A BASELINE SCENARIO OF MUNICIPAL SOLID WASTE MANAGEMENT

Abstract

The baseline scenarios of municipal solid waste management (MSWM) activities that will expose the specific challenges militating against sustainable waste management in many developing countries, are not properly documented or not understood. This paper established a baseline scenario of municipal solid waste management (MSWM) in Ghana, through material flow analysis and understanding of MSW handling practices, using the Wa Municipality as a case study. The study was theoretically based on empirical observation and an exploratory design. The findings showed that sustainable waste management has remained elusive because MSWM in the case study area and Ghana in general, consist of some waste collection, transportation and open dumping, where the entire amount of waste is open dumped without pre-treatment. The sorting of waste at the generation sources, and the provision of adequate MSWM infrastructure, through an integrated solid waste management system can ensure sustainable waste management in the country.

Keywords: Baseline scenario; Municipal solid waste; Sustainable waste management; Open dumping; Integrated solid waste management; Wa Municipality; Ghana.

Introduction

Rapid urbanisation and population growth together with inadequate detailed and accurate data on quantity and composition of waste are exacerbating the problem of MSWM in many developing countries. The commonly practiced MSWM option in in many other developing countries, including Ghana, basically involves the collection of mixed waste materials and subsequent dumping at designated dump sites (Ayuba *et al.*, 2013). It is not a practice to separate waste materials at the source or any point during its management in many developing countries.

In Ghana, MSW stream generally consist of putrescible, plastics, paper, textile, metal, and glass; similar to the waste streams in sub-Saharan Africa (Ayuba *et al.*, 2013; Miezah *et al.*, 2015). The African Development Bank (2013) indicates that Ghana generates about 3.6 million tons of solid waste (SW) per year, made up of predominantly organic compostable, such as food, yard, and wood wastes.

MWSM was initially meant to protect public health but has been modified over the years in pursuit of public policy objectives of pollution control, resource conservation and, most recently, sustainable development (Spiegelman and Sheehan, 2005). Despite these, the MSWM system in Ghana and other developing countries continue to bury or burn most of the wastes that enter their systems. The focus

of MSWM in most developing countries basically involve getting rid of the trash, by collecting and open dumping waste at designated sites.

However, to ensure sustainable waste management, the activities associated with solid waste management (SWM) from the generation point to final disposal normally include, generation analysis, waste reduction, reuse, recycling, handling, collection, transfer and transport, transformation (e.g., recovery and treatment), and disposal (Arafat et al., 2015; Arushanyan *et al.*, 2017). Therefore, a sound waste management program that combines some of these necessary activities into an integrated solid waste management (ISWM) system is vital in achieving sustainable solutions in developing countries.

Nevertheless, the baseline scenarios of MSWM that will expose the specific challenges militating against sustainable waste management in many developing countries, including Ghana, are not properly documented or not understood in most municipalities. Therefore, the objective of this paper is to establish a baseline scenario of MSWM in Ghana, through material flow analysis and understanding of MSW handling practices, using the Wa Municipality as a case study.

Literature review

In the past, the disposal of wastes did not pose a significant problem because the population was small and the amount of land available for assimilation of waste was large (Ray, ND; Bolund and Hunhammar, 1999). However, the need for adequate treatment and disposal of waste by man arose as populations moved away from dispersing geographical areas to congregate together in communities (Williams, 2013).

Consequently, safe disposal of waste is now a global norm, although, MSW treatment and disposal is still a neglected area in many developing countries. Improper disposal of MSW in developing countries are manifested in the dumping of MSW into water bodies and wetlands, and the burning of waste to reduce its volume (Khatib, 2011). These practices are known to have adverse environmental impacts ranging from polluting natural resources and the ecology to the creation of health problems, which might lead to long-term public health complications, causing a public nuisance, and degradation of the environment and aesthetics.

Nonetheless, inappropriate disposal of waste is not only peculiar to developing countries, as the practice has occurred in every country at a point in time. Rathje (2013) suggests that in the past:

> "*there were no ways of dealing with solid waste that have not been known for thousands of years. These ways are essentially four: dumping it, burning it, converting it into something*

that can be used again, and minimizing the volume of material goods – future garbage – that is produced in the first place".

Thus, every country at one point in time has been confronted with the challenge of improper waste disposal. For instances, there were reported cases of cholera outbreaks in the UK in the 1950s and 1960s due to poor sanitation, including SWM (Griffith, Kelly-Hope and Miller, 2006).

Presently, open dumping of waste is the norm in Ghana and many other developing countries (Ogwueleka, 2009; Papargyropoulou *et al.*, 2015). Open dumping is an illegal process, in which any type of waste such as household trash, garbage, tires, demolition/construction waste, metal or any other material is dumped at any location such as along roadsides, any available space either public or private property other than a permitted landfill or facility (Badgie *et al.*, 2012; Ali *et al.*, 2014; Karim *et al.*, 2017).

Open dumps are simple open sites with no engineered measures, and no consideration for leachate and landfill-gas controls. They have devastating effects on the environment with long-term impacts such as pollution of air, soil, surface and ground water. Accordingly, landfilling is the most recommended method for MSW treatment and disposal in developing countries (Yang *et al.*, 2014; Tozlu, et al., 2016; Zainu and Songip, 2017), because it is the simplest and normally cheapest method for disposing of waste (Aljaradin and Persson, 2012).

Hitherto, the main considerations in the design, construction, operation and decommissioning of landfills, which are emissions control and groundwater pollution prevention (Townsend *et al.*, 2015; Yusoff and Zamri, 2015), are often ignored due to the high capital cost and lack of technical skills needed for landfilling in most developing countries. Therefore, un-engineered landfilling, which is disguised open dumping, is the practice in most developing countries.

MSW is no more treated as the useless garbage with no intrinsic value, rather waste is considered as a resource in the present time (Zaman, 2015; Zaman and Lehmann, 2013), with resource recovery being the important focus in the design of most waste management systems presently. Consequently, waste reduction and waste separation are the two important components of resource recovery from waste and sustainable SWM (Permana *et al.*, 2015). These actions are apparently impossible to implement without high consciousness within the communities as well as a strong commitment and support from waste management authorities.

For several reasons, resource recovery is a major element in SWM in most developing countries (Badgie et al., 2012; Thaiyalnayaki and Jayanthi, 2017). Reclaimable inorganic components (metals, glass, plastic, textiles, and others) traditionally have been recovered mostly by way of unregulated

manual scavenging by private individuals (informal sector) (Srivastava et al., 2015; Leal Filho *et al.*, 2016; Stoeva and Alriksson, 2017), however, waste reduction and waste separation are rarely formally practiced by households and waste management authorities' due to poor waste management governance, which is militating against sustainable waste management in most developing countries.

Furthermore, many developing countries in an attempt to accelerate the pace of their industrial development, has failed to pay adequate attention to sustainable waste management (Mathieu and Williams-Jones, 2015). This has led to severe penalties in the form of resources needlessly lost and a staggering adverse impact on the environment and on public health and safety (Othieno and Awange, 2016). Therefore, every country needs to adopt appropriate waste management systems that meet their needs at every level of development in order not to pass on waste management challenges for future generations to solve.

Appropriate planning is key to sustainable development in the waste sector, through the development of sustainable waste management infrastructure and systems (Topić, et al., 2013; Sanford *et al.*, 2016). Planning balances the social, economic, political, governance, environmental and technical considerations for waste management (Marshall and Farahbakhsh, 2013; Rodríguez *et al.*, 2015), since MSWM planners are faced with a system that involves a variety of these factors. Therefore, in making decisions, the trade-offs among these factors are a central concern.

Unfortunately, MSW planners in most developing countries do not have the resources and the expertise needed to analyse all the information that is relevant to a proposed waste management policy or programme (McKay, et al., 2015). In most cases, only the financial cost borne by the municipality is considered (Rogge and Jaeger, 2013; Lohri, et al., 2014), effects on air and water, and environmental equity are only considered when a crisis with the public develops, or when regulations are imposed (Percival, 2015; Asomani-Boateng, 2016).

The key role of waste management planning is to establish which combination of waste management strategies and methods will ensure sustainable waste management. Thus, in planning for waste management, the baseline situation of waste management is essential, in order to set sustainable and realistic objectives that are consistent with environmental policies and regulations, and measurable so that progressive achievements are verifiable (Zaccariello et al., 2015).

Methods

The assessment of the baseline scenario of MSWM in the case study area (the Wa Municipality) was theoretically based on empirical observation and an exploratory design and was carried out through material flow analysis (MFA) and by investigating MSW handling practices. Both qualitative and quantitative research methods were applied in this study and the data collected, mainly from primary

sources through field survey. Questionnaires, interviews and observation were used to obtain information on MSW handling practices and attitudes towards MSWM of various waste management stakeholders (waste generators and service providers).

The fieldwork was carried out in the case study area from the last week of November 2017 to the end of March 2018. During this period, questionnaires were administered to households and Zoomlion Ghana Limited (ZGL), the only private waste collection company in the case study area, and interviews held with some key waste management stakeholders (municipal authorities, some household heads, and informal waste pickers), together with observation of waste management practices in the case study area.

Stratified random sampling (a probability sampling technique) was used to administer the waste generators (households) questionnaire. The households' questionnaire was distributed according to the residential typology and income levels of the households in the case study area. 211 households, representing compound-house/low-income dwellers, semi-detached/middle-income dwellers, and single-unit/high-income dwellers, answered the households' questionnaire. Although this households sample size was small, as the Wa municipality's household population was 102,264 (Ghana Statistical Service, 2014), because of a limited budget, it was "big enough" to be of scientific and statistical significance (Lenth, 2001; Zodpey, 2004; Ahmad *et al.*, 2012). The household respondents' distribution is presented in Table 1. The data obtained was organised, classified and analysed in themes as well as visual presentation in the form of charts.

Furthermore, the researchers arranged and held formal and informal interviews with senior officials of the Wa Municipal Assembly, including and not limited to, the director for the Municipal Waste Department (MWM), municipal engineers (two number), environmental health officers (five number), and budget officers (one number), to obtain information on the current management performance in the study area. Also, two senior staffs of Ghana's Environmental Protection Ghana (EPA) (the regulator of Ghana's environment, including waste management), some workers of ZGL (three drivers and ten cleaners), informal waste pickers/collectors (three metal waste merchants), and scavengers at the waste disposal site (one boy and three women) were also interviewed.

Additionally, the researchers arranged and held formal interviews with a senior staff each of government institutions with some functions over SWM to solicit their views on how their functions could help improve SWM and vice versa. These institutions included the Town and Country Planning Department, Lands Commission, Water Resources Commission, and the Department for Urban Roads.

Table 1: Household respondents' distribution

Residential Typology/Income Level	**Name of Residential Area**	**Number of Questionnaires administered**	**Average Household Size** (Ghana Statistical Service, 2014)
Compound-house dwelling (low-income)	• Dondoli • Kambale • Kpaguri • Konta	104	6.4
Semi-detached Dwelling (middle-income)	• Dobile Quarters • SSNIT Flats • Degu Quarters • Kpaguri Estates	64	5
Single-unit dwelling (high-income)	• Jdzedayiri – Tampalepani Residential Area • Xavier Residential Area • Xavier Extension • Airport Residential Area	43	5.4
Total		**211**	**5.6**

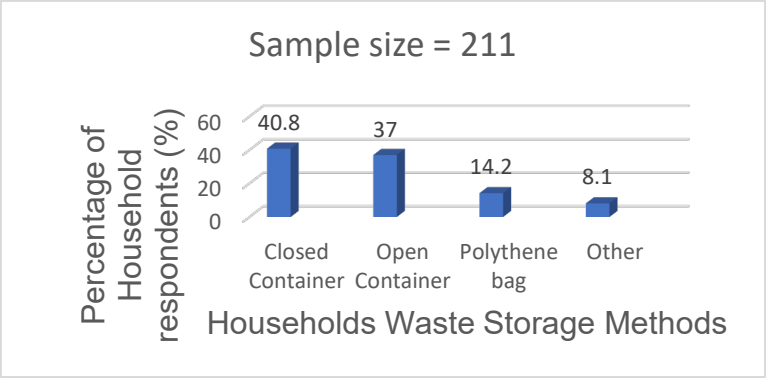
Results and Discussion

Households MSW Handling Practices and Management

There is a minimal provision of SWM facilities, such as communal collection containers, open dump sites, and house-to-house collection of waste across urban Ghana, including the Wa Municipality. Usually, the generators of solid waste (SW) are responsible for their storage and disposal. There is no segregation of waste at any point of its management, as waste is not sorted at the generation point, despite the dominance of recyclable materials in the waste composition, which comprised of hazardous and non-hazardous waste.

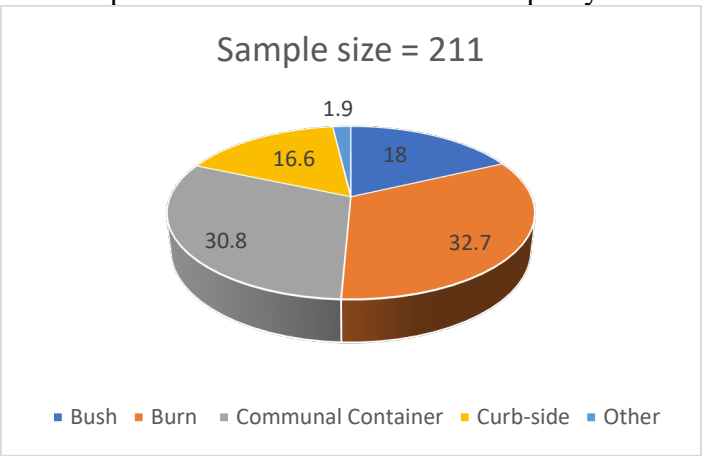
In the Wa Municipality, the fieldwork showed that majority of the households' respondents (40.8%) stored their mixed unsorted waste in closed containers such as bins, whereas, 8.1% resort to other storage methods such as storing the waste in a pit and subsequently burning to reduce the volume of the waste. The MSW storage methods are shown in Figure 1.

Figure 1: Households MSW storage methods



The fieldwork for this study also indicated that the most widely used method of SW disposal in the Wa Municipality is by burning, with 32.2% households resorting to this option; 30.8% of households depended on communal collection which constitutes the second widely used method of SW disposal; and only 16.6% of households relied on house-to-house waste collection service for their waste disposal, as shown in Figure 2.

Figure 2: Households waste disposal methods in the Wa Municipality



These MSW disposal methods show an improvement in MSW disposal methods in the Wa Municipality from the 2010 population and housing census, which indicated that 44.6% of the households in the Wa Municipality were provided with communal container for the disposal of their solid waste, but 24% of households' actual resorted to the communal containers for their SW disposal; as high as a proportion of 17.6% of households dumped their solid waste indiscriminately; 4.3% of households relied on house-to-house waste collection service (Ghana Statistical Service, 2014).

The most common system of waste collection is the central container collection system, whereby households are responsible for transporting their waste to refuse containers located within the communities. Both middle and low-income residential areas are serviced in this way, representing 30.8% of the household respondents of this study. Although the central containers are to be sited at a maximum of 150 meters from residences, the researchers in their fieldwork observed that in the Wa Municipality, containers are commonly located further distances than the maximum, sometimes up to 450 to 600 meters in some communities. Also, emptying of the containers were not consistent, and in most instances, were left to overflow (as shown in figure 3).

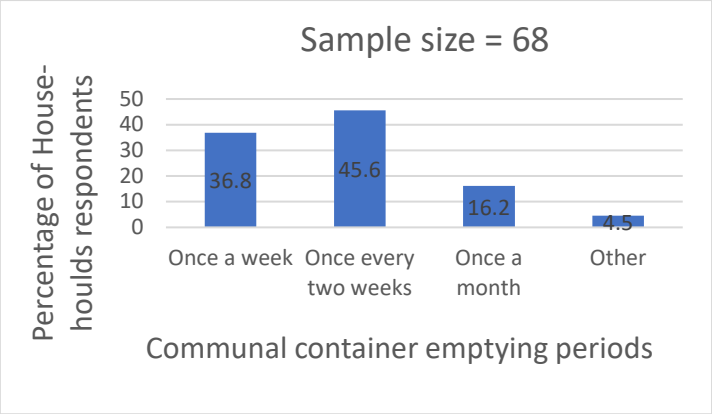
Figure 3: Container overflowing with waste in Wa

There were 37 communal containers positioned at various locations within the Wa municipality. 22 of these containers were managed by Zoomlion Ghana Limited (ZGL) and the remaining 15 containers were managed by the local assembly. Whereas, ZGL claimed that they emptied the communal containers under their jurisdiction daily, which contradicted the households' responses to the collection schedule, the local authority did not have any scheduled collection period, as a supervisor of the communal containers at the Wa Municipal Assembly (WMA) indicated that:

> "*it depends on the availability of fuel; the emptying of the communal containers can be within one week, two weeks, three weeks, one month, and sometime two months*".

This statement of the communal containers supervisor was confirmed by 68 household respondents of this study who depended on the communal collection service, as the household respondents gave varied emptying periods of the communal containers in their localities, with majority (45.6%) of the respondents indicating that the communal containers were emptied once every month as illustrated in Figure 4.

Figure 4: Communal containers emptying periods according households



The irregular emptying of the communal containers discouraged patronage of the service by residents, who then resorted to illegal disposal practices such as throwing of waste into drains, bushes, and burning. These often lead to the spread of communicable diseases such as cholera, and health hazards ranging from stench emanating from uncollected and decaying garbage to choked drains.

However, in some parts of the Wa municipality (accessible and high-income residential areas), ZGL operated house-to-house collection service. 16.6% of the household respondents of this study depended on the house-to-house collection service in the Wa Municipality. Unlike the communal collection service dependants who had irregular emptying of the containers, majority (76.9%) of the house-to-house collection beneficiaries confirmed in this study that their bins were emptied regularly (once a week). Since the house-to-house collection beneficiaries paid a monthly collection charge of 15 Ghana cedis (approximately $4) directly to ZGL, the private company seemed to over concentrate its operations on this service, to the detriment of the majority who depended on the communal collection service.

The study also found out that majority (43.8%) of the households in the Wa Municipality depended on the local authority for the collection of their waste, 10.5% of households depended on the private waste collection company (ZGL), 34.3% of households relied on both the local authority and ZGL for their waste collection, whiles 11.4% of the households were not covered by any waste collection service.

Institutional, Commercial, and Street MSW Handling Practices

The institutions covered in this study were mainly government departments/offices and the commercial area that this study considered was the Wa central market. Like household waste handling practices, there was no sorting of waste at the point of generation in the institutions and the Wa market.

The researchers observed that the institutional waste was mainly paper, which was usually stored in smaller bins and disposed of by open burning. The institutions were not covered by any waste collection service. In an interaction with some staff in some institutions in the Wa municipality, the staff did not want to be covered by any collection service as one staff indicated that:

> "*the waste we generate here is small and mainly paper, which we easily burn. So, why should we pay for someone to dispose of our waste which we can easily dispose of? Besides, no allocation is made for waste disposal in our institution. Do you expect me to pay for my office waste disposal from my pocket? Our cleaners empty the bins every morning and burn the waste".*

Additionally, a head of a government department justified the institutions burning of waste paper and not subscribing to a collection service with the explanation that:

> "*Most of the waste paper we disposed of are confidential documents, but we don't have paper shredders to shred them before disposal. The best way to keep confidential documents waste paper from the public eye is to burn them*".

Also, the Wa market waste was mainly generated by traders and shop owners in the Wa market. Organic waste dominates the Wa market waste stream. Bowan and Tierobaar (2014) in their characterisation of Ghanaian markets waste found the Wa market waste to be 46.6% organic, 13.1% paper/cardboard, 4.9% plastic, 3.4% textiles, 2.6% metal, and 29% miscellaneous waste. Communal containers were placed at vantage points for the collection of waste in the Wa market.

During the fieldwork, the researchers held informal interviews with some of the market traders and shop owners. These research participants complained about the irregular emptying of the communal containers as they claimed that the communal containers were usually allowed to over flow for many days. However, during the fieldwork, the researchers did not come across an overflowing communal container in the Wa market. The researchers, though observed that little children were open defecating by the communal containers.

Street cleaning in the Wa municipality is carried out by ZGL, a local private waste collection company. There is no provision of street bins in the Wa municipality and most parts of Ghana. Thus, street littering is a common practice in Ghana. The street litter is mostly made of plastics bags (sachet waste bags) and leaves. ZGL had 200 street cleaners in the Wa municipality who usually work between 5:00am and 8:00am daily. The researchers observed that majority of the street sweepers were women and illiterate. The few male street sweepers were provided with tricycles and motorised tricycles to enable them access clustered parts of the municipality to collect SW.

An observation of the street sweepers activities, revealed that there was inadequate provision of protective working gear for the street cleaners. The researchers observed that some of the street sweepers were collecting waste with their bare hands and wearing flip-flops. Through informal interviews, some of street waste workers told the researchers that their hand gloves had won-out, while others complained of discomfort with the use of the hand gloves. The collected street waste is usually disposed of into nearby bushes or burnt.

Material Recovery from MSW

There is no formal material recovery from waste in the Wa municipality. However, materials are recovered by informal metal waste merchants (scrap dealers) and scavengers. The informal metal waste merchants usually have working gangs called '*Zabarma'* who move from house-to-house in search of unwanted metals. The '*Zabarma'* weighs the unwanted metal with a scale and bargains with the owner to arrive at a compromised price.

The price of 1kg of metal waste was between fifty pesewas and one Ghana cedi (the equivalent of $0.11 and $0.22). The recovered metals were transferred in pusher carts (see Figure 5 (a)) to various open dumps sites (see Figure5 (b)), usually near the residence of the metal waste merchant and stored until the quantity is substantial (20 to 30 tons) before the metals are loaded and transported to the southern part of Ghana, *Tema* (an industrial city) in trucks, where the metals are recycled into product, such as iron rods usually used as reinforcement in construction.

Figure 5: Pusher cart (a) and metal waste open dump (b)

Plate (a) Plate (b)

The researchers during a visit to a metal waste merchant's residence realised that their operations had created a job opportunity for some unemployed people in the Wa municipality. The researchers observed that women between the ages of 25 and 55 were employed to load the truck that transported the metal waste from Wa to Tema (see Figure 6). The women in an interaction with one of these

researchers confirmed that the metal waste buyer's operations had provided them with an alternative source of livelihood, especially during the dry season when they could not engage in farming.

However, the women were not quite happy with their daily wage. Some of the women told the researchers that because of lack employment opportunities, they were not able to negotiate on their daily wage and were paid either 15 Ghana cedis or 20 Ghana cedis per day (equivalent of $3.74 or $5), depending on how exhausted they were after a day's work, based on the metal merchant's assessment.

Figure 6: Women loading metal waste truck

Another type of material recovered from waste in the Wa Municipality was plastic (rubber) waste (see Figure 7) at open dumping sites and the main disposal site by mostly women and children scavengers (see Figure 8). There are over 10,000 scavengers in Ghana (Madrigal, 2011). Scavenging at the main disposal site located in *Siriyiri* is prohibited by the municipal authorities, however, to outwit the managers of the disposal site, children scavengers between the ages of 7 and 16, usual visit the disposal site early in the morning (between 4am and 6am) to collect recover materials in the dumped waste before the arrival of managers of the disposal site and waste disposal trucks. Like the metal waste, all the recovered plastic/rubber waste is bought and transported to the southern part of Ghana (*Tema* and *Kumasi*) where the plastics waste is recycled into useful products.

Figure 7: Scavenged materials at the Wa disposal site

Figure 8: Scavengers at the WMA's disposal site

In an interviewer with a 12-years old scavenger at the disposal site, who was bare-footed and without protective clothe, he lamented about the posture of the municipal authorities towards their operations. He told these researchers that:

> "*we recover ferrous cans and rubber and sell them to support our schooling needs such as buying of pencils, pens, and exercise books because our parents cannot afford them; so why can't they allow us*".

When one of the researchers pointed out to him some possible dangers (infections and injuries) of scavenging for waste at the disposal site, he retorted that:

> "*I started scavenging for waste at this site when I was six years together with my elder brothers and sisters but none of us have ever been infected or injured on the site*".

MSW Flow in the Wa Municipality

The commonly practiced MSW disposal option in the Wa Municipality and the whole of Ghana (as in many other developing countries) basically involves the collection of mixed waste materials, and subsequent dumping at designated dump sites. Thus, in the Wa municipality, all the collected SW from residential areas, commercial areas, institutions and streets are carried to a lone dumping ground (as indicated in Figure 9) at *Siriyiri. Siriyiri* is in a different district - the Wa West District. The *Siriyiri* disposal site was created in 2001 and has been poorly managed - without any formal material recovery, though some informal material recovery is undertaken by scavengers.

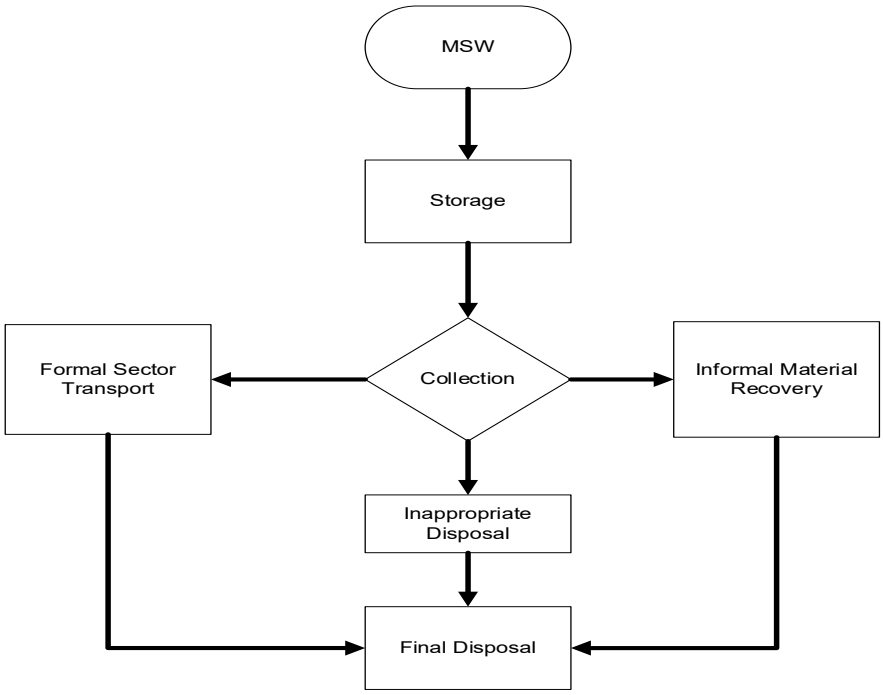
Figure 9: Opening dumping of waste at the Wa Municipal Assembly's disposal site

The MSW flow in the Wa municipality begins at the waste generation sources (households, commercial areas, institutions, and streets). As stated earlier, waste segregation, the technique by which SW is divided into its components (mainly organic & inorganic), is not undertaken at the generation point and throughout the waste management chain. As result, the municipal authorities did not have a good knowledge of the MSW generation and characteristics in the municipality.

Therefore, some MSW generators dispose of their waste inappropriately into bushes, by burning, and by burring in pits. MSW that was disposed of by these methods immediately after generation, did not enter the MSW stream and were not managed by the municipal authorities who are solely responsible for MSWM. However, other waste generators store their waste in various ways for collection and subsequent disposal, as discussed above.

MSW collection was undertaken by both the formal (municipal authorities and ZGL) and the informal (waste merchants) sectors. The informal waste collectors transport all the collected waste to designated dumping sites, usually near the waste merchant's residence, for onwards transportation to the southern part of Ghana for sale, whereas, the formal sector transported all the mixed collected waste to the main disposal site (un-engineered open dumping site) at Siriyiri for final disposal. Figure 10 illustrates the MSW flow in the Wa Municipality.

Figure 10: MSW flow in the Wa Municipality



The researchers during a visit to the Siriyiri disposal site observed that, most part of the disposal site is in a low-lying area (see Figure 11) and a borehole is located 300m away from the disposal site without any precautionary measures, however, both liquid (human excreta) and solid wastes were disposed of in the same dumping site. The researchers did not test the borehole water to ascertain its quality, however, there is the great potential of the contamination of the borehole water by leachate from the disposal site. The manager of the disposal site in an interaction with the researcher, said that the *Siriyiri* community has protested the location of the disposal site on several occasions but to no avail; which is a breach of environmental justice.

Figure 11: Waste disposed in low-lying areas at the Wa Municipal Assembly's disposal site

However, the researchers observed that the Wa Municipal dumping site is quite large (1000m^2), and thus, can easily be converted into a sanitary landfill. This can be achieved by partitioning the disposal site, such that the open dumping will continue near the area where the sanitary landfill cells development will begin. The disposal site already has a properly constructed office, although without services such as electricity and water supply. These services will be needed to facilitate the conversion of the disposal site in to a sanitary landfill.

The major challenge to effective MSWM in the case study area and Ghana in general is the non-segregation of wastes at the various generation sources and throughout the management chain, despite the dominance of recyclable materials in the waste composition, which comprised of hazardous and non-hazardous waste.

The MSWM in the Wa municipality included the storage of mixed MSW in a single bin, improperly disposing of waste - into bushes, by burning, and by burring in pits – waste collection, transportation, and finally open dumping at an un-engineered disposal site located 5km away from the municipality in a different district (the Wa West District).

This MSWM system has detrimental effects on the environment, ranging from polluting natural resources and the ecology to the creation of health problems which might lead to long-term public health complications, causing a public nuisance, and degradation of the environment and aesthetics. Various pollution (air, soil, water, and landscape) due to improper waste disposal would not only affect the natural environment but also exposed the community to various diseases.

There is substantial evidence that open dumping of MSW contaminates surface and ground water supplies in most developing countries (Odukoya and Abimbola, 2010; Alam and Ahmade, 2013). This occurs through leachate from MSW disposal sites and run-off that carry MSW into water bodies, which lead to rising levels of biochemical oxygen demand (BOD) in watercourses, and the presence of microbial contaminants (Henry, et al., 2006).

It takes only a small amount of leachate to contaminate a large volume of groundwater, which in turn can contaminate and affect biodiversity and enter the food chains (Garaj-Vrhovac, et al., 2009; Mukherjee and Mukhopadhyay, 2015). Consequently, the Ghana Water Company recently hinted of the increase in water price due to the increase in the cost of water treatment as a result of massive pollution of the Company's water sources from various pollutants including MSW (3new.com, 2017).

Additionally, the un-engineered dumping site attracts vermin and scavenging animals and provide food and habitat for disease vectors such as rats and mosquitoes. Gastro-intestinal infections such as

typhoid fever, polio virus infection, hepatitis E infection, and cholera are often transmitted through contaminated food or water (Boadi and Kuitunen, 2005; Cabral, 2010) by these disease vectors.

Furthermore, uncontrolled burning of the MSW at the disposal site to reduce its volume contributes significantly to air pollution. MSW contains considerable hazardous components and the open MSW burning in urban areas cause direct exposure of hazardous materials to citizens (Wang *et al.*, 2017). Globally, efforts are being made to control greenhouse gas (GHG) emissions from various sources, and the waste sector is one of them (Kumar *et al.*, 2004). This is because, GHG do not only contribute to climate change but also cause respiratory infection such as asthma, cardiopulmonary diseases, and lung cancer (Bruce and Perez-Padilla, 2002; Ayres *et al.*, 2009).

Notwithstanding these, the informal material recovery by metal waste merchants and scavengers at the disposal site was helping to ameliorate the impacts of MSW and served as a source of livelihood to some people (*Zabarma*, children and women) in the Wa municipality and neighbouring district assemblies, as recovered materials are sold to support their needs.

The operation of the informal waste collectors buttresses other researchers, who found out that resource recovery has been a major element in SWM especially in developing nations through the informal sector, where scavenging for recoverable materials is a source of livelihood for many people (Guerrero, et al., 2013; Laurent, Clavreul, *et al.*, 2014; Brunner and Rechberger, 2015).

Conclusion

The current MSWM in the case study area and the whole of Ghana consist of some waste collection, transportation and open dumping, where the entire amount of waste is open dumped without pre-treatment. This study identified the shortcomings of the case study area's MSWM system, which represents Ghana's MSWM system, as: not all the population is connected to the waste collection system, there is non-segregation of waste at source, no waste reduction programmes, municipal authorities have no knowledge of waste generation rates and characteristics, no formal material recovery from waste, no amount of waste is formally recycled, opening dumping of waste is the final disposal option, opening dumping of biodegradable waste results in large and long-term emissions (gas and leachate) and ineffective use of landfill space, and no ISWM.

Because of these, sustainable waste management has remained elusive in Ghana. However, informal material recovery of waste by metal waste merchants and scavengers are ameliorating the impact of MSW and serves as a source of livelihood to some people. Thus, both formal and informal material recovery from MSW present business and job opportunities in Ghana and should be harnessed to create job opportunities for the teeming unemployed youth. Material recovery from waste will not only reduce the quantity MSW that have to be disposed of but will also ameliorate the adverse effects

of improper MSW disposal. Furthermore, the study, recommends the sorting of MSW at the generation sources and the provision of adequate MSWM infrastructure through an ISWM system to ensure sustainable waste management in the country.

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