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# **Potentials for improved inorganic waste management options in Lagos, Nigeria**

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International environmental studies



## DECLARATION

I, Temidayo Paul Amosun, declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for award of any type of academic degree.

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Temidayo Paul Amosun



## **ABSTRACT**

A key implication of the improved standards of living and the increased consumption it entails in the developing countries of the world is the massive increase in the generation of waste. Inorganic waste forms a significant portion of the waste generated in the developing countries and has continually posed difficulties in terms of its disposal and management with attendant deleterious consequences on the livelihood of residents. This situation is particularly dire in a metropolis like Lagos with millions of residents. This study was therefore aimed at examining the potentials for improved inorganic waste management in Lagos State. This was approached from the standpoint of an examination of the current means of waste disposal and the constraints on waste disposal on the part of residents and the regulatory agencies and also the constraints on the adoption of advanced methods of inorganic waste management. Descriptive research design was employed in collecting quantitative data and the study revealed that social, economic and technological factors are significant constraints on the adoption of advanced methods of inorganic waste management.

**Keywords:** Inorganic waste, waste management, constraints on waste management.



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## 1. INTRODUCTION

This chapter provides an introduction to the study. The background to the study, research questions and the identified objectives of study would be discussed. The significance of study, overview of methodology and the limitation of the study would also be examined.

### 1.1 Background to the study

An important aspect of modern day living is the management of waste generated by the various human and non- human activities essential for life. According to Wilmoth (2012), *'managing waste has become one of the most important developmental challenges of the twenty first century, one that has continually necessitated the evolution of increasingly effective, comprehensive and efficient approaches'*. The rapidly increasing rate of urbanization especially in the developing countries have also transformed waste management into a top- priority issue especially among policy makers. As noted by Pijawka (2015), the achievement of waste management goals has taken on the status of a global concern especially among the developing countries where the level of infrastructural development has proved to be inadequate for comprehensive waste management programs. In such countries, the population is always at risk of environmental, social and health crisis that can be traced to poor waste management systems.

In the developing countries of the world, poor waste management have become a menace that threatens livelihoods. The slums and open dump- sites of Sub- Saharan African countries have continually served to illustrate the short and medium term effects of ineffective waste management systems. According to Olukanni, Akinwumi, Ede and Oluseyi (2014), *'Nigeria is increasingly experiencing environmental threats because of the ineffective waste management measures that have been adopted over the years'*. The fact that there are a different kind of wastes and the existence of specialized waste management techniques that could be tailored towards each kind of waste have made waste management more complex in the developing countries.

## **1.2 Problem statement**

A stark reality of living is that waste must be generated. Different societies have adopted different methods to ensure that waste is effectively managed. The management of inorganic waste have proved difficult because unlike organic waste, inorganic waste do not decompose and become reconstituted into different organic materials (Babalola et al, 2010). The population of Lagos is expected to double by the year 2050 (Opejin, 2014). This translates into an increase in population of more than ten million people with the attendant increase in inorganic waste generation. Waste generation is also estimated at 0.5kg per capita per annum (Opejin, 2014). These statistics necessitate the exploration of robust and sustainable waste management options, the absence of which might portend disastrous environmental catastrophes.

As reported by Lacoste and Chalmin (2007), inorganic waste management systems in the developing countries are not optimally designed and are based on the crude and sporadic implementation of policies around the options of landfilling, burning and primitive recycling. Generally, these measures have been inadequate in the management of inorganic waste and this is evident in the illegal landfills that dot the city of Lagos and the sporadic and uncontrolled burning of inorganic waste by households and commercial entities. Ogwueleka (2013) pointed out that the current options of open dumpsites and burning widely adopted in Nigeria are not efficient, effective nor sustainable in the long run. Agunwamba (1998) supported this view by stating that ‘the primitive waste management techniques used in Nigeria will only aggravate the country’s environmental problems in the long run’. There is therefore a need to adopt more sustainable solutions.

Nigeria is one of the largest producers of waste in Africa and a significant portion of this waste are inorganic in nature which indicates that they are non- biodegradable and thus more difficult to manage. Improper disposal and management of inorganic waste have been shown to lead to several environmental challenges such as pollution of water bodies, blockage of drainage

networks and sewer lines, as well as contribution of landfill disposals to climate change (Agunwamba, 1998). These challenges, if not resolved, have the tendency of degenerating into full-blown environmental crisis. However, the adoption of improved waste management options has the potential of stemming the effects of ineffective waste management practices that have been adopted in the past and also ensure a neater and more environmentally friendly future. Identifying potential inorganic waste management options will go a long way in ensuring that the waste management problems faced by developing countries generally are mitigated.

This study seeks to answer the research questions listed below

### **1.3 Research questions**

1. What are the types of inorganic waste generated in the study area?
2. What are the current methods of inorganic waste disposal, waste collection, and waste transportations and treatment in the study area?
3. What are the constraints on inorganic waste disposal and management by local residents?
4. What are the constraints on inorganic waste management and regulation by officials in the study area?
5. What are the realistic options for inorganic waste management in the study area?
6. What are the social, technological and economic constraints on adoption of identified options for inorganic waste management in the study area?

### **1.4 Objectives of study**

The general purpose of this study is to examine the potentials for improved waste management options in Lagos State while the specific objectives are to;

1. Identify the types of inorganic waste generated in the study area.

2. Identify the current methods of inorganic waste disposal, waste collection, and waste transportations and treatment in the study area.
3. Examine the constraints on inorganic waste disposal and management by local residents.
4. Examine the constraints on inorganic waste management and regulation by officials in the study area.
5. Identify the realistic options for inorganic waste management in the study area.
6. Examine the social, technological and economic constraints on adoption of identified options for inorganic waste management in the study area.

### **1.5 Significance of study**

The problem of waste management is an important one and the costs of inefficient waste management systems are catastrophic. This is more catastrophic in the developing countries of the world where the institutions that coordinate the management of wastes are largely non-existent and ineffectual (Igbinomwanhia, 2011). As such, the menaces of pollution and environmental degradation have continually plagued developing societies giving rise to various social and economic costs. A developing society like Lagos State have a projected populating growth rate of 3.6% per annum, this represents considerable increase in waste generated. This study is significant because it would provide an empirical framework for determining the various waste management options that are viable in Lagos State.

### **1.6 Justification**

The study would also identify the barriers to the adoption of inorganic waste management options in Lagos State, as such it would prove to be a valuable information tool for decision-makers and policy designers who are involved in the design and implementation of waste management processes. The study would also serve as a research reference point that would

inform the design of other researches into waste management options, their implementation, and the barriers to their adoption in the developing countries of the world.

### **1.7 Organization of study**

This study is organized into five chapters in order to provide a structure and logical flow of concepts. The first chapter provided an introduction to the study, and covered the background to the study, the research problem, objectives of study and significance of the study. Chapter two will provide a review of relevant literature with respect to the theme of this study and stated objectives. Chapters three and four will discuss the methodology of the study and a discussion of research findings respectively. Chapter five will discuss the summary of the study, conclusions and recommendations.

## 2. LITERATURE REVIEW

This chapter provides a thematic exploration of the various concepts necessary for studying the potentials for improved inorganic waste management options in the study area. The concepts of waste management and inorganic waste management will be examined. The constraints on inorganic waste management and the regulation guiding waste management in developing countries. A review of global advances in sustainable inorganic waste management will be attempted as well as the social, technological and economic constraints on the diffusion and adoption of such practices. A review of relevant theories and previous empirical literature would also be done. The last section of this chapter deals with an identification of gaps in research and how this study fills the identified gaps.

### 2.1 Literature

#### 2.1.1 The concept of waste management

A logical, visible and unavoidable product of the various human activities on earth is the generation of various types of waste. The recent concern on waste management is hinged on the fact that most countries of the world especially those that are termed as developing have not been able to design and implement frameworks for sustainable waste management. Even in the developed countries, there is a need to manage waste on a sustainable basis. According to Robinson (1986), solid waste management is described as the purposeful application of techniques that would ensure the orderly executions of such functions as the collection, transportation, processing, treatment and disposal of solid waste. In another definition, Igbinomwanhia (2011) defined waste management as *'a process whereby strategic combination of methods are employed to efficiently regulate waste from the source of generation up to the final disposal point with the aim of maintaining a perpetually safe and healthy environment at minimal cost'*.

Some other authors especially those working on waste management in the developing countries provide a conceptualization of waste management in terms of solid waste management. For example, Nzeadibe (2008) described integrated solid waste management as an approach that utilizes a wide range of methods and practices to handle municipal solid waste – in particular it encompasses the programmed and deliberate avoidance of waste, waste minimization methods’ dissemination and adoption; reuse and recycling programs and structured collection of waste and treatment. The focus on solid waste is informed by the fact that researchers in developing countries are more exposed to solid wastes than other types of wastes. However, as Williams (2005) noted, waste can be characterized as an item or material generated as one of the products of a particular activity and with the aim or intention of disposal.

Other authors have also stressed that waste management is made more effective when there is proper legislation, education, high level of citizens’ participation and collaborative efforts among local, state and federal governments (Kelley, 1992; Carisma, 2009). This is in line with the linking of poor waste management to a combination of factors including political barriers, poor citizens’ participation, poor economic incentives and a top- down policy with little public acceptance (Imam et al 2009; Ogwueleka, 2009). The relevance of waste management to a developing economy like Nigeria have being dealt with in various literature. This is justified in light of the tremendous amount of waste generated in the country. There is a rural- urban differential in waste generation with the rural areas generating 0.44kg/capita/day and the urban areas averaging 0.66kg/capita/day (Cointreau- Levine, 1982; Ogwueleka 2009; Onu et al 2012). From the studies, the density of solid waste ranges from 250kg/m<sup>3</sup> to 370kg/m<sup>3</sup> which is significantly higher than what obtains in the developed countries of the world.

### 2.1.2 Population growth, industrialization and waste management

The shift towards an increasing focus on waste management is justified in light of the various concerns that have being raised by different authors. Narayana (2009) have conceptualized

waste management to be a perennial challenge in various countries of the world especially the developing ones. The author reported that the challenge is more aggravated because there is a correlation between increased waste generation and population explosion, industrial development and urbanization. This assertion is corroborated by Izeze (1999) who reported that the problems of solid waste management in developing countries resulted from the surges in urban population, constantly changing lifestyles and rapid industrialization. As Alam et al (2007) also noted, ‘poorly managed wastes are perceived as environmental hazards of high significance and the inabilities of societies to manage waste generation effectively play no small role in increasing extant environmental pressures.

Olukanni et al (2014) have traced the increased focus on waste management to the increase in consumption which is a consequence of population increase complemented by rapid urbanization which have increased significantly the volume of waste generated. The author identified other causative factors as improvement in overall socio- economic status and increase in the rate of commercial activities which have necessitated increase in the rate of transformation of raw materials into finished products. These points are corroborated by Babayemi and Dauda (2009) and Olukanni and Akinyinka (2012). In the developed countries of the world there is a demonstrated healthy attitude towards sustainable waste management; this is because waste management is perceived as playing a policing role of ensuring that future generations are not subjected to deleterious consequences as a result of environmental choices made today (Khatib, 2011).

### 2.1.3 Complexity of waste management process

Different authors have presented differing views on what the waste management process entails. According to Ali, Cotton and Westlake (1999), waste management is a broad concept that relates not only to handling large volume of wastes but designing and implementing methods for dealing with specific compositions in a manner that is efficient and sustainable.

Also, Girling (2005) affirmed that environmental waste management is a process that extends beyond mere safe waste disposal but rather encompasses activities such as minimization actions, reuse and recycling activities, proper treatment and finally waste disposal. While most definitions of waste management are based on technical or process perspectives, Narayana (2009) have emphasized the human perspective. According to the author, effective waste management is predicated on an informed and participatory public. In essence, the effectiveness of waste management strategies cannot be guaranteed in the absence of popular public participation.

Modern waste management comprises the use of scientific methods, new technologies and an awareness that different types of waste require different types of treatment. As Olukanni et al (2014) explained, the importance of differing composition of waste as an important factor in waste management stemmed from the realization that waste components in a particular area is differentiated from those in other areas because of differences in standards of living, climate and consumption habits. Modern waste management also emphasize that waste management should be done within the larger context of environmental and public health management (Onibokun and Kumuyi, 2003; Agbesola, 2013; Olukanni et al 2014). In Nigeria, as in other developing countries of the world, solid waste- which is composed of organic and inorganic components- has become an important issue and this is reflected in the piles of wastes often found by the roadside, rivers and in open spaces in the urban areas (Imam et al, 2009; Ogwueleka, 2009).

#### 2.1.4 Waste generation and management in Lagos

The waste management situation in a developing city like Lagos is especially acute and reflective of what is obtained in the country. Agbesola (2013) suggested that while ‘Lagos have a waste management system that according to international standards is dismal, the state is the most progressive in terms of waste management policy design and implementation in the

country'. The amount of inorganic waste generated in the city have increased in the last two decades because of population surges and increase in per capita consumption of consumer and industrial products. Opejin (2014) reported that Lagos have a per capita waste generation of 0.5 kg per person with an aggregate generation of between 10, 000 and 12, 000 tons daily. Oshodi (2013) asserted that a significant portion of the waste generated in Lagos are inorganic and such waste are often indiscriminately disposed- off in a manner that is environmentally unfriendly and fraught with long- term deleterious consequences.

#### 2.1.5 Inorganic waste management in developed and developing countries

Conventionally, the waste generated in an area are divided mainly into organic and inorganic wastes. Inorganic waste makes up a considerable proportion of household wastes even though they are usually less bulky than organic wastes. According to a survey of Indonesian households, Aprilia, Tezuka and Spaargaren (2012) reported that kitchen waste constitutes the highest percentage of household wastes followed by recyclable household wastes such as plastic, paper and card- board. In the developing countries, inorganic waste is increasingly constituting a considerable portion of waste generated and according to Idowu, Omirin, and Osagie (2011), the major sources of such waste include households, markets and places of commercial activity. However, it must be noted that proportionally, developing countries generate more organic waste than inorganic waste (Oteng- Ababio, 2011).

There is a marked difference in the attitude of developed countries, where inorganic waste management is done on a scientific and planned basis and the developing countries where choices in inorganic waste management are weighed from the populist and socio- economic perspective (Agbesola, 2013). Inorganic wastes are perceived as a serious challenge to the ecosystem because their constituent parts make them largely unbreakable into forms that are less threatening to the environment. Kinyanjui (2014) have expressed the fact that inorganic wastes pose a greater threat to the environment because such wastes are non- biodegradable.

Because of this non- biodegradability, inorganic waste is often the poster issue for waste management especially in the developing countries. Inorganic waste management have being identified as a menace especially in the developing countries which have being caused by inadequate service coverage, operational inefficiencies of services, limited utilization of recycling activities, inadequate management of non- industrial hazardous waste and inadequate landfill disposal mechanism (Onibokun and Kumuyi, 2003; Igbinomwanhia et al, 2009).

Kinyanjui (2014) stated that inorganic wastes have posed serious environmental concerns which in consequence have necessitated the design of elaborate strategies and integrated program measures aimed at mitigating their contribution to environmental degradation and as such promote environmentally sound and sustainable development. In another study, UNEP (1992) opined that the generation of inorganic wastes pose a serious problem because they are not biodegradable and often litter around in huge unsorted quantities and have the potential have seeping into water bodies leading to massive pollution. Inorganic wastes are disposed using a wide range of techniques which have being captured in literature. However, Aprilia et al (2012) reported that a majority of households in Indonesia dispose hazardous waste together with other inorganic wastes thus leading to pollution and contamination of the environment. Burning is a predominant method especially in the urban areas and as a practice, it has had deleterious effects on the environment thus endangering the health of residents who inhale the smoke from the burning of such substances. World Bank (2005) noted that the burning of garbage is major contributor to urban air pollution, and it is a practice engaged in not only by residents but by collectors at dump- sites and generators of industrial wastes such as saw- mills and artisanal processing centres. Studies done by Lacoste and Chalmin (2007), Wakjira (2007) and Igbinomwanhia (2011) amply documents the extent of burning as a method of disposing inorganic wastes in the developing countries.

Another common method of disposing inorganic waste is open- space dumping. Agbesola (2013) reported that this is a widespread method in the developing countries and is often used as a preceding method before burning. Dumping also have deleterious effects because of the fact that such waste often finds their way into the ecosystem and pose health hazards. According to Lacoste and Chalmin (2007), health impacts can result from having contact with dumped waste and can include skin and gastro- intestinal diseases' outbreak. Randomly dumped waste can also pose a direct hazard to children especially if such waste contains toxic or hazardous materials (Miller, 2000). The use of open dump site also increases the potential of surface and ground water pollution- this is because open dump- sites are often situated without regard for the potential for environmental disruption, they are often sited based on convenience (Olu, 2009). The extent of groundwater pollution in and around dumpsites is still unknown because adequate pollution assessment studies have not been conducted on the groundwater in the developing countries but based on the degree of surface water pollution, it is possible to identify when pollution is taking place in the groundwater (Lacoste and Chalmin, 2007).

Wakjira (2007) expressed that the most common methods of disposing inorganic waste are sanitary landfill, open dumping, incineration, open burning and reuse and recycling. According to the author, the open methods of disposal have negative impacts on the environment as a whole and on the community living in the vicinity of the dump- site in particular. Recycling is increasingly being seen as a viable option for the treatment of inorganic waste in the developing countries. According to Miller (2000), the recycling of inorganic wastes such as glass, plastics, paper and metal can be done using two different methods which are primary or closed- loop recycling and secondary or open- loop recycling. Primary recycling is said to occur when the inorganic waste discarded by consumers are subjected to controlled treatment which essentially recycles them to produce the same kind of products from which they are derived in the first place (Johnston et al 2000). Secondary recycling entails the recycling of inorganic wastes which

results in different products. As Miller (2000) reported while secondary recycling reduces the weight of virgin material by about 25% primary recycling have the potential of reducing virgin material in a product by up to 90%. The recycling of waste has been touted as a method which much potential to reduce the amount of waste going into incinerators, open dump- sites and landfills.

Other literature has identified the occasional use of controlled landfills and dumpsites as the main methods of disposing inorganic wastes. Remigios (2010) confirmed that uncontrolled dumping is the main method of solid waste management in the African countries (most of which are ranked as developing) and it involves disposal of waste on open- areas without requisite structures and without considerations and contingencies for potential environmental impact. The author further noted that public health agencies in the developing countries of the world are veering towards the use of controlled or semi- controlled landfills for disposing inorganic waste. Such landfills are often controlled by the government and are used by the waste disposal contractors who collect waste from households and commercial and industrial areas for a fee. Such wastes are then transited to the landfills.

#### 2.1.6 Constraints on inorganic waste disposal in the developing countries

As Afun (2010) noted, there is a global concern for improved mechanisms of waste management because of the environmental health demands of the world's population that necessitates management of waste in an eco- friendly and acceptable way. Waste disposal by households have proved an intractable problem in the developing countries because of certain constraints on the use of efficient disposal methods. A constraint is the paucity of structured waste disposal systems in the developing countries. Zavodska (2003) reported that there is an ineffective and unreliable solid waste collection service in developing countries. Related to this is the insufficient number of- and complete lack of waste collection points in some areas. There is a perennial challenge of 'inadequate and improperly located waste disposal points' which

makes waste disposal by households a cumbersome task hampered by distance and accessibility (Agbesola, 2013). According to Walling et al (2004), solid waste management in developing countries have taken on magnitude proportions because of the paucity of public wastes receptacles. Momodu, Dimuna and Dimuna (2011) contended that a majority of urban households in Nigeria, which is a developing country, have being reported to lack access to adequate waste management services for over two decades and there appears to have being negligible improvement even in recent times. This finding is supported by the findings of Aderogba and Afelumo (2012).

In the developing countries of the world, a constraint on inorganic waste disposal especially by households is the low recycling rate. Magutu and Onsongo (2011) reported that recycling rates are low in the developing countries. The consumption attitude of households in developing countries have resulted in the fact that wastes are not utilized for other purposes- such as use for containers or crafts. The process is often dominated by the uncontrolled salvaging of inorganic materials by a largely un- organized informal sector made up of scavengers. Such recycling is often done inefficiently and on its own have historically portended environmental concerns.

The increasing population and rate of economic activities in the developing countries coupled with drastically increased consumption have led to waste management problems. The provision of efficient solid waste management services that would effectively handle inorganic wastes has proved to be a major problem of local authorities worldwide. There are various constraints that have resulted in low service coverage and poorly managed programs and initiatives. Awaisu (2011) noted that the constraints on waste management could create a dynamic that would eventually result in major environmental and health problems when the processes of waste management are not efficient and have low coverage. Inadequate logistics is a major bane on effective waste management in the developing countries. Agunwamba (2008) asserted that

solid waste management authorities are often comprised of an aged vehicle fleet which when coupled with bad road access makes waste collection and disposal a nightmare. The author further noted that in some instances, waste disposal vehicles are open vans which allow for littering of the immediate environment with waste being transported.

Another constraint hampering waste management relates to institutional capacities. As reported by Schwarz- Herion et al (2008), governments in developing countries have created various agencies and bodies tasked with waste management- the fact that there are massive functional over- lap results in general inefficiency and poor service delivery by these bodies. Ogawa (2006) supporting this claim noted that agencies and task- forces do not often have clear roles or functions and suffer from a lack of direction resulting from inadequate coordination of projects and activities. Onibokun and Kumuyi (2003) asserted that the poor monitoring and evaluation of waste management institutions have bred a culture of low performance and complacency which have had adverse effect on waste management in the developing countries. Another constraint to inorganic waste management and solid waste management in general is the low social status accorded to waste disposal workers. Waste disposal workers suffer from a negative perception because society regard the work they do as undignified; this has led to a drain of skilled labour from the profession with the attendant effects of high turnover, poor work habits, poor work attitudes and poor quality of work (Ogawa 2006; Agunwamba, 2008).

In close relation to social constraints are certain cultural constraints which result from certain practices in the developing countries that hamper the design and implementation of sustainable waste management policies. Such practices include the ritual dumping of dead animal and other substances at road junctions without consideration for the environmental effects the putrefaction and decay of such substances would have on the society (Igbinomwanhia and Ohwovorirole, 2012). The cultural dimension as a constraint have also being reported by Cointreau (1982) and Omran and Read (2008). Audu (2007) proposed that cultural attitudes

form part of the constraints on waste management in the developing countries; the author generalizing from a study in Nigeria maintained that people in developing countries have cultural practices that weigh more to consumption and waste generation than saving and investment and this reflects on waste management. This finding is corroborated by Zerberk (2003) who noted that in the developing countries, constant and ever- increasing material consumption is encouraged and perceived as progress in the economic sense, this results in the dominance of a 'buy and discard' mentality which aggravates the waste management situation.

The realization that advanced modern waste management practices require varying degrees of capital outlay pose a constraint especially in the developing countries of the world where incomes are relatively low. As Igbinomwanhia and Ohwovoriolè (2012) reported, a survey of households in Edo State in Nigeria reveal that family income average \$300 monthly, this creates a low demand for solid waste management practices and households have a propensity to engage in open dumping of wastes and open air burning. This point is supported by Omran and Read (2008) who also reported that the low household incomes in the developing countries prompts the patronization of cart- pushers as waste disposers. Such local waste disposers are not regulated nor trained and often do not make use of the designated solid waste dumping sites. The laws of demand and supply necessitate that in the face of high prices of structured waste management services, households patronize the low- cost options of cart- pushers, open dumpsites, drainage and uncontrolled landfilling. The constraint of funds is also mentioned by Agunwamba (2008) who deplored the funding structure of waste management which is dependent on the budgets of local, state and federal governments. This is also corroborated by Adewole (1992) and Zubairu (1992).

Of importance also is the economic context of an area which significantly influences the willingness and ability to pay for waste management service (Bartone, 1991). Ogawa (1996) also reported a dynamic that have severely constrained waste management practices in

developing countries. The user service charges collected by the disposal agents is too little to make any meaningful impact on solid waste management. However, users' ability to pay for the services is also limited by their income, and their willingness to pay for the services which are irregular and ineffective is not high either. More so the end point of the solid waste does provide financial reward to waste disposal agent hence the only source of finance to the disposal agent is the user service charges.

Another constraint is the shortage of funds available to waste management bodies for effective waste management. In a report, United Nations (2007) reported that waste management is generally given a low priority in budget except perhaps in the capital and large cities. This finding is supported by Beukering et al (2008) and Omran and Read (2008). The developed countries of the world such as Canada, USA, England, Norway, Japan and Denmark have large amounts of resources available for dealing with solid waste problems unlike the developing the countries of the world like Ghana, Egypt, Malawi and Nigeria where waste management is often aggravated by lack of funds (Nzeadibe, 2008).

According to Agbesola (2013), the constraints on the regulation of waste management in developing countries include weak institutional frameworks for waste management, corruption, bureaucratic bottlenecks, inadequate access to funds, dearth of appropriate technology, little staff encouragement, emergence of less environmental- compatible products and unending changes in the consumption trend. This corroborates the view of Oteng- Ababio (2011). Barise (2011) have mentioned the constraints on waste management in Africa to include inadequate resource allocation, lack of know- how, inadequate drive to find alternative solutions for waste disposal and low political priority. Adeyinka, Bankole and Olaye (2005) have asserted that the constraints on regulatory waste management include the dearth of funds which hampers the service delivery ability of local authorities saddled with waste management responsibilities. The corruption and low value addition of waste management services in the developing

countries of the world is also a major constraint on inorganic waste management. Igbinomwanhia (2011) and Agbesola (2013) reported that municipal expenses on waste management is more than one-third of total municipal expenses but the level of waste management service often offered by such municipalities remain poor and ineffective.

In the developing countries, a practice that have hampered waste management and waste management regulation is the dumping of solid wastes by households and businesses on major roads and dump-sites and setting such wastes on fire without pollution control (Walling et al, 2004). This assertion was corroborated by Igbinomwanhia and Ohwovoriola (2012) who also maintained that a larger portion of waste generated are dumped indiscriminate into drainage systems and water-ways and this practice resulted in various community environmental crises. The introduction of waste management machinery that are largely foreign designed and not compatible to the domestic conditions obtainable in the developing countries; have made waste management difficult especially for workers who are often unable and inefficient in the utilization and maintenance of the machinery as well as the local authorities saddled with prohibitive maintenance costs (Khatib, 2011). Babayemi and Dauda (2009) asserted that the constraints on waste management in Nigeria can be linked to inadequate equipment for collection and separation, lack of technical know-how, poor environmental consciousness, and a general weakness of the solid waste management guidelines and poor monitoring of compliance to such guidelines. A technical constraint hampering waste management in developing countries is the inadequate levels of qualified waste management personnel. Zavodska (2003) reported that there is often no formal training program for waste management personnel and communication is often very poor. Agunwamba (1998) reported that there is a paucity of human resources at the state and local government level and a robust private sector with expertise necessary for solid waste management planning and implementation.

Njiribeako (2003), expressed that data on waste management is almost non-existent in Nigeria and many other developing countries. The author noted that in cases where data is available, such data are only for isolated cases, largely inaccessible and grossly inadequate for decision-making. Daskalopoulos et al (1998) corroborated this assertion and added that poor state of data especially in the urban areas have transformed waste management from a uniquely environmental problem into one with social and economic dimensions.

#### 2.1.7 Models of waste management in the developing countries

While different techniques of waste management exist, the need for sustainable models to deliver waste management services is important in recognizing options and determining their applicability and sustainability. A review of literature revealed that the choice of model is based on how structured waste management is and public cooperation among other factors. The most common model of delivering waste management service in the developing countries is the public service delivery model (Ogawa, 1996; Saleh, 1991). The strategy of public service delivery that was adopted by many developing countries is a constraint on efficient and responsive waste service delivery. While the public service delivery model used to be the most predominant, changes in demographics and government revenue have caused a deterioration of services provided by this model. McCullough (1990) and Rondinelli (1990), reported that central governments have less than 5% of the resources they would need for effective waste management. The devolution of waste management to the local governments have not proved to be an effective panacea because the local governments rely mainly on the central government for their revenue. Bumi- Prasidi (1989) have highlighted the limitations of the public service strategy include the presence of a weak incentive system for efficient resource use because operators lack the authority necessary for collecting solid waste user charges. Other limitations include the poor state of operational, personnel and financial management practices (Saleh, 1991). According to Saleh, the inadequacy of management information systems -which are

necessary for monitoring operational costs and forecast investments- handicaps the delivery of efficient service.

The second model is the community service delivery model and it stresses the local involvement of a community or a civil society in waste management through the awareness and teaching of proper sanitary behavior, fund raising and communal labor in the collection, disposal and processing of waste (Nolan 1986; Saleh, 1991). Nolan (1986) further noted that the community could work in partnership with external bodies in order to achieve stated waste management goals. Community based waste management require ample levels of communal participation, communal management and communal authority and control over waste management service. According to Zavodska (2003), local leaders in the community play an important role by being active in the program and liaising with the municipal authorities and other external stakeholders. The drawback of this model is the tendency of households to focus on waste disposal in their homes only and neglect waste management in the public areas (Saleh, 1991). Frodo (2011) also reported that when communal waste management is adopted, there is a resistance towards paying a fee for the service. Other authors such as McCullough (1990) and Rondinelli (1990) have suggested that the community based model could be more effective if thorough research and consultation were done in the community- this is crucial because it enables the promoters of the model to generate a list of desired services, design appropriate incentives that would ensure widespread participation and efficient and realistic operational and monitoring systems.

The private service delivery model is one that have gained increased popularity in recent years and it is based on the gradual process of dissociating the government from the provision of waste management services and replacement with market- driven organizations (Awaisu, 2011). Over the years, the model has afforded the advantages of a reduced cost of public services to consumers, stimulating innovative practices, ensure improved responsiveness and reduce the cost implications of waste management to the government (Nolan, 1986). Roth

(1987) and Donahue (1989) expressed that the private service model is based on a system of contracts, franchises, concessions and private entrepreneurship. According to Bendick (1984), in this model the government acts as the coordinator of service delivery and mapped out its own duties as monitoring and regulating while private firms take up the duties of operation and maintenance. Schubeler (1996) have argued that the model is subjected to various shortcomings including; the selectivity of it services to the detriment of poorer areas with residents who are often not able to pay for the service, insufficient awareness and a marked inability to generate public support and the paucity of experienced and competent personnel. Nolan (1986) have also noted that the activities of the sub- sector have health and environmental implications as some of these companies utilize primitive techniques.

The commercial service delivery model entails the application of business principles to the overall framework of solid waste management in a particular area. Awaisu (2011) opined that the model involves the contracting of waste management services to private companies or setting up a public agency which is expected to act on the basis of cost recovery or profit-making. As Devas (1989) noted the model is informed by the belief that if the incentives are aligned, governments can promote efficient public service delivery. However, Agbesola (2013) have expressed that compared to government or public agencies, private enterprises should be the focal point of public services' delivery because such enterprises have greater pricing flexibility, improved and incentivized personnel and transparent financial systems which prompts accountability. The adoption of the commercial service delivery model also relies on the fact that the government must design private contracts to be of such a duration of time and operational scope that would allow investors to recoup their investments in projects (Devas, 1989). Cointreau- Levine (1991) have also stressed the need for competitive contracts in order to make them model work. The drawbacks of the model also include low personnel capacity,

inability to design sustainable financing mechanisms for waste management projects and poor monitoring and evaluation.

#### 2.1.8 Global advances in sustainable options for inorganic waste management

Solid waste management as a key societal service have as its goals the reduction of volume and composition of generated waste, increased accessibility by households to waste collection, improvement in public awareness and attitude towards waste management and recycling and finding ways to generate renewable energy. Awaisu (2011) maintained that waste minimization is the key to enhancing resource efficiency and competitiveness – several initiatives have already been put in place in various countries, for example, the ‘*UNEP/UNIDO Cleaner Production approach, China’s circular economy approach, Japan’s sound material recycling society and reuse, reduce and recycle approach, EU’s waste prevention and recycling strategy*’(Devas, 1989; Onibokun and Kumuyi, 2003; Kinyanjui, 2014). For a long period, landfilling was seen as the most viable and inexpensive option for waste management in the developing countries, however Kinyanjui (2014) stressed that waste reduction, reuse, recycling and composting are potential management options for the state as reliance on landfilling could be significantly reduced if these options are exploited to the maximum in a structured environment.

Band and Post (2004) reported that advances in waste management are dependent on the initiatives that have being taken by different governments. Nepal have adopted the ‘Strengthening Local Capacities in Integrated Sustainable Waste Management’- a program aimed at designing and enforcing grass- roots alternative waste processing centres in the municipalities. In Egypt, a waste pricing and cost remittance model have been designed and implemented, according to this framework, private firms are contracted to manage waste in the districts with the governorate of each district enforcing monitoring and evaluation. Fees are collected through electricity bills. The program has been judged successful in Alexandria,

Cairo, Aswan, Giza and Port Said. Sharholy et al (2007) have confirmed that inorganic waste form a significant portion of municipal solid wastes and they have the potential of being recovered for other uses. Such recovery purposes are widespread in the developed countries where sustainable options in inorganic waste management have being actively pursued on the grounds that such options are seen as integral to the process of ensuring improved standard of living for their citizens (Schultz et al, 1995).

A major advance in management of inorganic waste which have also proved to be sustainable is recycling. Schultz et al (1995) described recycling as the process through which materials previously used are collected, processes, remanufactured and reused. Recycling is an effective way of minimizing problems of solid wastes at generation point, transit and disposal, and ultimately reduces waste disposal cost. The waste recycling activities are also justified on both economic and environmental grounds because they can help save resources, protect the environment, and contribute to sustainable development (Millennium Assessment Report, 2005). Harlody et al (2001) reported that recycling remains a principal method of inorganic waste management and in the developing countries enforcement of the process is achieved through the utilization of curb- side programs for waste collection and segregation. Recycling is very relevant to the management of inorganic waste. In addition, recycling has proved to be attractive because while serving as a viable strategy for solid waste reduction, it also serves as a way to decrease resource use in the production of new products (Girling, 2005; Agbesola, 2013). The high rates of recycling in some developed and developing countries testifies to its benefits and its economic mode as a means of waste management (Troschinetz and Mihelcic, 2008).

According to Girling (2005), the recycling of solid wastes is a waste management option that also have the positive effect of generating formal and informal employment opportunities while proffering in a sustainable manner environmentally sound solutions to the challenges of waste

management. According to Furedy (1992) and Harlody et al (2001), recycling is manifested in dynamics such as the urban poor's reuse of refuse. According to the authors, recycling is not only a waste management option but is also survival strategy adopted by the urban poor when formal employment opportunities are scarce, during periods of economic downturns or when non- waste resources are unaffordable or unavailable.

Recycling also offer other advantages, inorganic waste recycling plays a considerable role in improving the aesthetics and functionality of the urban physical environment because it reduces the amount of waste in the dump- sites, in drainages or on the street (Furedy, 1992). Recycling also play an environmental conservation role by recycling materials which translates into reduced exploitation of natural resources for new materials and thus curtail the effects of such phenomenon as ecological footprints and global warming (Medina, 2005). Also, the ILO (2001) have recognized the potentials of recycling as a means of generating employment opportunities. Medina (2005) noted that even in the informal recycling economy that is widespread in Africa, a network of waste pickers and middlemen exist to ensure that end- users get access to materials. According to Mensah (2010), recycling also spurs entrepreneurial development in developing economies, according to the author, studies suggest that a range of entrepreneurs ranging from middlemen, waste pickers, traders and wholesalers are involved in the recycling value chain because of the low skill requirement, free entry and low capital investment. Lacoste and Chalmin (2007) also maintained that recycling could lead to the development of the environment ethic in the community and that recycling provides more jobs than what land-filling and open dumps could provide.

Harlody et al (2001) posited that various innovative community- level waste management schemes in Asian and Latin American cities which have being challenged with unregulated waste in the past have being based on the process of recycling. Band and Post (2004) reported that in Kenya, recycling is done by local artisan groups who work with a network of waste

collectors and out of waste items fashion products such as farm tools (watering cans and can-sprayers) and kitchen tools. Such tools have a large market and a cheaper to produce hence have a lower cost- price. The network of waste collectors is also involved in the purchase and resell of industrial wastes, scrap office equipment and discarded household wares. This finding is supported by Karanja (2005) who noted that recycling is widespread in East Africa with a value chain of waste- dealers, waste pickers and large- scale waste recyclers.

The economics of recycling have also prompted its adoption by different industries. As Klundert (2005) explained, recycling of materials means less energy will be expended in the production of new items. Specifically, recycling might save up to 50% of energy requirement when compared with production from virgin materials. In South- East Asia, recycling is widely adopted and have played a key role in industrial development because it stimulated the development of industrial skills, entrepreneurial ability and sustained resource use (Lee- Kuan, 2005). In several parts of Africa, recycling has also been adopted for the process of utilizing agro- residues for energy generation (Mwesigye et al, 2009; Onu et al, 2014).

Various inorganic wastes are also aggregated into composites that serve as aggregate in the production of construction materials such as tiles, ceilings and bricks (Mwesigye et al 2009). In Tanzania, recycling is a major solid waste management practice and have provided income to city councils and citizens who are involved along the value chain that transforms solid waste into items like knives, spoons, frying pans and plastic bags (Klundert, 2005). According to Mensah (2010), recycling is often confined to inorganic materials like plastic, scrap metal, paper, cardboard and glass bottles- this is because these items are in high demand and their waste still have ample percentage of usable material.

Another massive advance in sustainable waste management is the adoption of the commercialization option by many countries. According to Awaisu (2011), the existence of

certain conditions makes the adoption of the commercialization option the most viable path towards sustainable waste management. Such conditions include costly or subsidized public service delivery, inadequate public funds and misaligned incentives. UNEP (2002) stressed that commercialized programs have a higher potential of drawing upon local and international experiences in sustainable waste management. Such experiences are needed in the design and implementation of cost effective technologies for better waste service delivery.

Commercialization have been touted as a viable option by international agencies such as the United Nations and World Bank. Band and Post (2004) reported that the building of city- level projects based on the principles of commercialization have been popularized especially by the World Bank. The diverse claims that commercialization of waste management leads to larger coverage, improved quality of service and greater efficiency. Abdullahi (2008) stressed that successful commercialization of waste management is hinged on the creation of structured markets which are backed by the appropriate regulatory frameworks and the ability of the government to negotiate contracts and enforce service delivery standards. Williams (2005), mentioned that the role of the government in ensuring a successful commercialization program extends to the creation of operational standards for private operators and also strengthening local competition, accountability and transparency.

Besides recycling and commercialization of waste management services, another advance that have gained traction globally is the conversion of waste to energy. According to Band and Post (2004), waste to energy projects have the potential of totally removing waste from the environment. Waste- to- energy comprises of activities like incinerating waste and converting the waste to energy. However, Abdullahi (2008) reported that the public opposition to incineration because of the environmental effects of the process have led to the development of methods such as pyrolysis, gasification, plasma arc gasification and thermal depolymerisation. Much progress has also been apparent in the use of waste- to- energy projects because of the

depleting levels of energy resources globally and the massive increase in demand for energy especially in India, China and other emerging economies of the world. The methods are also popular because when they are utilized in the waste management, they have the potential of reducing the weight of waste by about 95% (Medina, 2005; Majid, 2010).

Other advances in the sustainable management of waste comprise a collection of innovations which if successful would play a significant role in ensuring an environment free from the deleterious effects of waste. The introduction of Radio- frequency Identification (RFID) have being instrumental in the gathering and collation of information on the sub- process of waste transportation (Medina, 2005; Onu et al 2012). The essence of using RFID devices lie in their ability to automatically identify objects and analysing data received through RFID tags and a reader device (Friedman, 2005). Related to this is the introduction of GPS (Global Positioning System) technology in tracking the movement of waste from one point to another (Klundert, 2005; Mensah, 2010). Other innovations that have signalled global advances in waste management are the use of underground waste treatment facilities and multi- stage waste recycling systems. The use of underground treatment facilities has been demonstrated to reduce waste volume by a factor of five because of special compaction mechanisms which are embedded in the systems (Petkova- Kozovska, 2017). According to the author, such facilities are already widely used in Finland. The multi- stage waste recycling system is an improvement on the traditional sorting and recycling modes and have being widely adopted in USA and in Japan. The system ensures speed of waste treatment and a reduction in the distance through which waste have to travel before being treated (Petkova- Kozovska, 2017).

#### 2.1.9 Social, technological and economic constraints on diffusion and adoption of sustainable options for inorganic waste management practices in developing countries

The blend of options that would prove sustainable in the developing countries is dependent to a large extent on local factors. This dependence has conferred a range of social, technological

and economic constraints on the diffusion and adoption of sustainable options for inorganic waste management practices in the developing countries of the world. Babalola, Ishaku, Busu and Majid (2010) contended that the adoption and utilization of sustainable options for waste management whether singly or in various combinations hinges on local geographical features, environmental regulations, size of population and socio- economic conditions.

As a sustainable option, recycling is plagued by some constraints. Recycling as a process also relies on viable and cost effective recovery processes which are often inadequate in the developing countries of the world. Waste recovery rates in Africa is still below 20% with recovery rates in Europe reaching up to 62% (Lacoste and Chalmin, 2007). The process of energy recovery for as a waste management option is often limited by technological constraints. As Narayana (2009) reported, the process of incineration leads to new products that developing countries do not often have the technological capacity for. This have created a chain of events culminating in many countries banning this option despite its benefits and future potentials. Another constraint on conducting the waste recycling business is the attitude towards waste (ILO, 2001). The study reported that marketing waste is a challenge because people generally do not want to associate with waste as the dominant perception is that the collection of waste and recycling are dirty businesses.

Furedy (2002) also asserted that ensuring the widespread utilization of recycling would be constrained by the fact that the sorting technology required for recycling is expensive for people in the developing countries. The fact that household wastes- whether organic or inorganic- are mixed up and as such needed to be separated in time consuming operations. Said (2015) explained that recycling in developing countries is affected by economic constraints related to transport costs to the recycling centres. Presently, local communities cannot afford to transport their waste to the urban areas where recycling takes place and where they would be paid higher prices. They are thus exploited by itinerant buyers who pay low prices for waste. Babalola et al

(2010) also mentioned the health constraints and occupational hazard related to recycling. Such hazards relate to chance exposure to toxic materials, chemicals, contaminated substances and sharp materials that might lead to injuries.

An important waste management option that have being successfully executed in the developed countries but still limited in the developing countries are landfills. Remigios (2010) asserted that landfills vary from open dumpsites which are common in developing countries and sanitary landfills which are used in the developed countries. The constraints on the use of landfills in the developing countries relates to the interplay of social, economic and technological forces that hampers the design and implementation of frameworks that would make landfill sites sustainable (Bogner et al, 2007). The technological constraint on the use of landfill in developing countries is mainly the inadequate technological capacity for the management of greenhouse gases and containment and treatment of leachate (Zhang, Keat, and Gersberg, 2009).

The effectiveness of governments in the collection of waste -which is often a prerequisite for other waste management options- is still low. According to Wilson et al (2006), analysis done by the World Resource Institute and USAID reveal that while local authorities often spend around 30% of their environmental budget on waste collection, the level of municipal waste collected still remains below 70%. The municipals spend up to 20% to 50% of their recurring budget on solid waste management although only 50% of urban population is covered. In low income countries collection alone, drains 80% to 90% of total waste management budget without significant results (Onibokun and Kumuyi, 2003). It can be inferred that the adoption of sustainable waste management options hinges on effective waste collection processes and limiting this constraint will go a long way in increasing the possibilities of achieving an effective, efficient and sustainable waste management.

Another constraint which combines social, economic and technological aspects is the lack of effective and efficient frameworks for material recovery. Kinyanjui (2014) expressed that while the waste recovery process in the developed countries is managed through the organized sector, in the developing countries, the process is managed by an agglomeration of informal operators. As Hui et al (2006) noted, the involvement of the organized sector in waste recovery is an essential element of a sustainable waste management option because it incorporates into the system various features such as supports for cleaner production and recyclable systems, extended producer responsibility, deposit systems and segregated waste collection systems. This is confirmed by Klundert (2005) who concludes that economic incentives, value of waste and legislation are the key drivers for sustainable solid waste reduction management and must be included in the frameworks for ensuring recovery in particular and waste management in general.

The funding needed for installing equipment for modern waste management is a constraint on the adoption of these practices. Onu et al (2012) opined that future uptake of new technology in the waste management sector may be dependent on the ability to raise low- cost funds because on the one hand the markets for waste management services in the developing countries is not advanced to be able to guarantee high prices. This creates the need to make prices low and consequently firms need access to low cost capital if they are to survive and remain profitable in the long run (Schubeler et al, 1996).

Low level of awareness is also a constraint that have being identified as a limiting factor on the diffusion and adoption of inorganic wastes. Aprilia, Tezuka and Spaargaren (2012) reported that in Indonesia, while policies and initiatives on proper waste management through source separation and treatment are in place, the public have a low level of awareness. This assertion is supported by Aye and Widjaya (2006) and Adeala (2015).

The fact that private companies have traditionally played a minor role in waste management is also a key challenge that must be resolved if sustainable practices are to be adopted in the developing countries. Awaisu (2011) stressed that in countries where waste management have progressed in the last two decades, commercial delivery of waste management services have often been adopted. However, drawing private companies into the waste management scene have always relied on the belief that service efficiency and larger coverage would lead to profits. A dearth of conditions that would ensure the profitability of the sector is a constraint that must be mitigated.

## **2.2 Theoretical frameworks**

The importance of theoretical frameworks to this study cannot be over- emphasized as such frameworks provide a paradigm with which a better understanding of the scope of the topic can be achieved. For the purposes of this study, institutional analysis ad capacity building frameworks will be adopted.

### **2.2.1 Institutional analysis framework**

Popularized by Scott and Meyer (1994), the institutional analysis framework provide a basis for understanding the changes from the standpoint of the institutions in which those changes are embedded, or which is expected to take a leading role in defining or implementing the change. Scott and Meyer (1994) defined institutions as ‘cultural rules giving collective meaning and value to particular entities and activities integrating them in to larger schemes’. From the context of this definition, what determines the actions or behaviours of people in different situations is a set of wider rules. The framework proposes that in any society and for a particular set of situations, there are rules, norms and cultural beliefs which affect how members of that society behave in those situations. For any situation, people can be assumed to be creating and applying norms, interpreting meanings and beliefs and formulating, modifying and adhering or

not adhering to rules. It is the collection of human actions in these domains that determine the stance of society on a particular situation or concept.

The theory recognizes the three pillars of institution to include normative, regulative and cultural cognitive systems. As Scott (2001) asserted, the regulative pillar seeks to constrain and sanction behavior utilizing a set of rules and laws which are designed to feed on the emotion of fear. The author continued that the normative pillar relies on the use of values and norms and expects members of the society to reflect the norms and values of the various institutions which are embedded in the society. The cultural pillar arises from the inherent interactions between members of a society and their being subjected to the cultural factors of how things are done in that particular society (Scott, 2001). The implications of the institutional analysis framework to a study of potential options for inorganic waste management lie in the fact that it provides a basis for understanding how human actions are shaped- this is a valuable knowledge in the design and implementation of initiatives meant to promote these potential options.

Another relevance of the framework is that it provides a structure to understanding the assertion that an actor's behaviour towards waste handling or the adoption of innovative practices in waste management have the potential of influencing the success or failure of such systems and as such what stipulates such behaviour should be studied. Also, the framework highlights the fact that people generally behave in congruence with their culture, as such the promotion of viable potentials for waste management have a higher chance of success if it is structured in a way that is in congruence with the culture of a people. According to Mungure (2008) 'the institutional context in which organizations and individuals operate is important to ensuring the necessary incentives and rewards for service delivery'. The criticism of the model lies in the fact that while it proposes an institutional perspective for studying openness to change, it is not robust in explaining how institutional factors themselves might be manipulated.

2.2.2 The capacity building framework

The relevance of the capacity building framework lies in the fact that insufficient capacity is a recognized constraint on effective waste management in the developing countries of the world. According to McGinty (2002), capacity building can be conceptualized as the process or means through which national governments, local communities and other administrative units design and implement plans for developing the skills and expertise necessary for the effective management of their natural resources or their environment. Janicke (1996) provided an analytical model for capacity building which can be used as a framework in considering the relevance of the concept. The table below illustrates Janicke’s capacity building model

Table 1: Janicke’s Capacity Building Model

<p>The capacities for the environment are constituted by:</p> <ol style="list-style-type: none"> <li>1. The strength, competence and configuration of organized governmental and non-governmental proponents of improved waste management</li> <li>2. The (a) cognitive-informational, (b) political-institutional, (c) economic- technological Framework conditions.</li> </ol>
<p>The utilization of the existing capacity depends on:</p> <ol style="list-style-type: none"> <li>3. The strategy, will and skill of proponents and</li> <li>4. Their situative opportunities.</li> </ol>
<p>This has to be related to:</p> <ol style="list-style-type: none"> <li>5. The kind of the problem: in the dimensions of urgency, power, resources and options of the target group</li> </ol>

Source: Janicke (1996)

According to Janicke (1996), the different stakeholders, in a change process have different levels of strengths, competence and configuration and as such for capacity- building to occur these stakeholders must take a proactive step towards the design and implementation of

capacity- building plans. This point was also noted by Schubeler (1996). The three framework conditions also provide a means for differentiating capacity- building, however they must be consciously connected in order to ensure the success of capacity building initiatives. The strategies will and skills of proponents is a function of existing knowledge while the situative opportunities are short term variables to the conditions of action. The capacity building model proposes that these elements are essential to the design of capacity building that is aimed at solving a particular problem.

The relevance of the capacity building model to a study of the potentials of waste management options is that it provides a structure for understanding the skills that an organization trying to promote, design or execute such options must possess. In the real world, the cultural cognitive, normative and regulative elements of a culture cannot be relied on to deliver change effectively, the reliance is often on capacity building to bridge the gap between the current level of skill-set and the desired level that would be necessary to meet the challenges of waste management in the developing countries of the world.

### 2.2.3 Solid Waste Management Hierarchy

An important concept that have significantly accelerated the awareness, design and implementation of structured waste management programs is the Solid Waste Management (SWM) hierarchy. Introduced by the United Nations Environmental Programme (UNEP), the hierarchy is a framework that have served as a foundation for contemporary waste management systems and have birthed a lot of policies at the national and international level. According to UNEP (2005) and Agbesola (2013), the framework is built on the pillars of reducing, reusing and recycling waste- referred to as the 3Rs. The hierarchy proposed the maximum utilization of resources and minimal waste generation. As stressed by Agbesola (2013), the '3Rs refer to the reduction in the amount of waste being generated, the reuse of items prior to their being commissioned as waste, and the recycling of items once they become waste'.

The SWM hierarchy have also informed the development and implementation of policies aimed at resource management, landfill management, water and air pollution control and the safeguarding of public health.

The table below highlights the operational trend that have being adopted by countries which have used the SWM hierarchy in the design and implementation of waste management policies.

Table 2: The SWM hierarchy

SW Management option	Advocated Desirability	Global Trend
Prevention/ reduction	<i>Most desired</i>	<i>Least practiced</i>
Reuse		
Recycling and Composting		
Energy recovery		
Landfilling	<i>Least desired</i>	<i>Most practiced</i>

Source: Agbesola (2013)

Waste prevention and reduction represents the top- most layer of the hierarchy and it portends situations where the entire process chain of materials is designed in such a way as to minimize waste. As Agbesola (2013) noted, the rationale of this stage which makes it relevant to the study of inorganic waste management is the fact that it stresses waste prevention as the earlier stages of a product lifetime to minimize waste impact. Williams (2005) proposed that the prevention- reduction stage of the SWM hierarchy can be incorporated into household decision- making in order to reduce waste generated. The next stage in the SWM hierarchy which is also the next stage is reuse- according to Williams (2005), reuse encompasses the purposeful and intentional utilization of an item after its initial use. Reuse is amply demonstrated in the reutilization of plastic bags, especially those in retail stores and used beverage bottles.

The next stage in the hierarchy is recycling. Recycling as a waste management practice is a composite process that involves various activities including collection, segregation and processing of waste which still have productive value (Pattnik and Reddy, 2009). Recycling is particularly relevant to inorganic waste management. As emphasized by Williams (2005), inorganic waste such as paper, metal, glass and materials and the structure of such materials makes them suitable for recycling. Before recycling is adopted, a cost- benefit analysis must show that the cost of recycling and the resultant pollution that would result from the process must be minimal when compared with what the use of fresh materials would take. Such cost-benefit analysis must confirm the cost and marketability of recycled products.

Much aligned with recycling is the process of composting waste. Composting is largely applicable to organic components of waste. Composting achieves a reduction in the volume of waste- up to 68% as reported by Sharholly et al (2007). According to Ali (2004), the attractiveness of composting lies in its mostly low technological requirements, its non- rigid requirements and the environmental benefits it confers. Another by-product of composting is methane gas which can be utilized for steam and power production and when subjected to purification can be used as fuel (Ali, 2004; UNEP, 2005b).

Energy recovery and landfilling are the two last stages in the SWM hierarchy. Energy recovery deals mainly with the extraction of the combustible organic components of waste and using such substances to generate electric power or heat. The process of energy recovery is hinged on the process of incineration which can be defined as the conversion of solid waste of organic nature into gas, steam, heat and ash residues in a specially designed plant (Magutu and Onsongo, 2011). Energy recovery is also a process that guarantees the reduction of waste. Landfilling as a stage in SWM hierarchy is characterized as the least desirable options because of the environmental concerns raised by the process. Narayana (2009) have defined landfilling as a process that entails the deposition of waste in a designated land area with the goal of

preventing the accumulation of waste and the adverse environmental effect that could result from such accumulation. As Bogner et al (2007) noted, a major drawback of this method is that fact that in the developing countries, the process of landfilling are not strategically mapped out or executed. Also, heavy reliance on this method have being discouraged because of the environmental effect of greenhouse gases (GHG) and also because of the finite nature of available space that can be used for landfilling purposes.

### **2.3 A review of empirical literature**

Different empirical literature has examined the concepts of waste management, inorganic waste and viable options for waste management. Awaisu (2011) have attempted an assessment of the commercialization programme of solid waste management in Abuja, Nigeria. The study had as its objectives a measurement of the outcomes of waste commercialization in the study area and the explanatory factors for the outcomes. The study utilized primary data- which was collected through the use of questionnaires, interviews and field observations- and secondary data. Descriptive statistics were used for analysis. The conclusions of the study are that; the commercialization programmes are largely inefficient and ineffective in the study area. The identified explanatory factors are institutional constraints, financial constraints, and poor choice of waste management technologies by the vendors.

Aprilia, Tezuka, and Spaargaren (2013) have studied inorganic and hazardous solid waste management in Indonesia. The study focused on household waste management in Indonesia with emphasis on the status and challenges for inorganic and hazardous solid waste management. Survey method was used in eliciting data for the study. The researchers weighed and compared over a two weeks period waste generated in different area of Indonesia. The study concluded that kitchen waste constitutes the largest percentage of household waste (52%) with inorganic waste accounting for 26%. The study also concluded based on results that more than 60% of inorganic wastes are recyclable. Inorganic waste management was shown to be

hampered by irregularities in the operational and legal frameworks guiding recycling in the country. Igbinomwanhia and Ohwovoriole (2012) carried out a study on the constraints on residential solid waste management in Benin Metropolis, Nigeria. The work involved a site-specific study to estimate the quantity of waste generated in the metropolis. Information for the study was obtained through the use of structured questionnaires to elicit data on the socio-economic characteristics of households and household practices as regards waste management- descriptive statistics were used in the analysis of data collected. The results of the study showed that poor education, poor income, institutional structures, social disposition and cultural norms are the constraints on waste management in the metropolis.

Agbesola (2013) have studied the sustainability of municipal solid waste management in Nigeria using Lagos as a case example. The study examined the extant trend for waste handling in households in the state as well as the trends in waste management in the formal and informal sectors. A case study methodology was adopted for the study with data obtained through primary data collection, field observation and interviews with identified stakeholders. A key discovery of the study is that the employed options of waste management are dependent on local conditions. The study concluded that reduction, reuse, recycling and composting are the viable waste management options in the state. Kinyanjui (2014) have studied the challenges and opportunities of inorganic solid waste reuse and recycling in Kenya. Data for the study was collected through the means of a questionnaire distributed to 235 respondents made up of households, businesses and waste traders. Data was analysed using descriptive statistics and inference was drawn using Pearson Product Moment Correlation to test for correlation between socio- economic characteristics and the waste- management practice of separation. The study concluded that opportunities abound in the study area for inorganic waste recycling. The challenges to inorganic waste management are found to be vandalism, poor funding and inadequate and unenforced policies and by- laws guiding solid waste re- use and recycling.

Olukanni, Ede. Akinwumi and Oluseyi (2014) worked on appraisal of municipal solid waste management with emphasis on effects and resource potentials. Site specific field work was used in eliciting data in the study. The field work involved quantitative and descriptive methods and assessments involving characterization of waste samples obtained from major bin locations. The study adopted a waste sample of 280kg for analytical purposes and discovered that 64% of such waste collected from four locations in a semi- urban area are recyclable. The study concluded that solving the problem of waste management can only be done through a productive partnership between the government and the private sector.

#### **2.4 Gaps in literature**

While past literature has touched on aspects of the subject of this study, a research gap exists. Previous studies have focused mostly on solid wastes as a whole while others have focused on organic wastes. There have being a relatively scant focus on inorganic wastes. This creates a research gap which would be filled by this study. Also, previous studies that have focused on Lagos State have done so in an evaluative perspective; dealing mainly with assessments of the levels of waste collection, current status of waste processing and constraints on waste management. There is a gap on the potential options on waste management that are viable and sustainable within the context of the Lagos environment. By focusing on the potentials for improved inorganic waste management, this study would be filling such gap.

#### **2.5 Literature Summary**

This chapter have examined the concept of waste management, it has also discussed the management of inorganic wastes in terms of models and processes. A review of waste management options that apply to inorganic waste management have being done. Such options include recycling, commercialization, waste- to- energy and specific innovations aimed at improving safe processing of inorganic wastes. A review of relevant theoretical frameworks

and empirical literature was attempted as well as a discussion of the Solid Waste Management (SWM) hierarchy.

### **3.RESEARCH METHODOLOGY**

#### **3.1 Overview of methodology**

This chapter attempts a discussion of the research methodology adopted for data collection and analysis. The research design and the underlying philosophy are explained as well as a description of the population of study. The adopted sampling procedure and sample size are presented along with the rationale for sampling and the processes and designated instrument for data collection. Lastly the validity and reliability of the data collected as well as ethical compliance measures will be discussed.

This study utilized mixed- methods' design for data collection and analysis. Both quantitative and qualitative methods was adopted in this research. As noted by Hughes and Sharrock (1997), the utilization of quantitative methods is informed by the need to collect measurable information on a phenomenon from various respondents. The choice of qualitative method was based on the need to explore the subjective perception of a group of respondents.

The choice of quantitative methods is informed by the purpose of the study and the identified research objectives. Information from respondents was collected through a field survey. A two stage sampling process was adopted in the selection of study sample which are households that generate waste. A multi- part questionnaire covering the research questions served as data collection instrumentation. An interview schedule was used in eliciting the perceptions of environmental waste management officials in Lagos State. The officials were selected through convenience sampling.

#### **3.2 Research design**

The success of a research is hinged on the adoption of a research design that fits into the purposes and objectives of the research. Newman and Benz (1998) conceptualized research design as the 'the plans and procedures used in research, the utilization of which spans the

choices of research assumptions and the detailed methods of sampling, data collection and data analysis'. The choice of research design determines the techniques that will be used subsequently for data collection and analysis. Bhattacharjee (2012) noted that a research design dictates the comprehensive plan for data collection in an empirical study and also provides the blueprint for the processes of sampling, instrument development and data collection. Research designs are categorized into positivist, interpretivist and mixed approaches.

The purpose of this study is identifying the potentials for improved inorganic waste management options in Lagos, as such a mixed approach was utilized in this study. The mixed approach is a systematic combination of the positivist and interpretivist approaches. According to Bhattacharjee (2012), 'the positivist method is underlined by the tenets of the positivist school of thought, as such the method is based on deduction and is basically aimed at hypothesis- testing'. The positivist approach uses data to test a theory. Positivist methods include survey research and laboratory experiments. The interpretive method is the logical opposite of the positivist method and it tries to build or support a theory using the available data on a particular phenomenon.

While the positivist method works from theory to data, the interpretivist method works from data to theory. Interpretivist methods include case research and ethnographic studies. The mixed method combines elements of positivist and interpretive methods. As Bhattacharjee (2012) further noted, 'the mixed method is desirable because it helps to generate ample insights into a complex social phenomenon'. In a mixed method research design, the positivist approach uses the relationship between variables to test objective theories while the interpretive approach provides a means for systematic exploration of meaning attached to the phenomenon under study. The mixed method design is underlined philosophically by the pragmatic approach (Kumar, 2005).

A study of the potentials of waste management options is a relatively complex phenomenon standing at the intersection of science and social science, while some variables relating to the study can be expressed in quantitative terms and with objective basis, others have a subjective basis which justifies the use of exploratory methods to extract subjective meanings given by respondents to a phenomenon. The objectives of this makes imperative the use of a mixed procedure of data collection which involved administration of questionnaires -to elicit information about respondents, beliefs, attitudes and opinions- and a case research involving the exploration of relevant literature relating to the purpose of this study.

### **3.3 Study area and population of study**

The study area utilized for this study is Lagos State, Nigeria. According to NBS (2016), Lagos State is the commercial center of Nigeria with 50% and 60% of industrial capacity and foreign investment respectively. Lagos has a population of 13 million residents and a land area of 3, 577km<sup>2</sup> (Boonke and Helke, 2017). This situation- large population and small land area- offers the natural conditions for the generation of a large quantity of waste. Increasing urbanization and industrialization have played a tremendous role in waste management in Lagos, various studies suggested that the amount of waste generated in the city have increased in the last two decades because of population surges and increase in per capita consumption of consumer and industrial products. Opejin (2014) reported that Lagos have a per capita waste generation of 0.5 kg per person with an aggregate generation of between 10, 000 and 12, 000 tons daily.

(a)



(b)



*A landfill in Lagos Island*

Source: Opejin, 2014.

(c)



(d)



**Open dumpsite and tire waste agglomeration in Lagos**

Source: Momodu et al (2011).

The population of study considered for this research are residents and officials of the central waste management authority in Lagos, Lagos Waste Management Agency (LAWMA). The choice of residents was informed by the fact that they have a vantage point in describing the constraints on effective waste management and the types of waste generated in the area. The choice of LAWMA officials as respondents was predicated on the fact that they are responsible for monitoring waste disposal in the state and typically are involved in the design, implementation and monitoring of various waste management options.

### **3.4 Sampling procedure and sample size**

The logistical and economic constraints of reaching all the residents of Lagos and all officials of LAWMA necessitated the process of sampling. Tuckman (1972) described sampling as the process of identifying and selecting a sub- set of the population being studied for the purpose of research. The importance of a structured sampling cannot be overemphasized in ensuring that a representative sample is chosen, and the research has validity and reliability. The sampling process is divided into probability and non- probability sampling, probability sampling means every member of the population have a chance of being selected to participate in a study, non- probability is the converse of probability sampling (Bhattacharjee, 2012).

A combination of systematic sampling, convenience sampling and simple random sampling was used in selecting the residents and officials of LAWMA that were included in the study. Systematic sampling was used in selecting 3 local governments while simple random sampling was used in selecting 4 wards in each local government and 10 respondents in each ward to give a total of 120 resident- respondents. Convenience sampling was used in selecting a sample of four LAWMA officials for interview.

### **3.5 Data collection**

Data for this study were collected through the use of a questionnaire and an interview schedule. Questionnaires and interview schedules are examples of survey research tools and are used in eliciting the opinions of multiple residents. The rationale for selecting the survey research method is that it had been identified as the best method in studies where the individual is the unit of analysis. Survey research have also demonstrated a number of strengths which apply to this study. Kumar (2005) noted that survey methods are ‘excellent vehicles for measuring a wide range of unobservable data such as people’s preferences, attitudes and behaviours. Survey method is also suitable in situations where the number of respondents is too large to observe directly, where the costs of direct interaction with a large number of respondents is expensive and where respondents place a premium on responding to questions at their own convenience.

The questionnaire designed for the study has its questions derived from the objectives of the study. The questionnaire has five sections and thirty five questions, the sections cover the types of inorganic waste generated, methods of inorganic waste disposal, constraints on inorganic waste disposal by residents, realistic options for inorganic waste management, and the constraints on adoption of waste management options. The interview schedule has three sections with six questions covering the methods of inorganic waste disposal, constraints on waste management and the global advances in the management of inorganic waste.

### **3.6 Data analysis**

Data analysis is an important aspect of research work and it is the process of uncovering the patterns and trends in the data collected and providing interpretations in line with the objectives of research. For the purpose of this research, descriptive statistics was utilized. Descriptive statistics are the most elementary methods of data analysis. They can be used in reducing the complexity of data and structure voluminous data into a form from which patterns can be discerned (Bond and Fox, 2007). Descriptive statistics such as mean, mode, frequency counts

and percentages were used in this study to gauge the perceptions of residents and waste management officials on the potentials for improved inorganic waste management options in Lagos.

There is a need to group perceptions based on similarities and differences in responses (Kumar, 2005). The different responses given by respondents were coded using successive numerals (1, 2, 3...5) and it is the numerals that served as keys in the process of coding responses of respondents into the analysis software after which the required analysis was run on the responses to each question.

In using the mean score as a descriptive statistic tool, the mean of each question was compared to the midpoint mean, if the mean is higher than the midpoint mean, the result is considered significant, and vice versa. This implies that any question whose mean is greater than 2.5 was considered *significant* while questions with mean less than 2.5 was considered *not- significant*. To calculate for the midpoint mean, the options are scaled i.e. Strongly Agree = 4, Agree = 3, Disagree = 2 and Strongly Disagree = 1.

Midpoint Mean=Total sum of response scale/number of responses

Midpoint Mean =  $\frac{4+3+2+1}{4} = 2.5$

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### **3.7 Validity and reliability of data collected**

The questionnaire as instrumentation of data collection that was used in this study was tested for reliability and validity before deployment to the field. Validity and reliability are measures taken to ensure that the instrument of data collection contains questions that reflect the research questions and objectives and as such meet the purpose of the study. The questionnaire was drawn up based on close collaboration with experts in the field and a review of past literature to ensure validity and reliability.

A pre- test was done by administering the questionnaires to respondents whose responses were gauged for relevance to the study and taken as feedback for the design of the final questionnaire. The test measured usability of the questionnaire by respondents in terms of simplicity, clarity and comprehensiveness.

### **3.7 Ethical compliance**

Certain ethical compliance issues were envisaged during the course of field survey. Such issues deal with the processes of data gathering, storage and usage. According to Saunders et al (2016), ‘the nature of the research, the selection of participants, information usage and storage, guaranteeing anonymity of participants and the effects of a study are issues that must be addressed from the ethical perspective’. In consideration of the responsibility on the use of collected information, all respondents were informed that the data obtained from the questionnaire are to be used for research purposes only. Respondents were also informed that participation in the survey is voluntary and that data obtained would be anonymized. Respondents were also made aware that they can elect to be removed from the research at any stage.

#### 4. RESULTS & INTERPRETATION

As stipulated in the section on research methodology, a grand total of 120 respondents were sampled for the study, 120 respondents responded to the questionnaire and 5 respondents to the interview schedule. Of the 120 questionnaires, 116 were retrieved, giving a return rate of 96.6%. This return rate conformed to expectations, according to Richardson (2005), a response rate of 65% or more can be regarded as ideal for face-to-face distribution of a questionnaire survey. Given that the current survey achieved a response rate of 96.6% percent, it is regarded as sufficient and ideal for the analysis. As designed, in analysing the data, descriptive statistics such as mean, frequency count, percentages and standard deviation were utilized. Tables 1 and 2 were analysed using frequency counts and percentages while tables 3- 5 were analysed and interpreted using mainly the mid- point mean.

##### 4.1 Part A: Questionnaire Analysis and interpretation

4.1.1 Table 1: Types of inorganic waste generated in the study area.

S/ N	Type of inorganic waste	Frequency	Percentage
1.	Paper and cardboard	79	68.1
2.	Plastic & Plastic bags	89	76.7
3.	Fabrics/ Textiles	34	29.3
4.	Metals and metal products	23	19.8
5.	Glass (Pottery and Ceramics)	12	10.3
6.	Wood	45	38.8
7.	Diapers	69	59.5
8.	Rubber and Leather	34	29.3
9.	Bones	79	68.1
10.	Composite materials	23	19.8

Source: Author's Survey, 2019

The table above showed the types of inorganic waste generated in the study area. Plastics and plastic bags come out top at 76.7%, followed by paper (68.1%), Bones (68.1%). That a larger majority believed that the biggest category of inorganic waste they generated is in alignment with previous studies, Aderogba (2014) and Adekomaya and Ojo (2016) who also found that plastic wastes signify the biggest category of inorganic waste in the urban areas of sub Saharan Africa. This finding also corroborates those of earlier studies-Ezeah and Roberts (2013) and Amasuomo and Baird (2017) which stressed the magnitude of plastic wastes in Lagos and the fact that it is an environmental menace. Metal and glass waste are often generated by individuals involved in metal or glass works as the household origins of these categories of waste is negligible.

4.1.2 Table: 2: Waste management methods

S/ N	Waste management method	Frequency	Percentage
1.	Dumping in dump- sites	99	85.3
2.	Dumping in drainage/ roadside	69	59.5
3.	Burning	89	76.7
4.	Incineration	45	38.8
5.	Landfilling	22	18.96
6.	Waste disposal contractors	17	14.65
7.	Designated collection points	12	10.3
8.	Recycling	2	1.7

Source: Author's Survey, 2019

The table above indicated the various waste disposal methods utilized by residents. Reflecting the poor state of waste disposal processes in Lagos, 85.3% and 76.7% utilize dumping and burning respectively as the main waste disposal techniques. This confirms earlier findings by

Ezeah and Roberts (2013) and Badaks (2018). In areas where government placed incinerators, the utilization of incineration as a waste disposal technique is marked (38.8%). The study also found that the use of waste disposal contractors is minimal, field survey revealed that such contractors are often engaged by highly organized middle-brow neighbourhoods or by commercial bodies. Recycling (1.7%) is the least utilized technique and as similar result is found in other studies- Henry et al (2006) and Kofoworola (2007)- this low utilization is perceived of as the predominance of a linear economy framework, in which materials are wasted after usage, over a circular economy framework in which materials are reused and recycled. Dumping in drainage sites (59.5%) is also a common enough waste disposal practice in the study area.

4.1.3 Table 3: Constraints on inorganic waste disposal by residents

S/ N	Constraints	SA	A	D	SD	Mean (X)	STD
1.	Insufficient waste collection points	65	37	10	4	3.4051	0.7910
2.	Far distance to waste collection point	43	40	32	1	3.0775	0.8251
3.	Lack of access to waste disposal companies	34	59	12	11	3.0000	0.8847
4.	High prices charged by waste disposing companies	57	29	17	13	3.1207	1.0396
5.	Lack of recycling technology	56	47	10	3	3.1130	1.0409

Note: SA denotes Strongly Agree, A denotes Agree, D denotes Disagree, SD denotes Strongly Disagree

Source: Author's Survey, 2019

The table above showed respondent's opinion on the significance of pre- identified constraints on waste disposal by local residents in the study area. All the constraints are found to be significant. Insufficient waste collection points ( $X=3.40$ ) and far distance to available waste collection points ( $X=3.07$ ) are constraints which respondents identified with. This finding confirms earlier ones by Kofoworola (2007) and Badaks (2018) which showed that households

whose homes lay outside main roads or thoroughfares often find it difficult to reach waste collection points which are often located in central open areas or near major roads or thoroughfares. The lack of access by waste disposal companies and the high prices charged by such companies are also significant at means of 3.00 and 3.12 respectively. As earlier studies- Sharholy et al (2008), Kumar et al (2009) and Ezeah and Roberts (2013)- show, waste disposal companies often find it economical to base their operations on neighbourhoods rather than individual houses, this leads to a lack of access. Also, in response to the lack of alternatives, waste disposal companies often charge what the market can bear leading to the perception by respondents that their charges are high.

The lack of recycling technology ( $X=3.11$ ) is also significant as a constraint on inorganic waste disposal. This lack is mainly a question of costs and access. As earlier studies-Guerrero et al (2013), Ghisellini et al (2016), and Badaks (2018) - show, recycling is still a relatively unknown technology in the developing countries of the world. Their diffusion and adoption have been low because of the high costs of setting up recycling operations, inconsistent supply of feedstock and dearth of expertise.

4.1.4 Table 4: Realistic options for inorganic waste management in the study area

S/ N	Constraints	SA	A	D	SD	Mean (X)	STD
1.	Recycling	86	19	7	4	3.6121	0.7549
2.	Conversion of waste to energy	43	21	25	27	2.6896	1.1971
3.	Selling inorganic waste to vendors	34	49	20	13	2.8965	0.9544

Note: SA denotes Strongly Agree, A denotes Agree, D denotes Disagree, SD denotes Strongly Disagree

Source: Author's Survey, 2019

This table reports respondents' perceptions on the realistic options for inorganic waste management in the study area. Recycling was perceived by most respondents as the most realistic option for the management of inorganic waste in the study area and it was significant

at a mean of 3.61. Respondents also favour the selling of inorganic waste to vendors ( $X=2.89$ ) who would then use such waste as feedstock or raw materials for various industrial processes. Field survey revealed that respondents favour selling inorganic waste to vendors because of the perception that such transactions will bring more income to the household. The conversion of waste to energy ( $X=2.68$ ) was also significantly practised among respondents and supported the findings of other studies including Ghisellini et al (2016) and Grigore (2017) who reported similar phenomena in their findings.

4.1.5 Table 5: Social, technological and economic constraints

S/ N	Constraints	SA	A	D	SD	Mean (X)	STD
1.	Waste management is perceived as a dirty profession	76	24	6	10	3.4310	0.9346
2.	Low funding of waste management operations	65	34	7	19	3.1600	1.0806
3.	Inadequate technical know- how	74	32	6	4	3.5172	0.7516
4.	Poor waste management legislation	65	21	3	27	3.5000	0.8706
5.	Costly waste management technology	56	35	20	5	3.2222	0.8611
6.	Distance to recycling centres	93	1	12	10	3.4831	0.9966
7.	Health hazards related to waste handling	65	23	11	17	3.1453	0.8616
8.	Low level of public awareness	78	21	9	8	3.4013	0.7984
9.	Low cultural perception of waste workers	56	29	26	5	3.2454	0.8765

Source: Author's Survey, 2019

The table above revealed that the pre- identified social, technological and economic constraints on adoption of inorganic waste management techniques are significant. Inadequate know- how ( $X= 3.51$ ) is a major constraint on adoption. Advanced waste management techniques often require specialist knowledge which is not always available on this part of the world.

Kofoworola (2007) also cited dearth of expertise as a major factor hampering the development of the waste sector in Nigeria. Poor waste management legislation ( $X= 3.50$ ) is also an important constraint on the adoption of improved waste technologies. In Nigeria generally, different studies- Bammeke and Sridhar (1989) and Agunwamba (1998)- highlighted the sheer incompetence that successive governments have demonstrated in ensuring compliance with stipulated waste management rules and regulations. Because these rules can be flouted at will, there is a system- wide disincentive to adopt better waste management technologies. This situation is a reflection of what happens in most developing countries of the world. According to Al Khatib et al (2010), in these countries it is generally cheaper to break an environmental law than to adhere or seek better alternatives.

The low level of public awareness ( $X= 3.40$ ) is also a significant constraint on the adoption of improved waste management technologies. Field survey revealed that public awareness on the need for recycling is not widespread among local community members. Adekomaya and Ojo (2016) reported that public awareness on waste management in the developing countries is often limited to admonitions against burning and indiscriminate dumping of wastes. Public awareness remains a gap to be bridged if waste management in the study area is to improve.

The health hazards related to waste handling ( $X=3.48$ ), low cultural perception of waste workers ( $X=3.24$ ) and the perception of waste management as a dirty profession (3.43) pose important limitations on the waste management in general and the adoption of improved waste management technologies in particular. These cultural biases effectively prevent the waste management sector from attracting competent human resources needed for the transformation of the sector (Aderogba, 2014). The low funding of waste management operations ( $X= 3.16$ ) also pose as a constraint on the adoption of improved waste management technologies in the study area. Al Khatib et al (2010) supports this finding by showing that low level of government expenditure on waste management technologies in the developing countries slows the growth

of the waste management sector as the government is the main driver of this sector in the developed countries.

Costly waste management technology ( $X= 3.22$ ) was also found to be significant as a constraint on the adoption of improved waste management technology. Waste management technologies are often developed in advanced countries, as such it is often difficult to fit them into the conditions in the developing countries. This is in alignment with studies done by Henry et al (2006) and Kircherr et al (2017).

## **4.2 Part B: Interview schedule interpretation**

### 4.2.1 Section A: Current status of inorganic waste management in Lagos State

Question 1: What is the current status of inorganic waste management in Lagos State?

*Respondent 1: 'LAWMA is the agency responsible for the management of inorganic waste in Lagos, it is not an easy task because of the ingrained habits of people who prefer to dump wastes into the streets rather than make use of incinerators or private waste collection companies. Also, some discretely burn refuse in the streets which is not allowed because of the dangers of fire. Sometimes we have people who load the waste they used for a week and take them into the bush, this is also illegal, and we have issues controlling this because we cannot just stop and search every car or bus going into the bus. overall, inorganic waste management in Lagos is poor and needs more efforts from the government in terms of funding'*

*Respondent 2: Lagos State has made vast improvements in terms of waste management in recent years. This is because we had three successive governors who care about waste management. Lagos used to be the byword for dirt and slums, but things have changed drastically. I would not say Lagos is perfect, but when you go to some areas like Lekki, Maryland, VGC etc. etc. You will be amazed at how neat these places; this is because there are organized waste*

*collection systems in place. Basically, inorganic waste management has improved in some areas, is improving in some areas and has not improved in some areas’.*

*Respondent 3: ‘Inorganic waste management deals with how inorganic wastes such as plastics, paper or metals or spare parts are managed. The differences in inorganic waste management depends on the area. For example, you can’t compare the way waste is managed in Lekki, to how it is managed in Ajegunle, some areas are more cooperative than others. Differences in inorganic waste management also have to do with the calibre and educational level of people living in an area. If people are more educated, they tend to take waste management very seriously and have facilities like waste bins and access to waste collection services. Poor people on the other hand do not take this seriously’.*

The outlook of polled LAWMA officers reflect disparities in waste management which is dependent on the socio- economic characteristics of an area. Areas which have higher incomes or with residents having higher educational levels are more compliant with environmental regulations and make use of private waste disposal services. This aligns with the findings of De Maria et al (2015) who studied the disparities in waste management practices between high income and low income areas.

Question 2: Which methods do households utilize in disposing waste?

*Respondent 3: ‘the major way through which households in high income areas dispose inorganic waste is through the use of waste disposal contractors, such contractors utilize collect waste from a neighbourhood using waste trucks and then convey such waste to government approved dumpsites which are often located at the far outskirts of the city. Waste disposal contractors come to these houses on a weekly, biweekly or monthly basis and they collect a fixed fee. In the low income areas, the predominant methods of waste disposal are burning, and dumping in dumpsites, the forest or inside drainage works’.*

*Respondent 4: 'burning is the predominant method of waste disposal in Lagos State. Most houses have a spot in front of their house where they can burn waste or sometimes, they make use of metal drums. This is especially common with the scarcity of dump- sites. In other areas like Obalende, Bariga, Yaba and some parts of mainland, people make use of incinerators provided by the government, there are also many incinerators on the island. Majority of places on the island make use of waste disposal contractors. There is also a company on the island- Wecyclers which buys waste products especially plastics.*

*Respondent 5: 'There have been improvements in the way households dispose waste in recent years. This is a result of the effort of LAWMA is ensuring a waste free Lagos. LAWMA have provided incinerators, established waste collection points and want to go into the recycling of waste, it is however evident that some people and companies in Lagos do not follow the laid down rules and regulations that affect waste, one of the duties of LAWMA is to ensure that rules and regulations are adhered to. For instance, in some parts of Lagos, people still sump waste by the roadside, or inside the culvert. In some cases, we have had to take the landlord associations up on maintaining a clean environment'.*

Filed survey reveal that waste disposal methods are not uniform in Lagos despite the efforts of a regulatory and compliance agency such as LAWMA, this is due to a number of factors which have been highlighted earlier in the study. From interactions with respondents, it is evident that burning and dumping still remain dominant methods of waste disposal, however attitudinal shifts have been achieved because increasing number of people are also using incinerators and waste collection services.

#### 4.2.2 Section B: Constraints on inorganic waste management in Lagos

Question 3: What are the constraints on inorganic waste management in Lagos?

*Respondents 1: 'There are many challenges to managing waste in Lagos, the first one is that Lagos is large and contain millions of people, I don't think we have the manpower and resources here to monitor waste with so many people. Secondly, there are some areas with bad planning, bad layouts, in which even if you want to manage waste you cannot make use of an incinerator or waste collection vehicles because of there are no routes that such vehicles will pass. Another constraint is that out of the millions of people who live in Lagos, there are bound to be mischievous elements who will not comply with rules and regulations.*

*Respondents 2: 'a major constraint on inorganic waste management in Lagos have to do with the fact that there is a lack of comprehensive and correct information on waste. There should be a waste information management office which would constantly compile and update information per area, per LCDA or per street. This would present a clear figure which policy makers will work with. It would also help in the acquisition of equipment such as incinerators because you would know where to place them based on population figures. Another constraint on inorganic waste management is that we do not have adequate manpower in LAWMA, sometimes there is need to go for inspection or enforcement exercise, but we can only cover a few streets in each local government'.*

*Respondents 4: 'an important constraint on waste management in Lagos is the fact that we as a public agency are handling some activities which could be contracted out to private organizations. This will make for more efficiency and it would enable us to focus solely on policy compliance. Another constraint on inorganic waste management is that we do not have recycling centers where waste collected can be taken to and converted into something of value like they have in the developed countries. However, for such a program to work in this country, it must be handled by the private sector so that it would be sustained'.*

This survey revealed that besides from the pre- determined constraints on inorganic waste management identified in the questionnaire. There are other challenges on which face inorganic waste management. Constraints such as the inadequate levels of manpower and resources in regulatory agencies, as well as unplanned road networks which hamper the flow of waste traffic within the city are significant. The lack of a central information collating body on waste is a constraint which leads to the design on flawed policies which are not informed by correct data.

Question 4: How can the constraints be mitigated?

*Respondents 1: 'Solving the inorganic waste management problems in Lagos is to a large extent dependent on an adequately staffed LAWMA complete with required equipment and vehicle. Another solution is the design and execution of consistent public awareness campaigns in all the LCDA of Lagos, this is important so as to involve the public in the campaign against waste. The truth of the matter is that without a cooperative public, waste management campaigns and the money spent on them will be a waste. However, if the public is involved it makes our work easier.'*

*Respondents 3: 'Solving the waste problem can be achieved if the government set up waste recycling centres in the state. If people know that they will be paid for their waste, they will manage it in a better manner. Establishing recycling centres and buying wastes from household will also increase drastically the number of people who have a stake on effective waste management. A recycling centre will provide employment to thousands of people and would also create a network of buying agents and aggregators, all of whom will have a direct stake in making the business work'.*

*Respondents 5: 'The constraints on inorganic waste can be mitigated if the government is committed to making waste management a priority. Sometimes, the government does not see waste management as a priority because its value might not be immediately apparent.'*

*Nevertheless, government must remain committed by increasing the funding for LAWMA, providing more incinerators, prosecuting offenders who violate waste codes and government itself should lay a good example by keeping offices, estates and properties compliant with waste management regulations.*

Respondents believe that mitigating the constraints on inorganic waste management revolve around improved government commitment, public awareness campaigns, establishment of recycling plants and increasing the funding for a waste regulatory and management agency such as LAWMA.

4.2.3 Section C: Global advances in inorganic waste management and their potentials as waste management options in Lagos.

Question 5: What are the potentials of recycling, waste- energy projects and commercialization of inorganic waste in Lagos?

*Respondent 3: 'Recycling and converting waste to energy are projects that will bring value to Lagos State, recycling means waste can be converted into other useful products which people can pay for. Recycling also means that recycling companies will be established, and this would provide employment for youths, add to the tax base of the state. Recycling is also valuable because people will then learn to attach value to the waste they produce, if you know something will fetch you money, then you will take care of it very much. Then, I don't think we have the capacity to turn waste to electricity yet, the technology required is very complex and as it is we cannot even provide reliable electricity from the relatively simple wind turbine or natural gas plants, so I doubt turning waste to energy is a viable project in Nigeria for now'*

*Respondent 4: 'recycling of inorganic waste has much potential in Nigeria generally and in Lagos State particularly, we already have the raw materials which are waste plastics especially plastic that have been used in packaging food, drinks and many other substances. Through the*

*processes of pyrolysis, mechanical recycling and chemical recycling, plastic waste can be converted into many different substances that can serve different purposes. There is also potential in commercializing or privatizing the waste management value chain in Lagos. Contracting out waste management to the private sector gives more efficiency and top- notch management which is often lacking in the public sector.*

*Respondent 5: Recycling is an integral activity in many developed countries of the world. Countries like Germany, Japan, UK and USA adopt what is called a circular economy. This initiative provides a cleaner environment, more income and less use of raw materials. This type of thing can also apply to plastics waste management and has many benefits for the Lagos economy. Converting waste to energy also have the potential of solving the electricity problem faced by the country. Also commercializing waste management in Lagos will add value to the process, government could work out public private partnerships (PPPs) which private companies. Concessions on waste management can be granted to these companies and government can earn more revenue from waste. The sector would also have more efficiency.*

Question 6: What are the constraints on social, economic and technological terms on potential utilization of options such as recycling, waste- to- energy projects and commercialization of inorganic waste management?

*Respondent 1: 'the main constraint on the use of advanced methods of inorganic waste management is mainly the financial requirements of such processes. Machines requiring for recycling are often expensive and the financial outlay is often daunting and require significant commitment from either the government or the private sector. Another constraint relates to the dearth of trained personnel which can handle recycling processes, the developed countries of the world have over the years emerged as centres of expertise on waste management, expertise that is often lacking in the developing countries.*

*Respondent 2: 'the constraint on the use of these technologies relates to the financial and the economic. The capital outlay required for such projects is a constraint on the adoption of such technologies. Also, investors need to be sure that they will reap returns on such costly undertaking.*

*Respondent 5: 'there are a lot of constraints on recycling technologies. The major ones are technological constraints, market acceptability of recycled products and social perceptions on handling waste.*

Certain patterns can be discerned from the interviews conducted. The interviews revealed that there are disparities in the level of inorganic waste management in Lagos State, such disparities are evident in terms of differences in waste handling in different income class areas. Also, residents in the state have entrenched waste management habits which are reflected in the way wastes are disposed in the state. From the interviews conducted, it is also evident that the powers of LAWMA are curtailed or limited due to inadequacy of resources required for an effective waste disposal monitoring program. From the interviews, it was also evident that the predominant means through which households dispose waste are the unsustainable methods of burning and dumping. The basic interpretation that can be given to this is that waste management is still at a relatively primitive level in the state and future waste management initiatives would need to be built on foundation aimed at effectively stopping burning and indiscriminate dumping of waste.

Based on the results of the interview, the interpretation derived is that inadequate resources to monitor waste management activities remains a constraint on waste management in the country. It can thus be deduced that effective waste management will remain a reflection of the efficiency with which the identified constraints in the study are mitigated. Basically, a key leverage point towards mitigating these constraints would be the design and implementation of

a comprehensive waste management database that would provide a base for objective and effective decisions.

### **Limitation of study**

The management of inorganic waste is a problem especially in the developing countries of the world. Various aspects of waste management have been the focus of research over the years. Some studies have touched on various aspects of waste management. However, this study was limited to the study of improved inorganic waste management with a focus on Lagos State, Nigeria.

## **5. CONCLUSION AND RECOMMENDATIONS**

### **5.1 CONCLUSION**

This study was aimed at exploring the potentials of inorganic waste management in Lagos State. The management of inorganic waste has been identified as one of the key actions that must be explored by stakeholders if environmental sustainability is to be achieved. This study had multiple objectives; an identification of current methods of inorganic waste disposal, constraints on inorganic waste disposal by residents and inorganic waste management by the regulatory bodies, an identification of the realistic options for inorganic waste management and the social, technological and economic constraints on adoption of identified options for inorganic waste management. From the results of the study, it can be concluded that the predominant means through which wastes generally, and inorganic wastes particularly are disposed in the study area are burning and indiscriminate dumping.

Burning and indiscriminate dumped ranked high as waste disposal methods- despite their unsustainability and the potential damage they cause to the environment- because of several reasons. The lack of an effective, comprehensive and well- organized waste management structure is an endemic situation in most of the developing countries of sub Saharan Africa, Nigeria inclusive, this has also impacted on the waste management situation of Lagos where the paucity of waste management structures such as incinerators, waste collection centres, recycling centres and accredited dumpsites has created a situation that has transformed waste into one of the strongest threats on livelihood in the state.

The various constraints on effective waste management are mainly an outworking of an accumulation of various waste policy design and implementation defects which has rendered the waste management sector inactive. The major constraints of insufficiency and distance of waste collection points, the high prices charged by waste disposing companies and the lack of widespread access to recycling technology have served to aggravate the

problems of inorganic waste management, this is because even in the face of public interest towards the adoption of sustainable waste management methods they pose as disincentives to adoption.

Because the adoption of sustainable waste disposal techniques is low in the first place, this had translated into a spill- over effect on the adoption of more advanced options for inorganic waste management. Options such as recycling of waste have generally received less serious attention from stakeholders, this can be attributed to a number of reasons. First, awareness of the potentials of recycling are not well known and this is a formidable barrier to adoption. Second, the success of recycling is based on the availability of a number of prerequisites which are mostly lacking in Nigeria. Such pre- requisites include the availability of comprehensive database on waste and waste management which can be used in making feasible business projections as related to the setting up of recycling plants. Another pre- requisite is a functional system for waste collection, collation and sorting which is still basically primitive in Nigeria. Because household wastes are often an agglomeration of different kinds of substances, which require sorting before further usage, the importance of waste collection and effective systems cannot be over- emphasized.

It can also be gleaned from this study that while the adoption of various options for inorganic waste management can be attractive because of the various benefits that can be accrued from such adoption, a number of social, technological and economic constraints exists which can severely limit adoption levels in the short run and in the long- run aggravate the environmental problems that are posed by inadequate waste management measures and the effect of such problems on human livelihood and survival. These constraints have been identified as the perception that waste management is a dirty profession, low funding for the waste management sector, ineffectual waste management legislation, inadequate

technical know-how, health hazards, the low level of public awareness, and the low cultural perception of waste workers.

The dynamics created by these constraints foster conditions which limit the diffusion and adoption of improved waste management options. It is also instructive to note that failure to address in a comprehensive and effective manner these constraints will lead in the long run to the lacklustre performance of the waste management sector.

From the above, a number of conclusions can be made; inorganic waste management is inadequate in the study area and this is caused by an interplay of social, economic and technological forces. The current methods of waste disposal in the study area- burning and dumping -are unsustainable and destructive to the environment. These methods are however perpetuated because the other viable options are limited in their use by certain limiting factors such as cost, accessibility and distance. There are other viable options that can be employed towards a more sustainable waste management system, but these are also limited by social, technological and economic constraints. From these, it can be asserted that ensuring the adoption of more effective inorganic waste management systems can be achieved within the framework of policy design and implementation which takes into account the various constraints which must be mitigated before such systems can succeed.

## **5.2 RECOMMENDATIONS**

Based on the findings of this study, a number of policy recommendations can be made towards ensuring a more sustainable management of waste in Lagos State;

- A most important base upon which more effective and encompassing waste management systems can be built is a comprehensive database on waste generation, disposal and management at a micro and macro-level. Such information is essential for planning purposes and the provision of such critical infrastructures such as incinerators,

dump- sites, waste collection centres and waste recycling centres. It is important to note that for such a database to be particularly effective, it must be constantly updated to take into consideration demographic shifts which would have implications on waste disposal and management.

- Waste management policies should also be promulgated and enforced around the design and implementation of economic means of converting wastes to wealth through proper planning, financing, and researching into locally feasible, inexpensive recovery processes in collaboration with commercial partners. The path followed in the developed countries of the world in which waste materials are transformed into other useful materials can be replicated in the developing countries and in a city like Lagos. Research into the recycling of secondary raw materials scavenged from waste should be encouraged to respond to the demands of private markets. Recycling activities proposed include multiple reuse of packaging materials (glass, bottles, aluminium cans etc.) recycling of brewery and poultry wastes to animal feed and manure respectively.
- Another policy recommendation suited to the management of inorganic waste is the use of waste economic instruments like tax concessions, product charges and recycling credits which would offer continuous incentives effect to waste generators, enabling them to seek out the least-cost combination of disposal, recycling and reuse. Such instruments help in enacting waste markets that are viable and robust and that can serve as platforms further innovations in waste management.
- Another important recommendation is that the design of government policies regarding the management of inorganic waste should incorporate the tenets of the circular economy. Under this mode, materials are designed to be recycled and companies are mandated to incorporate recycling and reuse where possible into their processes and

procedures. Such framework will go a long way in ensuring that sustainable waste management practices are widely diffused in a society.

- Government should also improve on the level of resource availability as it pertains to waste regulatory agencies. Such regulatory agencies are often the last resort in the process of ensuring that waste is disposed and managed according to laid- down rules and regulations. However, for such regulatory agencies to function effectively, there is a need for infusion of resources (vehicles, manpower, and equipment) necessary for smooth and effective operations. Such agencies should also be empowered by the government to be able to prosecute defaulters of waste disposal and management codes.
- Lastly, partnerships between the government and the private sector in managing waste should be fostered. Increasing populations in the developing world has put severe strains on public budgets, including in a formal way the private sector will serve to conserve government resources and also bring efficiency and innovation into the management of inorganic waste.

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## APPENDIX 1- STUDY QUESTIONNAIRE

### POTENTIALS FOR IMPROVED INORGANIC WASTE MANAGEMENT OPTIONS IN LAGOS STATE.

#### RESEARCH QUESTIONNAIRE

Dear Sir/ Ma,

I am currently doing a dissertation on the potentials for improved inorganic waste management options in Lagos State. This is in fulfilment of my MSc dissertation towards the award of a Masters' degree.

I will appreciate a few minutes of your time in completing the questionnaire below and be rest assured that the identity and responses will be treated with utmost confidentiality and be used for research purposes only.

#### SECTION A: Types of inorganic waste generated in the study area

Please indicate the type of inorganic waste generated in your area.

S/ N	Type of inorganic waste	Generated	Not generated
	Paper and cardboard		
	Plastic & Plastic bags		
	Fabrics/ Textiles		
	Metals and metal products		
	Glass (Pottery and Ceramics)		
	Wood		
	Diapers		
	Rubber and Leather		
	Bones		
	Composite materials		

#### SECTION B: Methods of inorganic waste disposal, collection, transportation and treatment.

Please indicate the methods of disposal, collection, transportation and treatment in your area

S/ N	Waste management method	
	Dumping in dump- sites	
	Dumping in drainage/ roadside	
	Burning	
	Incineration	
	Landfilling	
	Waste disposal contractors	
	Designated collection points	
	Recycling	

#### SECTION C: Constraints on inorganic waste disposal by local residents

Which of the following are constraints on waste disposal by local residents?

S/ N	Constraints	Strongly agree	Agree	Disagree	Strongly Disagree
	Insufficient waste collection points				
	Far distance to waste collection point				
	Lack of access to waste disposal companies				
	High prices charged by waste disposing companies				
	Lack of recycling technology				

SECTION D: Realistic options for inorganic waste management in the study area

Which of the following waste management options do you think will be successful in your area?

S/ N	Waste management option	Strongly agree	Agree	Disagree	Strongly Disagree
	Recycling				
	Conversion of waste to energy				
	Selling inorganic waste to vendors				

SECTION E: Social/technological/economic constraints on adoption of waste management options

Which of the following do you think is a constraint on adoption of waste management options?

S/ N	Social/Technological/Economic Constraints	Strongly agree	Agree	Disagree	Strongly Disagree
	Waste management is perceived as a dirty profession				
	Low funding of waste management operations				
	Inadequate technical know-how				
	Poor waste management legislation				
	Costly waste management technology				
	Distance to recycling centres				
	Health hazards related to waste handling				
	Low level of public awareness				
	Low cultural perception of waste workers				

## APPENDIX II- INTERVIEW SCHEDULE

### POTENTIALS FOR IMPROVED INORGANIC WASTE MANAGEMENT OPTIONS IN LAGOS STATE.

#### INTERVIEW SCHEDULE

Dear Sir/ Ma,

I am currently doing a dissertation on the potentials for improved inorganic waste management options in Lagos State. This is in fulfilment of my MSc dissertation towards the award of a Masters' degree in .....

I will appreciate a few minutes of your time in completing the questionnaire below and rest assured that the identity and responses will be treated with utmost discretion and be used for research purposes only.

#### SECTION A: Current status of inorganic waste management in Lagos.

Question 1: What is the current status of inorganic waste management in Lagos?

Question 2: Which methods do households utilize in disposing inorganic waste?

#### SECTION B: Constraints on inorganic waste management in Lagos

Question 3: What are the constraints on inorganic waste management in Lagos?

Question 4: How can the challenges be mitigated?

#### SECTION C: Global advances in inorganic waste management and their potentials as waste management options in Lagos.

Question 5: What are the potentials of recycling, waste-to-energy projects and total commercialization of inorganic waste management in Lagos?

Question 6: What are the likely constraints in social, economic and technological terms on the potential utilization of options such as recycling, waste-to-energy projects and total commercialization of inorganic waste management in Lagos?