondents was heap composting as acknowledged by 19%, against on-farm composting, windrows, trench/pit, static in-vessel and mechanized/automated composting methods acknowledged by 10%, 14%, 6%, 3% and 3% of the study population, respectively. After sensitizing the respondents on composting technology as a value-added organic waste material disposal technique, there was a shift in perception. Data showed that 82% of the total study population was willing to participate in community based composting for environmental sustainability. Moreover, 84% of them became eager and willing to practice waste segregation at source to facilitate community based composting (Fig.12).

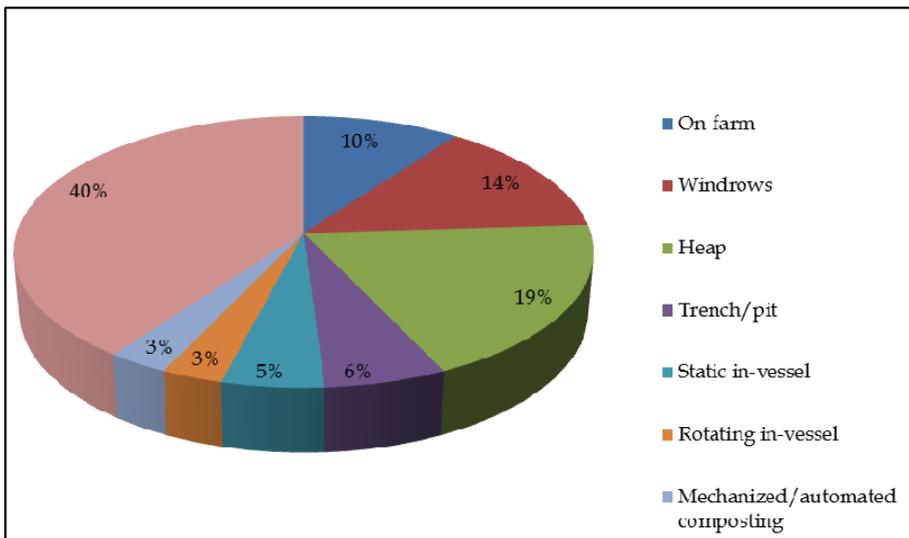


Fig. 11. Information on theoretical knowledge of composting techniques

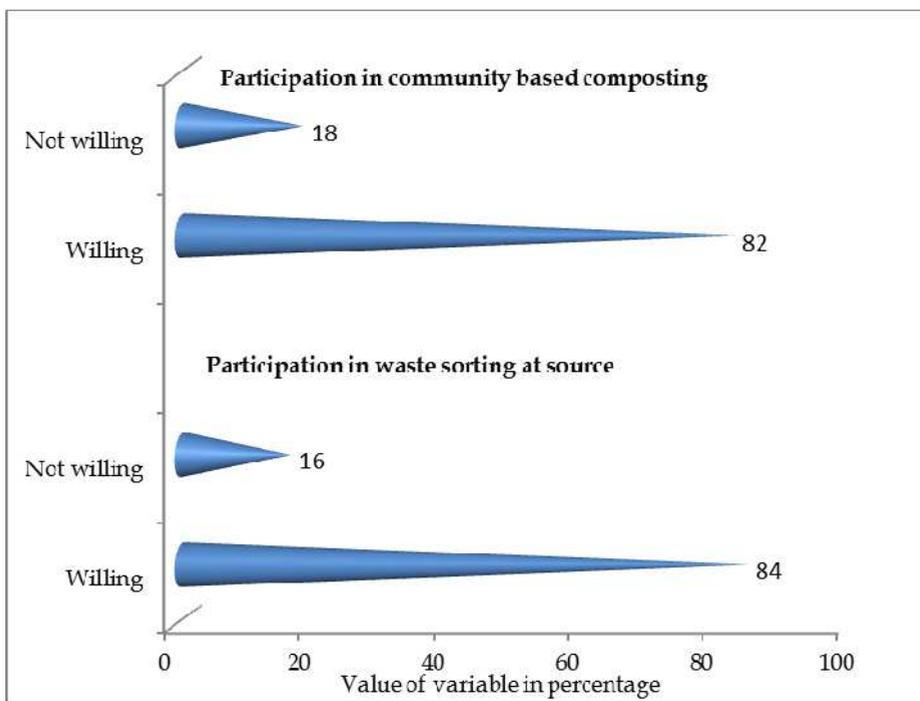


Fig. 12. Distribution of respondents in relation to willingness to participate in waste sorting at source and community base composting for value-added disposal of organic waste materials

3.6 Financial implication of waste management

The response of participants on financial implication of waste management is presented in Table 1. Exactly 84% of the populace considered waste materials as potential raw materials that could procure financial empowerment, but only 69% had actually derived monetary benefits from waste materials. For effective waste material disposal, 58% of the respondents have at one time or the other paid municipal waste management authority. Again, 86% of the people would be motivated to manage their wastes better if they could derive some degree of financial boost from their waste material and 79% would still be motivated even if asked to pay some specific amount of money to achieve effective disposal of their waste materials. The reason is not farfetched as 94% of them were convinced that adequate waste material management is vital to environmental sustainability (Fig.13).

S/N	Inquiry	Response (%)		
		Yes	No	Not sure
1.	Ever considered waste materials as raw materials?	84	13	3
2.	Ever been paid money for your waste materials?	31	69	Nil
3.	Ever paid to municipality for waste material disposal?	58	39	3
4.	Will you be motivated if paid some token for effective disposal of your own wastes materials?	86	10	4
5.	Will you still be motivated if asked to pay some token for effective disposal of your own waste materials?	79	17	4

Table 1. Response of participants on financial implication of waste management

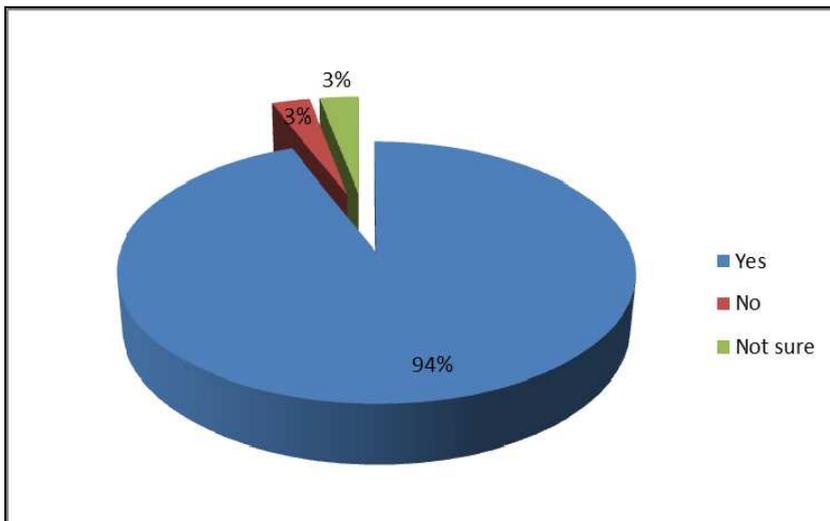


Fig. 13. Distribution of respondents regarding the consideration of waste management as an important factor to environmental sustainability

3.7 Possible militating factors against waste material sorting at source and community based composting

Results on the evaluation of potential factors influencing waste material sorting at source and community based composting are presented in Table 2. Regarding, waste sorting at source (WSAS), the impact of some suspected militating factors were obtained in the range of 15 - 36% for age, 17 - 20% for gender, 15 - 60% for marital status, 12 - 57% for educational level, 12 - 25% for income status, 17 - 20% for housing tenure, 14 - 42% for housing type, 15 - 19% for period of tenement, and 12 - 24% for household size.

S/N	Possible influencing factor	Total number of respondents in response to a given factor	Fraction of population opposed to waste sorting at source		Fraction of population opposed to community based composting	
			Actual number	*Impact (%)	Actual number	**Impact (%)
1.	Age (Years)					
	18-21	64	23	36	16	25
	22-50	567	83	15	88	16
	≥ 50	69	21	30	18	26
2.	Gender					
	Male	420	71	17	71	17
	Female	280	56	20	51	18
3.	Marital status					
	Married	489	73	15	63	13
	Single	197	46	23	55	28
	Divorced	5	3	60	1	20
	Widowed	9	4	44	3	33
4.	Educational level					
	Standard 6/Primary school	28	16	57	11	39
	Modern school/secondary school	87	29	33	23	26
	Diploma/NCE	95	19	20	9	9
	First degree and above	490	60	12	79	16
5.	Income level					
	Low	240	60	25	43	18
	Medium	402	50	12	55	14
	High	58	11	19	13	22
6.	Housing tenure					
	Owner	240	48	20	44	18
	Tenant	460	77	17	78	17

7.	Housing type					
	Residential	598	85	14	97	16
	Institutional	30	10	42	5	17
	Commercial	72	30	42	20	28
8.	Period of tenement (Year)					
	Less than 1	206	39	19	40	19
	Between 1 and 10	334	52	16	78	17
	Between 11 and 20	46	7	15	4	8
9.	Household size (people)					
	Between 1 and 2	243	39	16	51	21
	Between 3 and 4	252	38	15	40	16
	Between 5 and 7	133	31	23	22	17
	Between 8 and 10	37	9	24	7	19
	Ten and above	33	4	12	2	6

*Computed as the number of population opposed to WSAS relative to the total number of study population in response to a given factor, ** computed as the number of population opposed to community based composting relative to the total number of study population in response to a given factor.

Table 2: Evaluation of possible influencing factors to unwillingness in the participation of waste material sorting at source and community based composting

In the perspective of community based composting, the contributions of potential militating factors varied from 16 -26% for age, 17 -18% for gender, 13 - 33% for marital status, 9 - 39% for educational level, 14 - 22% for income level, 17 -18% for housing tenure, 16 -28% for housing type, 8 -19% for period of tenement and 6 -21% for household size.

4. Discussion

This study revealed that most of the respondents were very ignorant of best practices in waste material disposal and management. About 84% of them considered waste materials as potential raw materials but were incapacitated by lack of knowledge. The financial benefit from waste materials as acknowledged by 69% of the respondents came from their own ingenuity. They were involved in practices such as trading in old clothes, shoes, boxes, plastic bottles and glass bottles to generate income. It was also revealed from this survey that the impact of population awareness on waste disposal and management from the media (46%) and schools (13%) were very poor. The factor commonly considered as basic to inappropriate disposal of wastes in developing countries is poverty. Some environmentalists are of the opinion that improper waste material handling in developing countries is compounded by the vicious cycle of poverty; population explosion and decreasing standard of living (Zerock, 2003; Al-Khahb et al., 2007; Ogwueleka, 2009). Surprisingly, the findings from this study did not tow the same direction. This study revealed that impact of income status on either waste segregation at source or willingness to participate in value added waste management, typified by community based composting, was below 30%; varying from 12 to 22%. Similarly, household population

impact ranged from 6 to 24%, indicating that poverty and population are not really the foundational causative factors to unsafe waste material disposal and management in developing countries. Pre-survey analysis revealed zero practice of waste segregation at source but proper enlightenment of the respondent awakened their interest to participate in segregation by 84% and value-added waste management (community based composting) by 82%. It then confirms that positive attitudinal change in the citizens towards best solid waste management practices will be achieved with proper education and mobilization of the populace. Non-segregation of waste materials at source due to ignorance, resulting in lack of easy access to raw materials to work with is, therefore, a major mitigating factor to the Public-Private-Partnership enterprise in solid waste management. Consequently, the investors largely depend on human scavengers who source for raw materials by handpicking waste materials lumped together in the open dumpsites, as shown in Fig. 14.



Fig. 14. Typical informal sector involved in waste recycling in developing countries

This practice is a messy and unhealthy procedure and also undermines the efficiency of Public-Private Partnership. Effective waste material disposal is paramount to a successful Public-Private Partnership. Despite policy promulgation by government authorities and workshops at high places, if the citizens are not properly mobilized or carried along in waste disposal/management program, effective waste disposal in developing countries will still be a mirage.

The respondents were not unaware of the adverse impact of improper waste handling and disposal, prevalent in their environment. These include unsightly aesthetics and corresponding reduced tourist appeal, air pollution, surface water contamination, land

pollution, drainage blockages resulting in flooding and water borne diseases. They also acknowledged that the current solid waste handling, pose risk to public health and the ecosystem in general. They appear to be helpless with the unfavorable and non-conductive conditions of waste management. For instance, there is no proper infrastructure in most cities where one can conveniently dispose segregated wastes. Even if convinced to segregate at household levels, where will these wastes be finally conveyed? They will ultimately end up in a common community bin or dumpsite! Regardless of the form of waste management strategy adopted by municipal authorities, the foundation to value-added waste material transaction is linked to proper handling of the waste materials at source. The problem of waste material management in the developing countries, when properly investigated will be traced to faulty foundations.

The effective disposal of municipal waste material is a major responsibility of the state and local government agencies that often attribute failure to effectively manage waste materials to the fact that the capacity of most municipal services is overwhelmed by rapid, unplanned for population growth against existing infrastructure. The current study revealed that waste material handling at source, as acknowledged by the study population, fell below internationally accepted best management practices in waste management. Results from this study suggest that these agencies are still battling with waste management as a result of less attention paid to the basics of effective waste disposal. Adequate waste material management is beyond a technical issue. It no doubt involves institutional, social, legal and financial aspects but beyond these, involvement of stakeholders - the populace, is paramount. When successful waste material disposal becomes a priority, the mass/citizens have to be carried along by pragmatic and grassroot awareness and enlightenment campaigns. Figure 15 illustrates the current trend in solid waste management/disposal in developing countries as opposed to the ideal focus for value-added waste management approach (Fig.16).

In addition, an important factor that will promote the success of privatization of solid waste management in the developing countries is the enforcement of waste material segregation at source. If the different kinds of waste materials are lumped or mixed together in one collection vessel, which could range from paper bag, polyethene bags, plastic buckets to metallic containers; the values of the materials are lost to a large degree so also the viability of Public-Private-Partnership. For PPPs to succeed, the raw materials procured from wastes must be in good shape. From this study, the major reason solid waste management in developing countries is a herculean task is not because the quantity and complexity of the materials are greater than the ones generated in the developed nations, neither is it essentially due to lack of high - tech facilities. The reason why privatization of solid waste management is not yet a thriving business in developing countries is not due to over population or increased trend in rural-urban migration. There is no doubt to obvious challenges to waste management in developing countries which include:

- material composition, density and quantity
- inefficient waste collection method
- access to waste materials and improper disposal
- bottlenecks from political and economic frameworks
- technological platform (facilities and human expertise).

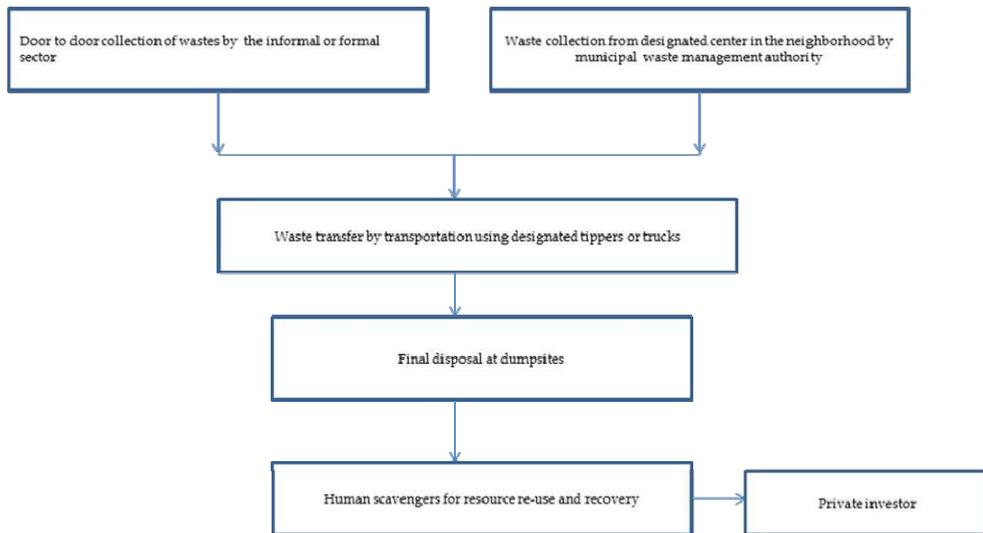


Fig. 15. Schematic diagram on the overview of the current waste management system in Port Harcourt and Nigeria in general

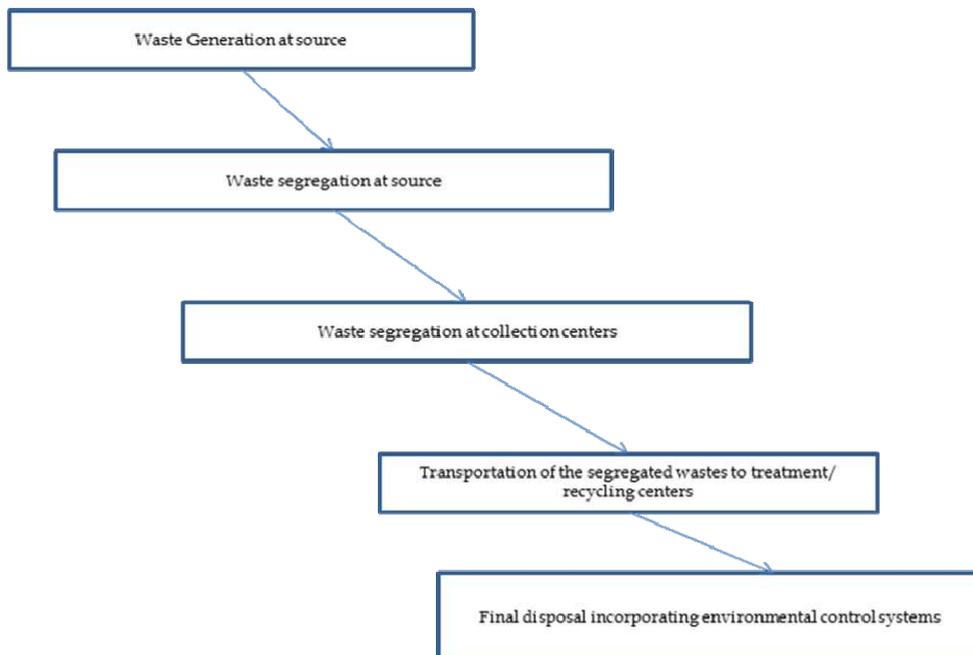


Fig. 16. Schematic diagram on the overview of ideal value-added waste material handling and disposal

These factors notwithstanding, this study has shown that waste management in developing countries could take a leap in the direction of Public-Private-Partnership if the citizens are properly oriented. Ignorance and lack of energetic mobilization of the populace are primary factors to low sanitation habit of most people in developing countries. It is often asserted that people living in developing countries are chronically of low hygiene but let us pause and ponder. When people from developing countries travel and live in developed countries, do they not conform to the laws and regulations on waste disposal? This is because of the awareness they get in such places. Furthermore, are all of the immigrants from the developing countries to the developed countries educated and rich? It will, therefore, not be very correct to say that people in developing countries enjoy the poor sanitary condition they find themselves in. In developing countries, an attitudinal change is expedient to effective waste materials disposal and management for a healthy environment and this can only be achieved through proper orientation and mobilization of the populace.

After enlightenment of the respondent, the fraction (84%) that are willing to participate in waste segregation at source and 82% in community based composting points to the eagerness of the citizens to see their waste materials transformed to resource materials that can be utilized beneficially. This is an indication that they consider source segregation as a step in waste management for environmental sustainability. It then follows that if properly informed, mobilized and conditions made favorable, the citizens will actively participate in effective waste disposal and value-added solid waste management such as segregation at source and community based composting scheme, for a cleaner and healthier environment. This step will also facilitate the Public-Private-Partnership in waste management.

Improper disposal of waste materials constitutes environmental and health hazards and contravenes an aspect of the Millennium Development Goals (MDGs), in particular, Goal 7 that focuses on environmental sustainability. Proper and effective waste disposal is an important component of environmental sanitation and sustainability. This makes waste segregation at source a practical and mandatory measure to attaining the goal 7 of the MDGs, which can only be achieved through proper information dissemination to the citizenry. This survey revealed positive attitudinal change as an area that should be worked on by relevant waste management authorities in developing countries for environmental sustainability. This study also showed that information performance on this subject decreased as follows: media (46%)> school (13%)> neighborhood (4%) > miscellaneous (internet, office: 3%). How different it would be if the percentage impact from school on information dissemination was very much higher (on the average of 70%)! This is an avenue where the citizens in developing countries could be captured young and proper waste handling becomes part and parcel of their daily activities. This is where the hearts and mind could be positively influenced and piloted towards effective and value-added waste disposal and management.

4.1 Role of population perception on value added waste material disposal

Perception is a way of regarding, understanding or interpreting something; a mental impression of a given phenomenon, in this case, solid waste management. More emphatically, population perception of waste management describes the whole process of

how the populace comes to know what is going on regarding best practices in waste management. Simply put, it is the emotional and mental disposition of the mass/citizens towards waste management protocols. Awareness and enlightenment programs through information, education (formal and informal), capacity building, coupled with implementation and execution of laws and regulations on proper waste disposal will affect the population's perception and willingness to participate in best waste management practices. Presently, municipal governments in Nigeria, particularly Port Harcourt city, are solely responsible for all waste related activities. The possibility that some personnel involved in waste management under the auspices local authorities do not know better should not be ruled out, hence, it is also important to get them well informed on effective waste material disposal strategies. Population participation in waste management protocols is the process by which individuals in the families and communities; both old and young understand and take responsibility for their generated wastes. The cooperation of the citizens leads to a successful solid waste management system in any city. The people should be involved in the following processes:

- proper waste storage at source
- waste segregation at source
- waste collection and transfer to an approved point in the neighborhood where wastes are also segregated prior to collection by municipal authority.

This organized waste handling results in safe and environmentally friendly waste material disposal. There is no denial about some ongoing orientation activities and programs in developing countries, Nigeria inclusive, on waste management but the clarion call is that a more pragmatic approach should be adopted. Result oriented, goal achieving strategies are needful. Mass mobilization in ways and languages the people understand should be adopted. In Nigeria, the most current program is an activity that requires residents to spend the last or first Saturday morning of each month to clean their surrounding and clear waste materials dumped on the streets. This implies that in most places, improperly disposed wastes pile up, waiting for the appointed day of state sanitation exercise. This type of program provides a temporary measure, ensuring that proper sanitation is carried out only twelve times a year in each city.

Benefits of effective population participation in waste management include:

- reduction of waste generation at source
- increased re-use of materials before final discarding
- safe collection of wastes
- proper storage of organic biodegradable waste for value-added disposal
- adequate storage of recyclable waste materials separately at source for value-added disposal
- reduced indiscriminate discarding of wastes, which minimizes the quantity of litters on the street and those thrown into drainages
- provision of less polluted raw materials for private investors, in contrast to the more polluted waste materials picked from the waste dumps as currently practiced
- improved environmental aesthetics
- improved public health
- viable Public-Private-Partnership in waste management

4.2 Approaches to enhancing population participation in value-added waste material disposal and management

The family and community are pivotal to all human activities including waste material disposal. Avoiding or ignoring these important stakeholders creates a void in waste management system. Public participation is an important factor to the success of safe waste material disposal and as a matter of necessity must be encouraged. In most cases, countries in developing world comprise of diverse ethnic groups, cultures and beliefs, so it is essential that each country/city decides on the methodology that is best suitable to the citizenry, seeking their cooperation and effective participation. However, basic strategies to enhancing population perception and participation in best practices in waste management are briefly discussed:

4.2.1 Identification of stakeholders

Identification of stakeholders involves assessing the group of people that constitute the populace in a community. The stakeholders can be categorized in a variety of ways, using different criteria such as age, gender, education, income level and marital status. They can also be grouped according to housing schemes such as those living in the residential areas, commercial areas and institutions. Dividing the populace into these fragments gives a more effective outreach. For instance, addressing the highly educated and the illiterates using the same method will obviously bring disparity in understanding. Waste management seminars, workshops, conferences and publications will be of little use to the uneducated. The point made here is that there should be an all encompassing outreach to the grass root. This creates an enhanced interaction with the populace, which is the most important issue because of the diversity in the level of awareness and sensitivity in each group.

4.2.2 Community mobilization

Reaching the community is quite a difficult task but an effective methodology that could be helpful. To achieve the desired result in this area, the local authority in waste management could select reliable community representative that could initiate consultative processes. This will facilitate the understanding of the population perception and expectation, which will in turn help the authority on how to tackle the people's attitude, influence their willingness to participate in safe waste material disposal and the relevant option in effective value-added waste management. It is important to stress that the community representative are more effective if they are able to speak the language of the people for enhanced interaction.

4.2.3 Public awareness campaigns

This is a process in which people are made aware of the problems of improper waste material disposal and the benefits of safe disposal in waste management. The essence of public awareness, public education and motivation programmes is to (i) give diverse possibilities for public/stakeholder interaction, (ii) influence public perception (iii) induce attitudinal change, (iv) clarify doubts and negative perceptions (v) give constructive follow-up and (vi) provide platform for policy makers.

The enlightenment campaign should be conducted in the most suitable mode that appeals to the populace in a given region. These activities will ensure that people become aware of the problems and negative environmental impacts of waste accumulation in streets and gutters, emphasizing how it directly affects their lives. The message should promote reduced waste generation and provide information on safe handling of generated wastes. The campaigns should inform the populace on the waste management program outlined by the government and possible penalties for defaulters. Taking the issue of road safety campaign in Nigeria as an illustration; until recently, most Nigerians drove cars without fastening the seat belt but the concerted efforts of the Federal Road Safety Commission (FRSC), who embarked on grass root awareness campaign, implementation and execution of promulgated policy and dispensing punishment to defaulters; has brought a positive change to the perception of the use of seat belt in driving. Similarly, some other Institutions in Nigeria such as the Shell Petroleum Development Company (Nigeria) Limited, have performed excellently in educating their workers on safe waste material disposal. If significant levels of success have been achieved by the two cited examples, it indicates that adequate awareness and enlightenment campaign on safe waste materials disposal will achieve a great level of success. Public awareness could be actualized through the under listed approaches:

Environmental education: this involves group meetings in the community, workshops, exhibitions, seminars, lectures series, panel discussions, dramas, posters, banners and fliers. Institution of waste management clubs in primary, secondary and tertiary schools; propagation of slogans that promote clean environment and outreach services/programs through the media in both national and local languages should be encouraged.

Open education: in most practical cases, it may not be possible to reach out to the relevant stake holders through the conventional educational institutions. Mass/open education through the formal and informal sector therefore comes to play. The vital factor here is effective communication. Avenues to achieving this include print, web/internet and audio-visual media. Also effective are the use of entertainment media such as cinema outreach, comedy forum, street plays, street dances, animations (e.g. puppet shows and cartoons), carnivals and reality shows. The display of pamphlets, handbills, posters, banners, and fliers with good photographs and messages with few and readable words also raise awareness. In addition, messages can be conveyed by paintings on walls and buses.

Academic curricula: Inclusion of waste management for environmental sustainability in academic curricula at all levels of education will immensely contribute positively to population perception and attitudinal change. If the citizens are mobilized at a tender age, safe waste material disposal then becomes a natural habit. This promotes sense of responsibility and best practices in waste management becomes inculcated in the citizens very early in life and their hearts and minds are captured; children from homes where parents are not formally educated become powerful educators/communicators, bridging important gaps. The establishment of literary and debate clubs in waste management in school, who would be involved in various competitions, would reinforce safe practices. Prizes and awards to winning contestants, who will be publicized as role models for others would further strengthen the efforts, bringing life and vitality to issues of waste management.

Involvement of faith based organizations: the involvement of religious leaders would facilitate safe waste material disposal in developing countries where religious leaders play significant roles in influencing peoples' perception on sensitive issues. Seminars/capacity building workshops on waste management issues can be organized by government for faith based leaders, who in turn will speak to their followers in much more effective ways.

Mobilization of women: the female gender is an important change agent in most societies of the world, especially in the developing countries. "Train a woman, train a nation" says the old adage. Furthermore, women are more accountable to the maintenance of health and hygiene in most homes.

Involvement of health sectors: the medical practitioners such as doctors, nurses and paramedics are also in the position to influence the populace. They are held in high esteem by their patients, so counsels from them will be appreciated and practiced by their clients.

Involvement of non-faith/governmental based organizations: Many non-governmental organizations (NGOs) should be encouraged financially by government and international bodies to actively participate in mass mobilization and public enlightenment regarding safe waste material disposal. In most cases, NGOs have personnel equipped with good mass-communication and education programs who could develop programs for the public.

4.2.4 Enforcement of promulgated policies

The very many policies, totaling up to eleven, on environmental issues in Nigeria have not effectively addressed the problems of inadequate waste material disposal. These statutory laws and regulations are often reviewed, revised, updated and often leads to the promulgation of new laws thereby increasing their numbers but not necessarily their effectiveness. There are diversities of understanding potentials in a group of people. In an attempt to exhaust all avenues of educating the populace to willingly participate in safe waste material disposal for a sustainable environment, it should be noted that there are differentials in the understanding rate for a given hum population. Their norms, values, commitment and dedication to a national course also differ. It then becomes necessary to use alternative tool in bringing about attitudinal change and demonstrated change in perception. That tool is enforcement by the appropriate agency without compromising standards. In this process of enforcement, defaulters should be punished to serve as deterrent to adamant ones. The laws enforcement agent should live above boards in terms of corruption. Any officer involved in corrupt practices should be brought to book.

4.3 Value-added solid waste disposal management

The most viable waste recycling procedure currently practiced in developing countries is equally dangerous. In these countries, resource recovery and recycling activities on waste management are driven by the informal sector. Populations of low socio-economic status consisting of both the elderly and the young (scavengers) pick valuable items found in the waste dumps (Fig.14), including bottles, metallic wares, perfume containers, and sell them to private sectors. There is a school of thought that this is a means that provides livelihood to thousands of poverty stricken citizens. These human scavengers, who use their bare hands and spend long hours in the dumps, sifting through the rubbish for valuables, are

exposed to health risk and when they become infected with contagious diseases such as diarrhea, dysentery amongst many, the populations of high socio-economic status are not spared, putting the nations at risk. Furthermore, lack of personal protective equipment puts the scavengers in direct contact with needles and different types of hospital wastes, exposing them to diseases such as HIV and AID (Agunwamba, 1998).

Value-added solid waste disposal focuses on the transformation of waste materials to useful end-products or raw material for possible industrial applications. This is a trend that has gained global acceptance but has not blossomed in the developing countries (Adekunle & Adekunle, 2006; Garg et al., 2007). The promotion of population participation in waste management brings about feasible and viable Public-Private - Partnership. For PPP to thrive in developing countries, the waste collection system must undergo a drastic change. The advent anchors on waste segregation at source, which is currently being neglected. The objectives of PPPs are to establish an integrated solid waste management system mode to achieve excellent level of collection and disposal, whereby the private sector will be involved in the process; from collection of waste material till its final disposal. Aside from waste segregation at source, meeting infrastructure needs is a militating factor against PPP in the developing countries. Viable options (Lavee & Khatib, 2010; Selke, 2002) in the evolution of PPP in solid waste management include:

Metal scrap recycling: the scrap metal recycling industry encompasses a wide range of metals but are divided into two basic categories: ferrous and nonferrous. Ferrous scrap is metal that contains iron. Iron and steel (which contains iron) can be processed and re-melted repeatedly to form new objects. Most common nonferrous metals are copper, brass, aluminum, zinc, magnesium, tin, nickel, and lead. Commonly recycled metals (by volume) are iron and scrap steel, copper, aluminum, lead, zinc, and stainless steel. Sources of ferrous scraps include: mill scrap (from primary processing), used construction beams, plates, pipes, tubes, wiring, old automobiles and other automotive scraps, boat scrap, railroad scrap, railcar scrap and miscellaneous scrap metals. Aluminum is the most widely-recycled nonferrous metal. The major sources of nonferrous scrap are industrial or new scrap and obsolete scrap. Industrial or new scrap may include: aluminum left over when can lids are punched out of sheets, brass from lock manufacturing, copper from tubing manufacturing. Other major sources for metal scraps are: copper cables, copper household products, copper and zinc pipes and radiators, zinc from die-cast alloys in cars, aluminum from used beverage cans, aluminum from building siding, platinum from automobile catalytic converters, gold from electronic applications, silver from used photographic film, nickel from stainless steel and lead from battery plates (OSHA, 2008).

Waste plastic recycling: this is the process of recovering scrap or waste plastics and reprocessing the materials into useful products, sometimes completely different in form from their original state. Often, this could involve melting down plastic bottles and then casting them as plastic chairs and tables. Academic materials such as rulers are also produced by plastic recycling. Typically, a plastic is not recycled into the same type of plastic, and products made from recycled plastics are often not recyclable. Plastic wastes also serve as secondary feedstock for blast-furnace coke production (Fortelny et al., 2004; Melendi et al., 2011).

Waste paper recycling: there are three major categories of paper materials that can be used as feedstock for making recycled paper: mill broke, pre-consumer waste, and post-consumer

waste. Mill broke is paper trimmings and other paper scrap from the manufacture of paper, and is recycled internally in a paper mill. Pre-consumer waste is material which left the paper mill but was discarded before it was ready for consumer use and post-consumer waste is material discarded after consumer use such as old magazines, old newspapers, office paper, old telephone directories, and residential mixed paper. Paper suitable for recycling is called "scrap paper", often used to produce molded pulp packaging (Huhtala, 1997; Merrild et al., 2008).

Waste tire recycling: tires are often recycled for use on basketball courts and new shoe products. However, material recovered from waste tires, known as "crumb," is generally only a cheap "filler" material and is rarely used in high volumes. Tires can be recycled into, among other things, the hot melt asphalt, typically as crumb rubber modifier - recycled asphalt pavement. Tires can also be recycled into other tires and discarded tires that are not recycled through retreading could provide a source of hydrocarbons for use as fuel, feedstock materials. In summary, waste tire recycling practices include retreading, recycling as crumb rubber and combustion for thermal energy (Wolsky & Gaines, 1981; Yang, 1993; Jang et al., 1998).

Waste to energy initiatives: waste-to-energy conversion involves the processing of many different types of unusable waste streams into heat, electricity, and other forms of energy. A variety of technologies are used to convert waste into energy. Several of the more prominent technologies include: (a) incineration, which possesses low efficiency and high environmental burdens; often requires a large footprint and high costs, (b) bioconversion, which has a low throughput, low conversion rate, and large footprint, and requires large volumes of water per unit mass bacteria, (c) plasma gasification which requires a large-scale system and demands high volume input for economic feasibility; and (d) downdraft gasification, which demands a small-scale system and requires low volume input and results in the cleanest syngas (Wolsky & Gaines, 1981).

Recycling of biodegradable organic wastes: biodegradable waste materials are putrescible, therefore, can undergo decomposition. The common recycling methods for these are (i) anaerobic digestion to produce biogas and (ii) composting to produce formulations useful in the fields of agriculture environment (Adeoye et al., 1994; John et al., 1996; Adekunle, 2011; Adekunle et al., 2011). Major mitigating factors to these initiatives in developing countries include low product quality, lack of guidelines for product acceptability and low market demand (Adekunle, 2010). All these factors are traceable to lack of technology and human expertise in science and technology of organic solid waste management.

Bearing in mind that the nature of wastes generated in developing countries constitutes largely of organic materials, recycling of organic solid wastes appears to be a viable waste treatment and disposal method and perhaps the most feasible due to its viability under low-tech infrastructure conditions. This study has clearly demonstrated the ignorance of the respondents regarding composting technology but it is believed that for a more efficient public-private-partnership in organic waste management strategy, there must be a concerted effort in mass mobilization/ re-orientation to positively change the attitude of citizens in waste material handling and disposal. If the perception of the citizens is steered towards proper management of biodegradable waste materials via composting technology, it will greatly enhance the reduction of the waste stream going to both legitimate and illegal

waste dumpsites. In addition, this move will contribute positively to reduced emission of methane (CH₄), a greenhouse gas, from decomposing organics. By implication, composting technology; under best management practices, will impact positively on the environment, not only in terms of land applications but also in the abatement global warming and extreme weather events.

4.3.1 Value added waste material disposal via composting technology

Reports from literature indicate that over 50% of wastes in a typical developing country could be readily composted; being biodegradable in nature (Hoornweg et al., 2000; Ogwueleka, 2009; Adekunle et al., 2011). Composting is a cornerstone of sustainable development, which is neglected within integrated municipal solid waste management in developing countries. It is a technology that does not necessarily involve complex infrastructure. Composting is certainly not a panacea to all the waste management problems in developing countries but it is an important component within most integrated municipal waste management strategies. It can be applied to various types of wastes ranging from municipal solid wastes (biodegradable materials) to wastes generated in the oil industry such as soil, sludge and oil based mud (OBM) drill cuttings (McCosh & Getliff, 2004).

Composting is a simple process where optimization efforts are used to increase the rate of decomposition (thereby reducing costs), minimize nuisance potential, and produce a clean and readily marketable finished product. Composting helps to increase the recovery rate of recyclable materials such as paper, glass, plastics; if wastes are source separated. Essential benefits of composting as highlighted by Hoornweg et al., (1999) are;

- increases overall waste diversion from final disposal, especially since as much as 80% of the waste stream in low- and middle- income countries is compostable
- enhances recycling and incineration operations by removing organic matter from the waste stream
- produces a valuable soil amendment- integral to sustainable agriculture and remediation of contaminated soils such as crude oil impacted sites and those impacted by chlorinated hydrocarbons
- promotes environmentally sound practices, such as the reduction of methane generation at landfills
- flexible for implementation at different levels, from household efforts to large-scale centralized facilities.

The second phase of this study, a pilot scale demonstration on the utilization of indigenous biodegradable waste materials, sourced from Port Harcourt city and environs in the bioremediation of crude oil impacted environmental matrices (soil, sludge and OBM drill cuttings) via composting technology, is approaching the final stage. It is postulated that by the success of this venture, the under listed benefits will be achieved:

- waste to wealth initiative
- community based organic solid waste management
- human capacity building
- job creation for the unemployed youths
- poverty alleviation
- improved environmental sanitation through safe waste material disposal

5. Conclusions and recommendations

Conclusions reached from this study are:

- over 70% of the study population were aware of the negative impact of unsafe waste material disposal
- the current public awareness and mobilization on safe waste material handling, treatment and disposal is very low (below 50%)
- waste segregation at source is rarely practiced
- waste mix at source is currently practiced by virtually all respondents
- impact of municipal authority in effective waste collection is below 50%
- the people were willing to participate in waste segregation at source and composting technology as value-added waste material disposal, if properly educated and
- population awareness and mobilization is pivotal to value-added waste disposal in developing countries.

It is recommended that machinery to enhance positive population perception on value-added waste material disposal be put in place. Basic tools in the machinery must constitute aggressive grass root orientation programs, environmental education and mobilization and enlightenment campaigns. Further studies should focus on (i) pilot scale trials on waste segregation at source using selected communities in urban areas of the developing countries (ii) community based composting schemes aimed at formulating composts suitable for land applications and bioremediation purposes.

6. Acknowledgements

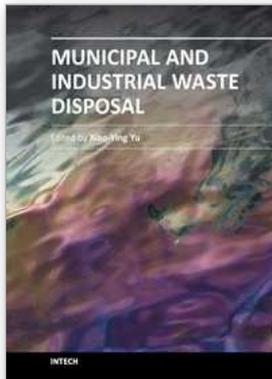
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This book reports research findings on several interesting topics in waste disposal including geophysical methods in site studies, municipal solid waste disposal site investigation, integrated study of contamination flow path at a waste disposal site, nuclear waste disposal, case studies of disposal of municipal wastes in different environments and locations, and emissions related to waste disposal.

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