



Integrated Waste Management System as a Sustainable Option for Managing Plastic Waste in Ghana: The Case of Madina-La Nkantanan Municipality

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Authors' contributions

This work was carried out in collaboration among all authors. Authors AAR and NR and AKA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors RAA, NR and AKA managed the analyses of the study. Author AKA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This study elucidates the current state of plastic waste management in urban areas of Ghana, with a particular focus on Madina-La Nkwntanan municipality. As a result of the current uncontrollable plastic waste challenge, the Government of Ghana, is seeking sustainable approaches to reduce the effect of plastic waste in the country. A number of arrangements, including various forms of privatization, tax regimes and public-private partnership have already been initiated as first step solutions to the challenge, yet management of plastic waste, has not been encouraging. Using a case study from one municipality in Ghana, this paper shows that domestic plastic wastes forms the second most generated wastes in the study area. The results show that the practice of separation at source, which is the first step toward dealing with plastic waste, was uncommon in the study area, although pockets of houses in the municipality and other places in the country

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practiced it. This article proposes the integrated waste management (IWM) concept, as one of the possible sustainable options that could help tackle the plastic waste issue in municipality. This is in view of the sustainable nature of the concept as well as its integrative way of dealing with waste. This reality has been confirmed by other authors in several countries.

Keywords: Domestic waste; plastic wastes; sustainable; integrated waste management; Ghana.

1. INTRODUCTION

Municipal solid waste management, especially plastics continue to be a major environmental and health challenge. Although a global success story [1], inadequate management of waste plastics has become a major environmental and health concern. In developing countries, plastic waste has become one of the major challenges facing governments. Waste management become an almost permanent agenda on development policies. It is therefore not surprising that out of the 17 sustainable development goals (SDG), 12 focus on solid waste management (SWM) including plastics. It is therefore not surprising that by virtue of its crosscutting nature plastics and therefore plastic wastes have become an integral part of our communities. The low rate of degradability, unsustainable use and disposal of plastic products are the main challenges with plastic production. This is the consequences of rapid population growth, human activities, urbanization, and industrial growth [2]. While several control measures have been proposed and used to clean up cities and towns of the filth, current strategies attempted to reduce threats to economies, ecosystems and other hazards by plastic waste. In order to meet targets of the SDGs for countries, the efficiency of energy utilization in every step of the waste generation value chain, from production to disposal should, be maximized to ensure that a higher quality of life becomes achievable.

Plastic is the general term for a wide range of synthetic or semi synthetic organic solid materials. They are polymers that contain carbon and hydrogen and few other elements such as chlorine, nitrogen, among others. As polymers, plastics consist of small molecules called monomers combined together through a polymerization process to form polymers such as polyethylene (PE), polyvinyl chloride (PVC), polystyrene (PS), polypropylene (PP), nylons or polyamides (PA). Plastics are relatively cheap, durable, versatile materials and have light-weight. They are by nature non-corrosive and pliable but non-bio-degradable synthetics. As a result, plastics substitute for natural materials in

almost every aspect of life. Today plastics have become an integral part of society. The benefits of plastics to the society include job creation, income generation and improved quality of life. The products of plastics have the potential to reduce energy consumption and greenhouse gas emissions in many circumstances, when compared to other alternatives [3]. In the last few decades, production of plastics has increased to the extent that it has become difficult to manage the waste generated in several communities. There is therefore the need to address any challenge that such uncontrollable waste production may pose to the continuous existence of humans and communities.

Using a mixed method approach, this paper explores how the study community deals with solid wastes, especially plastics and to suggest based on the findings, the integrated waste management (IWM) approach as one way to manage waste sustainably in the municipality.

1.1 Plastic Waste Management in Ghana

In Ghana, it is observed that improving the present status of solid waste management (SWM) will substantially contribute to improving living conditions and health of about 3 million people who currently lack services [4]. This single process of improving waste management in the country will help prevent plastics entering the oceans or causing other environmental challenges in urban areas. Today issues of waste management have taken a centre stage in politics, media and public discourses in the country. A recent study on waste management in Ghana, suggests that reliable waste generation data for planning is limited [5]. Worsening the situation is the reality that managing waste, particularly plastics seems to be rising alongside increasing population and human activities [2]. This makes it difficult for the waste management companies and the state to have control over waste management. The challenges seem to be more pronounced in the cities, resulting from the increased form of economic activities in such areas [5].

In 2015, a study by [6], indicated that over the last three decades, there has been a steady rise

in plastic waste in municipal solid waste streams in Ghana. Analyses of the trend of waste generation in Ghana revealed that the share of plastic wastes by percentage in the waste stream has been increasing since 1979 [6]. It is on record that between 1999 and 2015, the share of plastics almost doubled and in 2014 alone, plastic waste in solid waste in Ghana stood at 1,779 metric tonnes per day [6]. Analyses of the waste composition estimated by [6] shows that organic waste topped with 61% and recyclables, including plastics, textiles, metals, glass, rubber and leather accounted for 22% of waste generated in their study. The increasing amount of plastic waste is because of the high demand for plastic materials. Increasing demand and profit incentives for manufacturers have contributed to the large amount of plastic manufacturing industries in the country. This suggests that the production and consumption of plastics in the country, particularly in cities and towns will continue to rise, which may lead to increase in plastic waste generation with corresponding pollutions to the environment, if not well managed.

According to [7] it is widely recognised that until a change in the current system of mass consumption, environmental sustainability will be a difficult task to achieve. A study conducted in 2019 suggested that currently there are 25 active small to medium plastic waste recycling enterprises operating in Ghana. This includes 10 in Accra, 3 in Kumasi, 10 in Tema and 2 in Takoradi [5]. All these are of varying capacities and therefore handles different capacities of waste in the aforementioned. It is estimated that all the 25 recycling companies process about 320 tons of plastic waste daily. Some of the products made from recycled plastics include take-away carrier bags, refuse bags, buckets, dustbins, shoe soles, doormats, car mats among others. In view of this, closing the gap between plastic generation and plastic waste generation is critical, if the adverse effects of waste on the environment and humans are to be checked. This brings into question the need to have a relook at waste policies, regulations and laws governing particularly plastic wastes in the country. The study revealed that until now, Ghana depends mainly on landfill sites and waste dumping sites for waste disposal [5].

1.2 Waste Management Policies in Ghana

The lack or inadequate control of waste management in Ghana does not suggest lack of policies and laws to deal with the waste

generated. Rather the inadequacy of policy implementation. In Ghana, plastic waste management is carried out in accordance with principles and guidelines contained in the Environmental Sanitation Policy (ESP) of 1999, which was revised in 2010 and the Local Government Act (LGA) of 1994 (Act 462). Legislations for managing solid waste and maintaining environmental quality are simple by-laws made by MMDAs subject to the LGA (Act 462). The by-laws guide the activities of the MMDAs regarding the management of solid waste at the local level. The main goal of the ESP [8] is “to develop a clear and nationally accepted vision of environmental sanitation as an essential social service and main determinant for improving human health and quality of life in Ghana.” The broad principles of the ESP [8].

- i. The principle of environmental sanitation services as a public good,
- ii. The principle of environmental sanitation services as an economic good,
- iii. The polluter-pays-principle,
- iv. The principle of cost recovery to ensure value-for-money that ensures effective and efficient services,
- v. The principle subsidiarity in order to ensure participatory decision-making at the lowest appropriate level in society,
- vi. The principle of improving equity and gender sensitivity,
- vii. The principle of recognizing indigenous knowledge, diversity of religious and cultural practices,
- viii. The precautionary principle that seeks to minimise activities that have the potential to negatively affect the integrity of all environmental resources and
- ix. The principle of community participation and social intermediation.

The principal components of environmental sanitation as defined by ESP [8] include:

- i. Collection and sanitary disposal of solid, liquid, industrial and other wastes;
- ii. Storm-water drainage;
- iii. Cleansing of thoroughfares, markets and other public spaces;
- iv. Control of pests and vectors of disease;
- v. Food hygiene;
- vi. Environmental sanitation education;
- vii. Nspection and enforcement of sanitary regulations;
- viii. Disposal of the dead;
- ix. Control of rearing and straying of animals; and

- x. Monitoring the observance of environmental standards.

As of now, there is no legislation and policy on plastic waste but the Ministry of Environment, Science, Technology and Innovation is working on one which was due to come into force by 2020. The COVID19 has contributed in the delay of release of the document.

1.3 Objective of the Paper

The choice of waste management method depends on several factors including the quantum and composition of waste stream, equipment capacity and the capacity of resources such as finance, technical support and human resources. In view of this, this paper seeks to propose model for sustainable management of plastic waste in the study area by exploring the waste management environment in Ghana. The study approaches the challenge by:

- (i) Ascertaining the state of plastic waste in the study community by exploring the composition of the domestic solid wastes in the study community.
- (ii) Examining mechanisms for household plastic waste treatment through identifying the preferred mode for plastic wastes collection by households.
- (iii) Identifying and proposing a more sustainable plastic waste management approach by identifying challenges faced by households and waste collection institutions in order to propose integrated waste management as a sustainable option.

2. METHODOLOGY

2.1 Study Area and Design

This study was conducted in the La-Nkwantanang Madina Municipal Assembly (LaNMMA), geographically located at the north eastern part of Greater Accra Region. Prior to the second half of 2012, LaNMMA was part of the Ga East Municipal Assembly. But due to governance and political reasons such as strengthening decentralization and taking development to the door step of the people, LaNMMA was established in 2012 by the Legislative Instrument (L.I.) 2030. Furthermore, the LaNMMA metropolise can be described as

the major source of plastic wastes in the Greater Accra region and the third in Ghana.

The La Nkwantanang-Madina Municipal Assembly (LaNMMA), was used as a case study community. It is one of the sixteen (16) established Metropolitan, Municipal and District Assemblies in the Greater Accra Region. It is boarded on the north by the Akwapim South District Assembly, on the south by the Accra Metropolitan Assembly, on the east by the Adentan Municipal Assembly and on the west by the Ga East Municipal Assembly. The choice of the Municipality as a case study area was based on several factors including the population size (111,926 people) and diversity of the dwellers (over 84% urbanized) [9,10]. The study area over the last few years has been experiencing increasing population of people and economic activities. The Municipal capital is Madina which has developed into a vibrant Central Business District (CBD) with several economic activities and opportunities. LaNMMA has a total land surface area of about 166 square kilometres, which is about 5.1% of the total land area of the Greater Accra Region.

In addition to the primary data, secondary data was used in the study. In view of the shortness of time to collect waste and analyse in the laboratory, estimates of the municipal waste composition collected from the Assembly was used in assessment of the plastic proportion of the municipal waste stream (see Table 1).

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2.2 Sampling and Sample Size

The [11] formula (equation 1) which is widely applied for calculating sample size for continuous data was used to estimate the representative sample [12].

$$n = \frac{(z^2) \cdot (p^2)}{d^2} \tag{1}$$

Where,

n = sample size;

z = value for selected alpha level of each tail, (=1.96, the alpha level of 0.05 indicates the level of risk the researcher is willing to take that true margin of error may exceed the acceptable margin of error); = estimate of standard deviation in the population, (unknown in this case but 0.5 or 50% was used for conservative estimate); and

d = acceptance margin of error for mean being estimated (= 0.07 with confidence interval of 93%).

$$n = \frac{(1.96^2) * (0.5^2)}{0.07^2}$$

$$n = 196$$

Using this formula, a sample size of 196 household heads were selected for the study.

2.3 Data Collection and Analyses

The random sampling approach employed in the data collection yielded 98% retrieved questionnaires of the total 250 administered. Collected data was analysed descriptively. A careful explanation of the questions gave respondents who could not read and write a chance to complete the forms. Questionnaires were unmarked to ensure confidentiality of respondents. Compilation of data using a Microsoft Excel to tally the responses. A Statistical Package for the Social Sciences (SPSS) version 18 was then used to perform the analyses.

3. RESULTS AND DISCUSSION

3.1 Age of Respondents

The study results (Fig. 1) show that waste management responsibility at the household level lies mainly with people between the ages of 21 and 51 years old (with more people 33.64 from the 41-50 years category). This suggests that cleaning of the home is not the responsibility of children but adults. It shows that majority (70.9%) of the respondents were females while the remaining 29.1% were males. The results show that 64.6% of those whose responsibility it is to clean the home were adult females, while 22.7% were children, with the remaining 12.8% representing adult men. According to a study in Bolgatanga Municipality of Ghana, [13], reveals that mothers ((adult females) constituted 46% and children (45%). This suggests how serious

households take waste management and cleanliness.

3.2 Education Level of Respondents

On formal education the result (Fig. 2) shows that most (86.4 %) of the respondents had different levels of formal education, with about a third of the respondents having attained a tertiary education. The statistics (Fig. 2) shows that about 13.64% had no formal education and 2.7 % had basic education. This shows that a good number of the respondents were well educated and therefore it was expected that their level of keeping to good sanitation practices would be high.

3.3 Occupation of Respondents

The results (Fig. 3.) on occupation, suggests that the respondents were sampled from among people with different occupational backgrounds. These include traders, farmers, public servants, students and business people. The results (Fig. 3.) suggests that students and farmers formed the least number of respondents (6.34%) and 1.82% respectively. This corresponds to the Ghana statistical service records, which described the municipality as one inhabited by traders who carry out their businesses mainly at the popular commercial centre of the municipality, Madina market and its environs [14].

3.4 Storage of Waste at Home

Fig. 4 shows how the households in the study area, typically stored waste after generation and before the waste collection trucks come for them. It shows that to store the waste so generated, the various households use a number of items. Those who cited the usage of dust bins were more, represented by a proportion of 43.6% and followed by the use of polythene (31,8%) and then use of old sacks (20%) to store the waste before haulage by the collection companies to dumping sites.

3.5 Composition of Waste Stored at Home

Information on waste characterisation provides opportunity for local Assemblies to design effective mechanisms for sustainable waste management and practices. According to the Assembly, the component analyses of waste generated at home in the study community shows that organic or food waste forms the largest (45.3%) proportion of waste generated in

the homes. According to Table 1, plastics constitutes about 17.9% and the least waste generated in the home is from wooden materials, which forms only about 2.4% of the total waste generated. Glass, which is another non-biodegradable material, constitutes about 4.3% of total waste in the home. This result (Table 1) shows that plastic waste in LaNMMA is higher than the 9% reported for Accra Metropolitan Authority (AMA) [15], 16.5% for Kumasi Metropolitan Authority (KMA), 16% in [16] and the national average of 14% in [6]. This results show a high rate of use of plastics in the community of study. This phenomenon is likely to have huge negative implications for disposal or waste management, given that plastics are not biodegradable [17].

3.6 Mode of Waste Disposal

The current study revealed that almost equal proportion (Table 2) 50% of the households' surveyed separate their waste before final collection from homes. The plastic materials households sorted out included sachet water bags, water bottles and polythene bags, which they gave out free to plastic waste pickers or some employees of waste companies, who

intend sell to make money. A pilot study conducted in selected cities and towns across the country by [6] revealed that household separation of waste at source had the potential for a cleaner environment, was a good management practice and good for recycling. Household source separation although desirable as a solution to solid waste management has not received much patronage in Ghana [17,18].

3.7 Plastic Waste Collection Mechanisms

The survey results (Fig. 5) show that two main waste collection modes were used by the households in the collection of the plastic wastes in the Municipality. These mechanisms of plastic waste collections in the municipality include (1) door to door and (2) communal. The statistics from the current study show that between the two mechanisms more than two thirds of the survey participants used the door-to-door mechanisms. Majority of the surveyed households employ the door-to-door mechanism to collect the plastic waste in the households. The study shows that while a fifth used the communal system to gather their plastic wastes, the remaining 11.82% cited other mechanisms such as self-lifting to dumping site, burning and burying of waste.

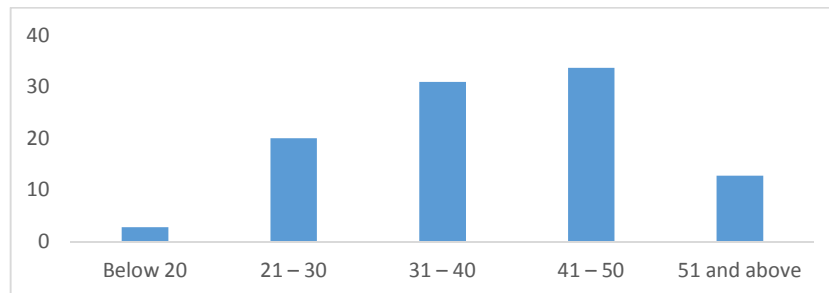


Fig. 1. Age Distribution of respondents

Source: Field Survey

Table 1. Composition of solid waste generated in the Municipality

Component	Percentage by weight
Food	45.3
Plastic	17.9
Textiles	9.5
Metals	9.1
Paper	8.0
Glass	4.3
Construction materials	3.5
Wood	2.4
Total	100.0

Source: LaNMMA, 2015

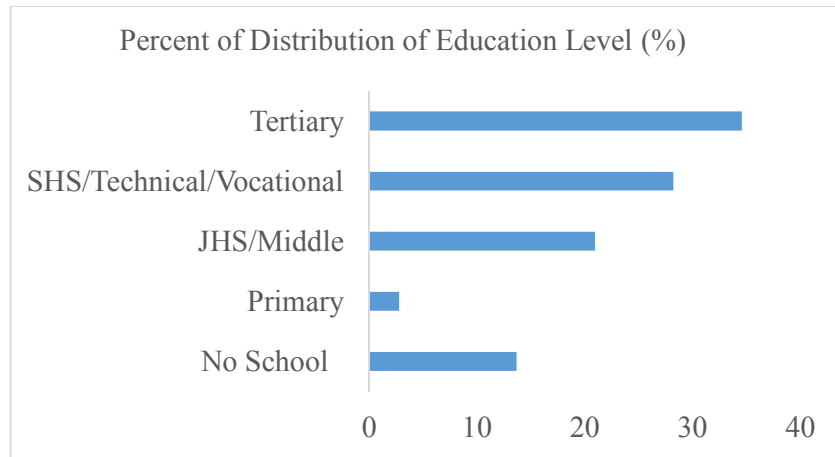


Fig. 2. Educational level of respondents
Source: Field Survey

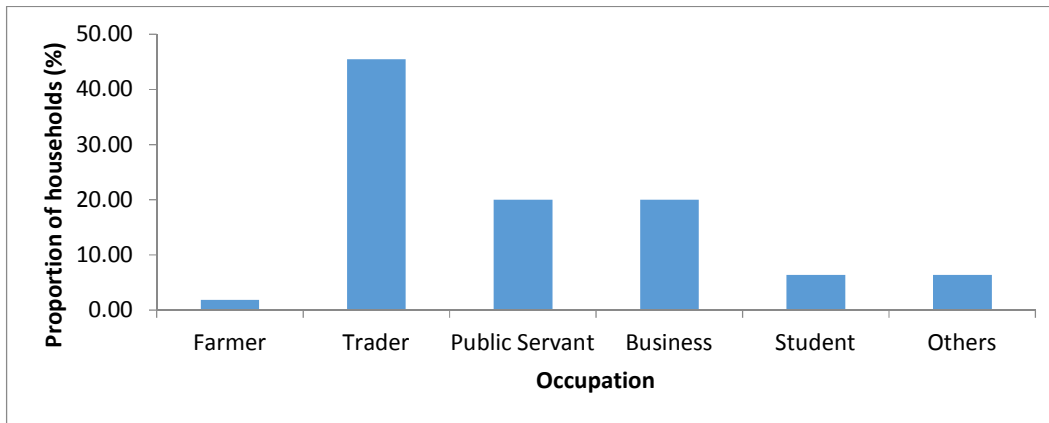


Fig. 3. Occupational status of respondents
Source: Field Survey

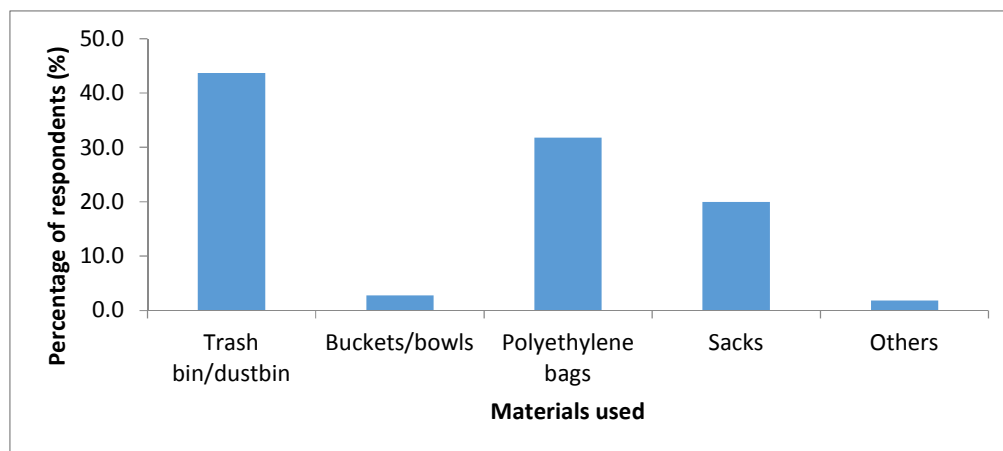
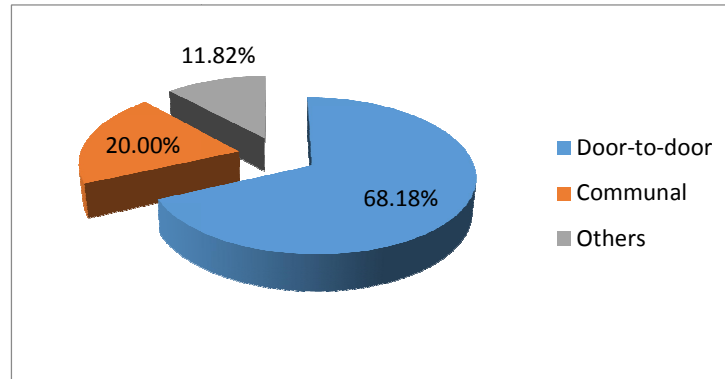


Fig. 4. Temporary storage of waste at the household level
Source: Field Survey

Table 2. Mode of plastic waste disposal

Mode of disposal	Frequency	% of respondents
Separated from household waste	56	50.91
Not separated from household waste	54	49.09
Total	110	100.00

Source: Field Survey

**Fig. 5. Mode of plastic waste collection**

Source: Field Survey

3.8 Final Disposal Mechanism at the Household

The survey results (Fig. 6) reveals that households in the Municipality are using a number of final disposal methods. These methods included, public dumping site, open space dumping, dustbin, skip, burning, burying and others such as bola taxi and truck pushers/"Kaya" solid waste carriers. The widely used disposal method by household was dustbin representing 63.64% of households. The second disposal site used by households was skip accounting for 11.82%, followed by public dumping site (10%) and others (6.36%). Furthermore, about 4.55% burned their waste, 2.73% of households resorted to burying their waste in the ground while a small proportion of households (0.91%) indiscriminately dump plastic waste in open places such as gutters. This has been confirmed in other studies in Ghana [12,13].

3.9 Extent of Waste Management Challenges

The study showed that communities surveyed, had a number of challenges including the collection, storage and disposal of household waste. Others included inadequate information on plastics separation, lack of dustbin to store

waste, inadequate dumping sites for final disposal, and irregular collection of plastic waste from the house. The results (Fig. 7), shows that among the households who responded, about 76.25% considered irregular collection of plastic waste is the major challenge they were confronted with and this was followed by another 36.25% and 40% who cited same as very serious and serious problem respectively. Although households considered the distance to disposal sites as challenging, majority (65%) thought it was less of a problem while 35% of them especially those who lived far from skips and dumping sites said it was a serious/very serious problem. In the case of those who complained of lack of dumping site, there was a split in opinions with half of them indicating that it was a serious or very serious issue while the other half thought otherwise. The overwhelming majority (about 91.83%) of households who stated that lack of dustbin was a critical issue indicated that it was a major challenge with, 56.12% confirming it was a very serious problem and 35.71% said it was a serious one. However, the overwhelming majority (94.68%) of households confirmed that lack of adequate information on plastic separation was a real problem. About 71.28% indicated it was very serious while 23.40% claimed it was serious. This is an important issue, which needs serious attention from the Municipal Assembly if it seeks to curb plastic waste in its environs.

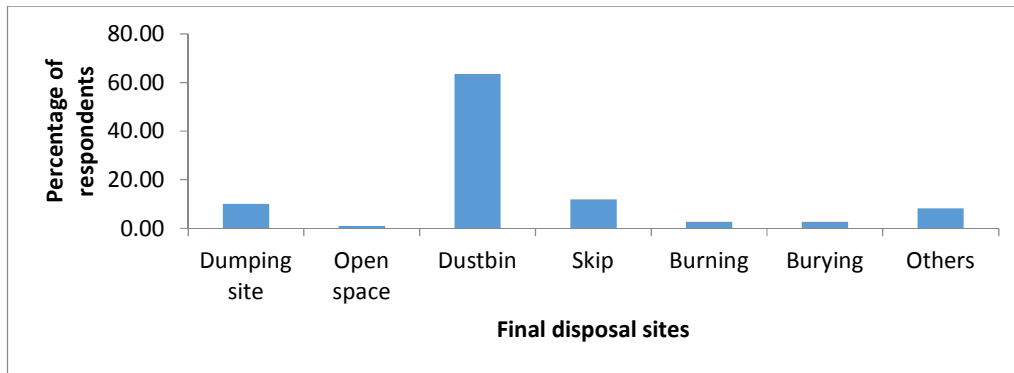


Fig. 6. Methods of final disposal of plastic waste by households
 Source: Field Survey

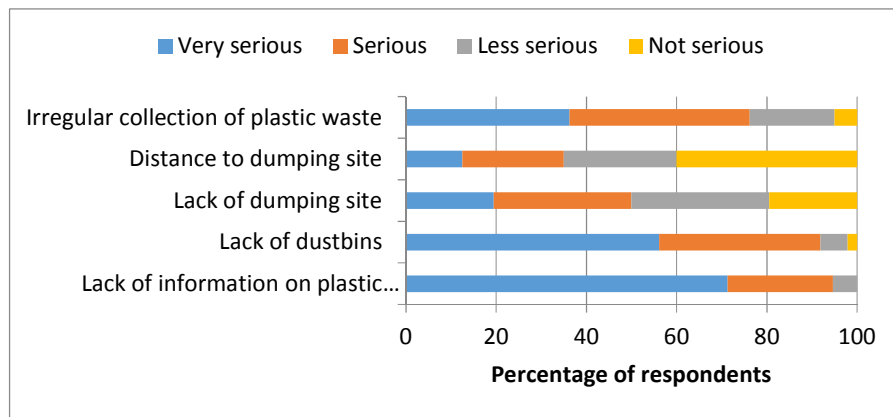


Fig. 7. Extent of the seriousness of waste management challenges
 Source: Field Survey

3.10 Proposed Waste Collection Model

In addition to identifying the waste component of the municipal waste stream and the current practices employed in the collection of plastic waste, the study also proposes an approach that is more sustainable compared to the current system of dealing with plastic waste. This proposition is based on the three elements of sustainable waste management. These include source separation, waste management and waste reduction. These three elements were found to be practiced all right in the community but in a fragmented way which does not make it sustainable. Sustainable waste management should be integrated and in a way follow a value chain approach techniques.

The study show that the current system of dealing with waste, particularly, plastics in the municipality is not sustainable. This is evident by the obvious display of inadequate financing mechanisms, dumping sites, and poor waste

separation culture among the households. The current practices is unsustainable and such unsustainable way of dealing with waste has the potential to cause various environmental and human health challenges. For a more efficient and sustainable way of dealing with the plastic waste, a mechanism that focuses on plastic waste retrieval or reuse should be ideal. Yet, this form of waste management is uncommon in the municipality, excerpt in the bourgeoisie communities, where it is practiced on a very low scale.

The current study shows that some form of waste reduction and waste management activities were carried out in the municipality. These includes burying of waste for compost, landfill operations, and some form of reuse and recycle of plastic waste. While this form major part of the proposed integrated solid waste management concept, current waste collection and management system in the municipality is not integrative. Waste treatment is more efficient if carried out in

an integrative manner. this is because an ISWM system considers how to reduce, reuse, recycle, and manage waste in a way that protect human health and the environment, premised on local conditions and needs. Reducing waste at the source and reusing wastes means that less waste left for collection. This reduces cost and the pollution generated in transporting the waste and at the disposal site. The interdependence of the waste management and waste reduction practices as observed from the study result suggests that an integrative process or concept will be easier to introduce in the municipality since the communities are already practicing some forms of it.

The current paper proposes the use of Integrated Solid Waste Management (ISWM) system as a sustainable way of handling waste efficiently in the municipality. This proposition is based on the study results and other considerations from the literature. In the study, the authors observed that currently the households in the study communities and others captured by the literature review employ the mechanisms such as burying waste in landfill sites for compost, burning waste in incinerators, recycling, reusing and compositing of waste. These are all techniques of ISWM in practice, yet the community practice them in a non-integrated fashion. This therefore does not ensure efficient handling of the plastic waste. This makes it easier to employ the integrated concept in managing waste in the country.

The efficiency of integrated waste management systems has variously been evaluated using different methodologies. Investigations have suggested that the concept is good and hence its application in the developed world [19]. It is estimated that when utilized, between 75 and 90% of municipal waste in the United States of America could be eliminated. In view of this, several countries in both developed and developing countries have and are implementing policies to use ISWM to deal with plastics waste. An ISWM combines a variety of strategies for both waste management and waste reduction. According to the US Environmental Protection Agency (EPA), Integrated Solid Waste Management is a complete waste reduction, collection, recycling and disposal system. It ensures the productive use of waste represents a means of mitigating some of the associated problems of solid waste management. Adaption and adoption of this system will help resolve the inefficient, linear and traditional approach to deal with waste in the country.

4. CONCLUSIONS

Treating and disposing mixed solid waste is a herculean task that requires a lot of efforts, time and finance to be able to do a complete job. This presents a challenge to many developing countries including Ghana. The danger posed by these form of waste, particularly plastics in the waste stream to health and environment [20] calls for an alternative approach that incorporates a selection of suitable techniques, technologies, and management programs to achieve sustainable waste management [21,22]. The current study shows plastic wastes constitute a considerable part of urban waste stream and by its non-biodegradable nature; this is not a pleasant news as it poses a greater danger to the environment and human health. The study results did not show a difference between those who practiced separation and non-separation of waste in the homes. The results show that those who practiced separation at the household were slightly higher. Adoption of this technique will lead to improved waste management in the country. some of the challenges faced by the households included distances of dumpsites, lack of dumpsite and dustbins as well as irregular collection of waste and finance to pay for waste generated.

The study results show that the solutions to the problems of the plastic menace using the ISWM in the community study and largely Ghana is realistic as evidence on the ground indicate that waste management and waste reduction principles, which are integral of the ISWM system are not new to the community of study. The only exception is that they are observed in a non-integrative manner. With a change in attitude towards waste generation, separation and disposal mechanism, introducing the ISWM concept on a larger scale is not likely to pose any serious challenges.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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