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CHALLENGES AND PROSPECTS OF SOLID WASTE MANAGEMENT IN THE CITY OF MASVINGO, ZIMBABWE

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Abstract:
Municipal solid waste (MSW) management constitutes one of the most crucial service provision challenges facing African towns and cities (Achankeng, 2003). Due to the economic meltdown experienced in Zimbabwe during the ten years, between 2000 and 2010, many challenges militated against sound urban solid waste management. These challenges included the inability of municipalities to supply safe water to residents, the inability to dispose of sewage, and the breakdown of infrastructure and service delivery in MSW management activities from waste generation, storing, collection, and safe disposal. The cholera outbreak of 2008-2009, which claimed over 3,500 human lives in Zimbabwe, was a direct consequence of a breakdown of municipality services, including irregular refuse collection, among other factors (Federation of Red Cross & Red Crescent, 2010). MSW management involves five stages. They include waste generation, storage, collection, transportation, and disposal. This research sought to establish the extent of the breakdown of the solid waste management system in Masvingo City. It establishes the challenges faced throughout the MSW management activities. Solid waste management across the globe now focuses on waste reduction and recycling before disposal. Diverting waste away from dumping sites and landfills towards reuse, recycling, and recovery can

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improve the livelihoods of thousands of informal waste re-claimers while also creating new jobs. Improving the standards of landfills and their life span can reduce the use of red flags to Masvingo city council by EMA. The study highlights the challenges in waste disposal by the municipality and makes recommendations on waste reduction and recycling opportunities.

Keywords: dump sites, landfills, solid waste management, challenges, Masvingo City, Zimbabwe

1. Introduction

In recent decades, the global landscape has witnessed an unprecedented confluence of rapid economic growth, accelerated urbanization, and a surge in population. This surge, in turn, has led to an alarming increase in resource consumption and, consequently, a substantial rise in environmental waste (Smith, 2021). Despite increasing awareness, current global waste and resource management frameworks exhibit a notable deficiency, lacking a holistic approach that is imperative for addressing the complexities of waste in contemporary society (Jones *et al.*, 2020). This chapter serves as the gateway to a comprehensive exploration of the challenges inherent in urban waste management, with a specific lens on Masvingo urban, while underscoring the critical importance of addressing root causes and enhancing feedback mechanisms for a sustainable future (Brown & White, 2019).

Solid waste management remains a persistent challenge in developing countries, characterized by financial constraints that impede effective refuse collection (Johnson, 2018). The escalating volume of waste production in urban areas of Zimbabwe has led to chaotic disposal practices, posing a substantial threat to residents' health (UNEP, 2022). Despite the relatively low waste density, the sheer increase in waste generation necessitates a more robust and sustainable management approach (World Bank, 2019). Recent studies continue to underscore solid waste as an acute environmental issue in Zimbabwe, emphasizing the imperative of capacity-building initiatives (Smith & Green, 2020).

In Ethiopia, inadequate waste management contributes to adverse environmental conditions, directly impacting residents' health (Ethiopian Environmental Agency, 2021). Tanzania grapples with waste control challenges in both urban and rural areas, exerting influence on economic status and marine biodiversity (Tanzanian Ministry of Environment, 2018). Similarly, Ghana and Zimbabwe face the challenge of insufficient waste management infrastructure, resulting in heightened health risks (Ghana Environmental Protection Agency, 2019). The urgency of the global waste management issue necessitates both local and international interventions to mitigate the environmental, health, and economic consequences (World Health Organization, 2021).

Recognizing the global interconnectedness of environmental challenges, the urgency of addressing the waste management issue extends beyond national borders. The World Health Organization (WHO, 2021) underscores the imperative for both local

and international interventions to mitigate the far-reaching consequences of inadequate waste management on the environment, public health, and the economy. As the world grapples with the escalating impacts of improper waste disposal, this study aims to delve into the intricacies of the waste management challenge in Zimbabwe, Ethiopia, Tanzania, and Ghana, seeking innovative and context-specific solutions to foster sustainable development in these regions.

Moreover, the issue extends beyond the immediate environmental and health concerns. In these developing countries, the lack of effective waste management systems is intrinsically linked to broader economic challenges. Insufficient infrastructure and mismanagement of waste impact the quality of life for residents and hinder economic growth potential. The misallocation of resources to address the consequences of inadequate waste management diverts funds that could otherwise be invested in critical areas such as education, healthcare, and infrastructure development.

Furthermore, the globalized nature of trade and the interconnectedness of economies highlight the importance of collaborative efforts. In an era where environmental challenges know no borders, shared responsibility becomes paramount. International organizations, governmental bodies, non-governmental organizations (NGOs), and local communities need to work in concert to develop and implement effective waste management strategies that address the unique circumstances of each country while fostering global cooperation.

As this study embarks on an exploration of potential solutions, it seeks not only to shed light on the challenges faced by these developing nations but also to contribute to a broader understanding of the intricate dynamics involved in solid waste management. Through this comprehensive examination, the aim is to propose sustainable, adaptable, and context-specific interventions that can pave the way for a more resilient and environmentally conscious future for these regions and, by extension, the global community.

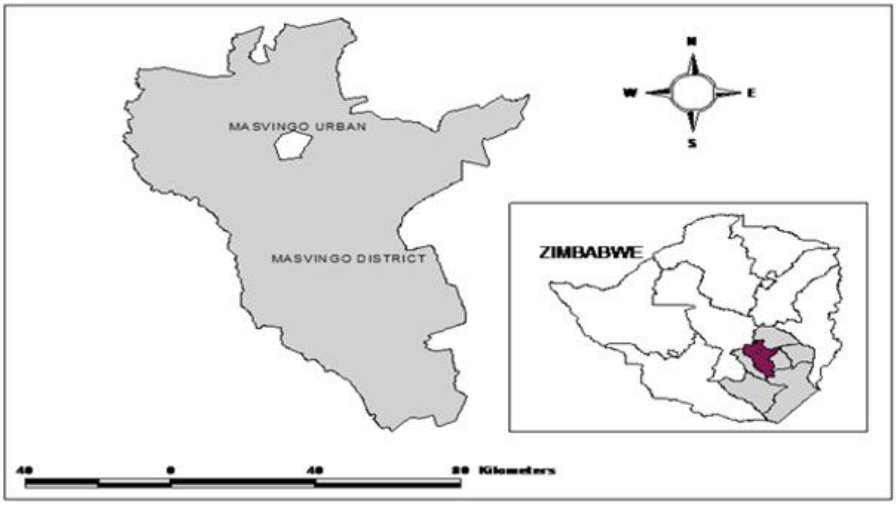
2. Study Area

Masvingo City (Zimbabwe), is carried in terms of geography, climate, and land use, providing a comprehensive context for research (Masvingo Geographic Society, 2021). Zimbabwe is a landlocked country found in Southern Africa, and it shares borders with South Africa, Zambia, Mozambique, and Botswana. This study was carried out in Masvingo City which is the oldest city in Zimbabwe.

Geographically, Masvingo is located in natural regions 4 and 5, which are characterized by high temperatures and low rainfall. The city lies in the lowveld where rainfall is low and uncertain, and summers are very hot and wet whilst winters are cool and dry. Temperatures during the hot wet season are always high, which makes the presence of the dumpsite felt by the surrounding communities. The average summer temperature for this region is 25-30 degrees Celsius. Masvingo consists of a wide range of land use, which is designated for residential, commercial purposes, agricultural activities, education, and tourism. Masvingo town is situated in Masvingo Province in

Zimbabwe (Figure 1). It is 292km south of Harare and 285km north of Beitbridge. It is found on the coordinates of 20^{0}30′54″S 30^{0}49′25″ /20.06250^{0}S 30.82361^{0}E, and at an elevation of 1.075m. Masvingo is sandwiched between the Shagashe and Mucheke rivers, which empty their waters into Lake Mutirikwi, some 30km to the southeast. The province is located in the Lowveld of the country where rainfall is low and uncertain. A large portion of the southern part of the province is prone to drought. Most parts of the province are therefore generally dry, with an average rainfall of 500mm per year (Dube, 2003).

Figure 1: The Study Area



3. Research Methodology

Archival research was conducted in order to lay a foundation for the study. This involved the perusal of municipal documents, newspapers, journal articles, and textbooks in the university library at Great Zimbabwe University. This was followed by a pilot study of the municipal dumpsite as well as the new landfill, which is not yet functional. Questionnaire surveys and interviews were conducted in various parts of the city in order to collect the necessary data from reliable sources. These sources of information constituted the main sources of data that determined the views expressed in this article. The conceptual framework of the study established a foundation for exploring the contrasts between dumpsites and landfills, considering economic, infrastructural, and environmental factors. By examining why regions adopt either method or the consequent environmental impacts, the study aimed to contribute valuable insights into sustainable waste management practices at the local level. The varying choices made by different regions shed light on the complexities surrounding waste disposal and the importance of adopting environmentally sound solutions to safeguard ecosystems and public health.

4. Results and Discussion

The study noted that 35% of the respondents were male, while 65% were female. This gender distribution is attributed to the higher prevalence of female employment in waste recycling companies, particularly evident in Masvingo's urban recycling. The pivotal role of women in recycling is underscored by their status as chief daily waste producers. This trend is amplified by the fact that women tend to have a more frequent association with the environment compared to men. Consequently, they can implement waste management more effectively, as their daily activities contribute significantly to waste generation. Moreover, it's worth noting that key informants, primarily sourced from Masvingo City Council's health department, possess extensive experience, with more than 10 years of service at the city council. The pie chart below visually represents the status of waste collection in Masvingo City Council, highlighting the different types of waste involved (Figure 1). This is followed by a scatter plot and regression line (Figure 2).

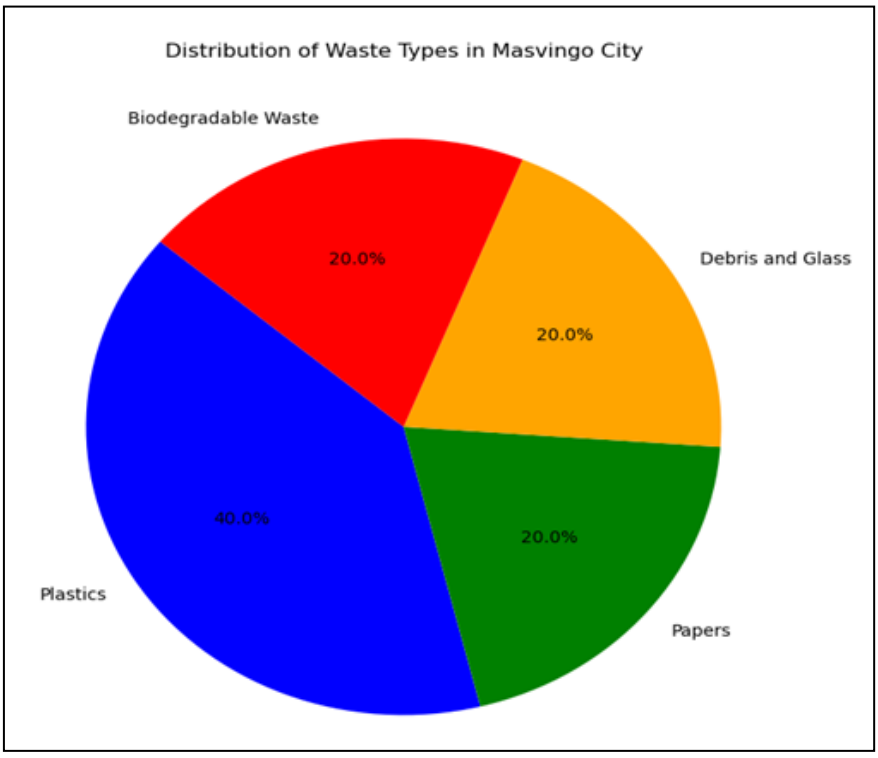


Figure 1: Waste Types in Masvingo

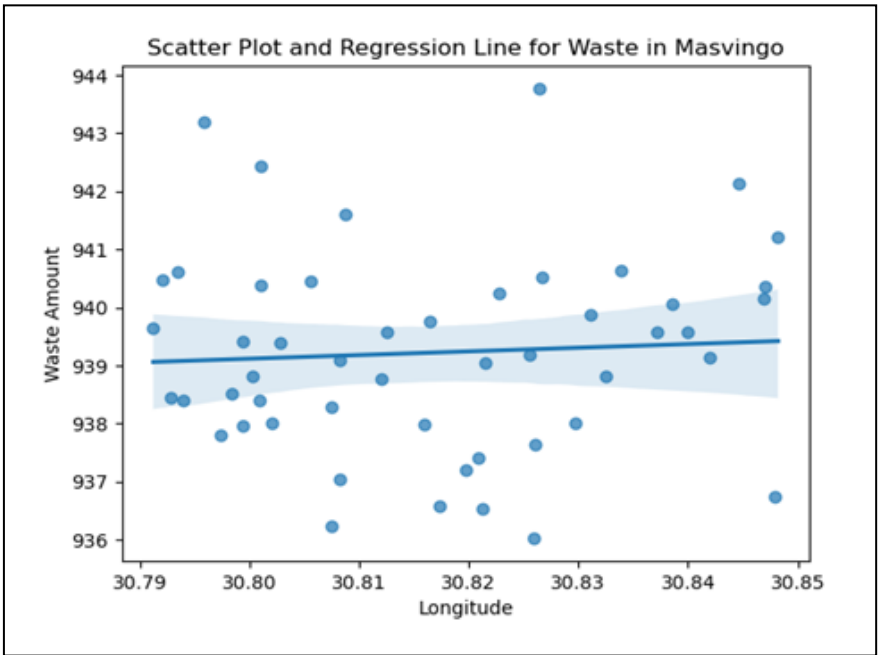


Figure 2: Scatter Plot and Regression Line

4.1 Challenges of Solid Waste Management in Masvingo City

In Masvingo city, as with many other city councils in Zimbabwe, poor solid waste management poses a significant threat to the urban environment. This issue is primarily attributed to the lack of stringent laws and penalties, coupled with a shortage of refuse trucks for garbage collection. While Zimbabwe has numerous laws addressing solid waste management, the core challenge lies in the effective implementation of these laws, which presently do not foster sound environmental management practices. Masvingo City, among others, encounters several challenges in the management of solid waste. These challenges stem from various factors, including shortages of refuse trucks, inadequate equipment, insufficient funds, and an undersized labour force.

Table 1: Masvingo Solid Waste Collection Timetable

Sector	**Policy on frequency of refuse collection**
City center	Daily
Hotels	Daily
Households	Once a week
Hospitals	Once a week
Industrial site	Once a week
Market place	Daily
School	Once a week
Colleges	Once a week

4.2 Collection and Disposal of Waste in the City

According to information provided by the municipality management, the responsibility for the collection of Municipal Solid Waste (MSW) falls under the purview of the Environmental Health Department. The prescribed frequency for MSW collection is outlined in the municipality's policy:

4.3. Residential Areas

MSW collection should occur once every week in residential areas.

4.4 Central Business District and Public Places

MSW collection is expected to be conducted daily in the Central Business District and other public places, aligning with the municipality's policy on refuse collection frequency.

This policy framework establishes guidelines for efficient and regular waste collection in different areas of Masvingo city. However, the effectiveness of these measures depends on addressing the broader challenges mentioned earlier, such as shortages of essential resources and adequate funding for waste management initiatives.

4.5 Lack of Resources

Most local authorities in Zimbabwe are facing financial resource challenges as the economy is yet to recover from the economic meltdown. Thus, it results in poor budget performance as the organization's objectives do not match their budget, leading to resource mismanagement. Also, due to financial hardship, local authorities are finding it difficult to purchase new machinery needed for refuse collection. Masvingo City Council (MCC) lacks refuse trucks to carry waste. Currently, MCC has only two functional trucks for refuse collection. The truck was donated by a partnering city, Kernen, in Germany. This was done after the city had gone for years without proper refuse collection trucks after all its vehicles were attached in a legal battle with employees. The two trucks are currently servicing the whole town, and the drivers are also serving as waste-collecting employees.

The shortage of adequate vehicles also results in high wear and tear, which is the major cause of frequent breakdowns. The MCC uses the waste compactor for refuse collection. There are five vehicles for refuse collection in Masvingo city council, but only two are operating very well, one breakdown, and two are in service. The main problem identified on the vehicles is the hydraulics that compacted waste as well as pushed waste out of the vehicle. Currently, they are in a shortfall of two vehicles if the current four are operating very well. However, there will also be a persistent outcry on waste management when Victoria Ranch suburbs come under the supervision of Masvingo municipality from Nemamwa Rural District Council. The Municipality will require 12 vehicles to complete the job effectively. Therefore, the effectiveness of Masvingo waste management is highly compromised by a shortage of vehicles.

The municipality used two vehicles (a waste compactor 7-ton truck) to collect and dispose of the waste at the dumping site. On arrival at the dumpsite, scavengers mobbed the vehicles and were observed jumping and clinging precariously onto the truck before they off-loaded their cargo. All waste collected was disposed of at the municipality dumpsite. The municipality used the open dumpsite type of waste disposal. The dumpsite was located about four (4) kilometres out of the town. The choice of the dumpsite was prompted by its proximity to the town and settlements and not as a measure for land reclamation through landfilling. The site also took into account the

prevailing wind, (northeasterly). In view of the town expansion in the direction of the dumpsite, the city council intended to relocate the dump site to a Cambria landfill. The council had no special procedures laid for the disposal of all industrial wastes, whether toxic or not. The most common wastes received from the industry were scrap metals.

4.6 Challenges Faced in Disposal of Waste by the Municipality

Waste disposal is now a logistical and costly issue globally (Vencatasawny *et al.*, 2000), not just for developing countries. The council has two subcontractors for the collection and transportation of MSW from the town, including the use of one vehicle from the Wanzai in 2021. In Masvingo, the collected waste was disposed of at the municipality's open dump site in Victoria Range. The open dump site method involved compacting waste under constraints imposed by the Environmental Management Agency of Zimbabwe. Flies and other disease vectors were observed at the dump site. Houseflies, which are effective carriers of sanitation-related pathogens for diseases such as cholera and diarrhoea, are capable of flying up to 5 kilometers (Prickford, 1983). The nearest residential area is, therefore, susceptible to these vector-borne diseases. There was no segregation of waste before or during waste disposal. The mixture of waste poses health hazards to scavengers who are active at the site. Some mothers were seen feeding their babies at the site. The Masvingo dumpsite was characterized by indiscriminate fires. The dumpsite attendant reported that the waste remained uncovered for more months due to a lack of equipment. Such a condition promotes the breeding of disease vectors, such as houseflies. The leachate from the dumpsite could pollute the underground water, which is an important alternative water source for the residents situated close to the dumpsite, and also pollute the Mucheke River, which is nearby.

4.7 Poor Cooperation between Important Stakeholders

Masvingo City Council lacks cooperation with other stakeholders in the management of waste. The levels of cooperation between important stakeholders such as communities, local civil society organizations, councilors, and technical personnel in local authorities are to greatly improve so as to come up with an integrated solid waste management system. To some extent, the local authorities may face political squabbles that hinder the process of waste management, and the Masvingo mayor is aligned with the opposition party, and the EMA department is under the leadership of the current government; hence, they may beat loggerheads over some issues concerning waste management instead of working hand in glove.

4.8 Poor Compliance with the Existing Legislation on Waste Management

Illegal dumping of waste was noticed by the researcher in some of the places it might be a result of socio-cultural practices, norms, and beliefs that contribute to negative attitudes of community members towards solid waste management. Community members are often seen dumping and burning waste in open spaces. This practice results in environmental pollution and hence affects public health. The public is encouraged to cooperate as poor disposal of waste is a danger to everyone, including those who live

further away from the dump site. Thus, people have developed a culture of dumping waste anywhere they see fit. This has led to an upsurge in the amount of solid waste that the local authority has to contend with. Thus, the local authority needs to apply stiffer penalties for defaulters consistently.

Bandara and Hettiarachii (2003) state that poor solid disposal in developing countries causes citizens to practice open dumping, thus threatening the environment. Also, Lack of capital and poor government policies regarding waste contribute to such conditions.

4.9 Environmental and Health Impacts of Solid Waste

Dumpsites are known for their smelly and unsightly conditions. These conditions are worse in the summer because of extreme temperatures, which speed up the rate of bacterial action on biodegradable organic material. Also, in the rainy season, the dump site becomes washed out, and the leachate with its pollutants drains into the Mucheke River, thus affecting soil, ground, and surface water quality and ultimately becoming harmful to the health of humans in the food chain. Most solid wastes are disposed of on the land in open dumps. Disposal of solid waste on the land without careful planning and management can present a danger to the environment and human health. The environment should be clean and less polluted by all means. Below are some of the impacts of solid waste:

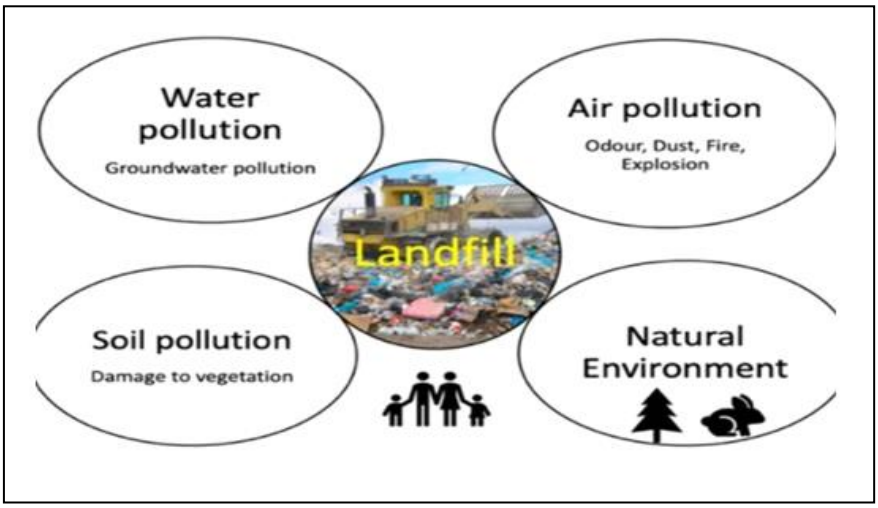


Figure 3: Impacts of Poor Waste Management

Toxic gases from the rotten trash fuse the groundwater and produce leachate. Groundwater exists in the pore spaces, rock fractures, and sediments beneath the earth's surface. Rainfall has a major influence on leachates and then moves through the soil profile into the groundwater system, where it eventually makes its way back to surface streams, lakes, or oceans (Ugohwa and Emete, 2015). Surface runoff and biological decomposition also lead to leachates. Poorly managed waste sites are sources of groundwater pollution, groundwater pollution is the introduction or presence of organic or inorganic, biological, and physical foreign substances in water that tend to degrade its quality. This is mainly so as the waste produces leachate, which percolates and infiltrates

through refuse into the water table posing a high risk to groundwater resources. Leachates from waste dumpsites are the main sources of heavy metal pollutants in both soil and aquatic environments. This, therefore, affects the groundwater that serves as the domestic water supply. Most concern over groundwater pollution has centered on pollution associated with human activities like haphazard dumping of wastes followed by incineration of the wastes. In Masvingo's main dumpsite, leachates are suspected to be contaminating the groundwater. Unfortunately, there are no monitoring wells to detect the degree of contamination.

Water naturally contains small amounts of dissolved substances like zinc, calcium, magnesium, and even impurities like silt, sand, and microbial substances under normal circumstances (Saidu, 2011). These quantities are considered safe for human use; however, when they exceed the threshold limits, then the water is polluted. High levels of nitrates are quite toxic to human health, and the toxicity is a result of the natural reduction of nitrates to nitrates by gastric enzyme. It causes serious disturbances to the exchange system that lead to blue baby syndrome and the formation of nitrosamines, which supposedly produce carcinogenic cells in adults. Heavy metals can adversely affect mental and neurological functions and alter metabolic processes in the human body, including impairment and dysfunctions in the blood, cardiovascular, endocrine, immune, reproductive, and urinary systems (Okuo *et al.*, 2007). Hence, the leachate could have contaminated groundwater.

4.10 Impact on Soils

Soil pollution is also another impact of solid waste dumpsites. Soil pollution is the contamination of the ground surface and it greatly affects soil fertility. Unscientific dumping of solid waste mainly leads to the introduction of toxic chemicals in the ground. The indiscriminate and open disposal of waste can cause environmental degradation by introducing different toxicants, including heavy metals, in the soil ecology (Mapira, 2011). These pollutants usually enter the human body through contaminated crops, food products or water, and animals. Also, the waste damages the terrestrial ecosystem, resulting in the deterioration of the conservation and amenity value of the environment.

4.11 Health Impacts

In addition to this, there are also health impacts that are affecting communities surrounding the dumpsite. Such identified impacts are respiratory diseases, skin problems, malaria, and diarrhea. There is also an impact on the waste pikers in the streets. They are prone to diseases.

Organic domestic waste poses a serious threat as it ferments, creating conditions favourable to the survival and growth of microbial pathogens. Direct handling of solid waste can result in various types of infectious and chronic diseases, with waste workers and rag pickers being the most vulnerable. In most developing countries, waste pickers operate informally, and they do not have adequate protective clothing. This has led them to be at high risk of being infected by HIV as a result of handling contaminated hospital waste. Healthcare waste and other medical waste are disposed of in dumpsites, mixed

with domestic waste, increasing the risk of infection with Hepatitis B and HIV and other related diseases (World Bank, 2005). Also, metal found in dumpsites has been oxidized; therefore, they contain rust, which will expose waste pickers to tetanus.

4.12 Impacts on the Local Community

The UNEPA (2006) stated that improperly managed waste especially solid waste from households and the community, poses a serious health hazard and leads to the spread of infectious diseases. These unattended wastes lying around attract flies, rats, and other creatures that, in turn, spread diseases. Flies, which are effective carriers of sanitation-related pathogens such as cholera, dysentery, diarrhea, and typhoid, are capable of flying 5 kilometers (Ngaza, 2018). Hence, the nearest residential areas are susceptible to these vector-borne diseases.

Normally, the wet waste is the one that decomposes and releases a bad odor which affects the people settled next to the dump site. Dumpsites emit obnoxious odors and smoke that cause illness to people living in, around, or closer to them. Thus, the dumpsites have serious effects on people settled around or next. Exposure to hazardous waste in dumpsites also affects human health, with children being the most vulnerable to these pollutants. Direct exposure can lead to diseases through chemical exposure as the release of chemical waste into the environment leads to chemical poisoning. In addition, the dumpsite has smelly and unsightly conditions. These conditions are worse in the summer because of extreme temperatures, which speed up the rate of bacterial action on biodegradable organic material.

4.12 Social Impacts

The social impact that was identified in this study was that animals and people, especially school kids, were attracted by the dumpsite and the school kids were even dodging school just to collect things in the dumpsite. This was also witnessed by (Tsiko and Togarepi, 2012) that some dumping sites are open spaces that encourage and attract many children as well as some adults to turn to street life since they scavenge for items from the dump sites which they sell. There is also animal death, such as dogs and cats, as they eat dangerous things that lead them to death. Moreover, the public perception of the worst impacts of present solid waste disposal practices is seen as direct social impacts such as the neighbourhood of dumping to communities, breeding of pests, and loss in property values.

4.13 Environmental Impacts

Environmental impacts that were identified in this study were smoke, fleas, polluted environment (littering, windblown papers, and plastics), mosquitoes, and odour. It was indicated that people who were scavenging in the dumpsite were burning tires and other objects and that caused smoke to go around the residences that were around the dump site. Papers and plastics were always blown by the wind on the residences and caused pollution to the environment as it is an open dumpsite. Air pollution from the site, groundwater pollution from leachate, health problems due to the breeding of disease-

causing pests, global warming due to the emission of methane and other greenhouse gases, and biodiversity loss as the living conditions in areas near dumpsites are altered since the pH-value may be changed and social problems such as decreasing land values and aesthetic appeal of an area are some associated problems.

4.14 Economic Impacts

There are significant costs associated with operating a dumpsite, processing waste is quite costly, and these costs are borne by a taxpayer's money. This is because measures need to be implemented in order to manage gases that are emitted as well as to manage groundwater contamination and thus comply with environmental policies. Moreover, there are also some social costs due to negative externalities imposed by dumpsites on nearby residents. These externalities include visual pollution, odour nuisance, and adverse health effects. Thus, the operation and maintenance of dumpsites impose significant costs on the society.

4.15 Challenges of Manpower the Department

Human resources are another major challenge that the MCC is suffering from. Shortage of sufficient personnel is a major hindrance to the provision of a sustainable waste management system in the town. Although at the managerial level, the municipal has adequate skilled personnel who have relevant professional qualifications, the number is generally inadequate. The council does not have permanent human resources that work in the refuse collection; they, therefore, shift people from other departments, for example, from the farming department, to refuse collection, and most of these workers do not like the task therefore, waste accumulates before it is collected and by the time it is collected, it would have already been in a bad state. The main reason for the shortage of manpower in Zimbabwe is due to financial constraints.

The senior supervisor highlighted that waste in southern Africa is very heavy compared to Western countries, like the United Kingdom, Canada, etc. Therefore, in Masvingo, waste is very heavy; hence, the department requires a very strong and energetic workforce for the effective execution of its duty. The standard number of four workers per vehicle is not enough per day. Therefore, they require a vehicle that can carry more than four people to manage each vehicle.

4.16 Protective Clothing is also Another Challenge Faced

Refuse collection workers are not sufficiently provided with the necessary clothing, some resort to using their own work suits, and some use overalls which are not environmentally friendly. Protective clothes include gloves, safety shoes, mass boots, gumboots, and rain suits in the season. Protective clothing protects workers against injuries, contracting diseases, and so on.

4.17 The Victoria Ranch Dump Site

The Victoria Ranch dump, used as a dumping site, was decommissioned in 2006, but they are still using it. The Cambria farm landfill is not up to standard; hence, they do not use it at present. They only test its function. The municipality will dump the waste in the pit and then spread it. They put gravel on top of the waste, and a roller hummer will compact the waste, as shown below.

Figure 4: Spatial location of the dumpsite map

The spatial map shows that the red vector points are highly concentrated within the buffer zone.

4.18 Landfill at Cambria Farm

Figure 5: Council Workers at the Cambria Landfill

The Cambria landfill is not yet fully functional. The landfill was supposed to have been fully operational in 2023. The completion is taking too long to function, hence the

current dumpsite at Victoria Ranch being worse. The other challenge is the durability of the landfill. The experience of the Victoria Ranch dumping site shows that the city council is in the habit of ignoring dumping site lifespans. The Victoria Ranch dumping site was decommissioned in 2006 but continues to function to date.

Figure 6: Cambria Landfill after Waste Compacted

4.19 Waste Sorting in Masvingo City

The Masvingo city council does not have waste separation at the point of collection. Only people noticed around the dumping site collecting waste from the recyclers. There is also no waste separating bins around the collection centers only noticed at Halsted shop and at EMA offices. Maybe it is due to economic hardships. They cannot afford to buy several bins to put on the streets. However, Delta Beverage sometimes puts some waste sorting cags on most business centers. However, due to vandalism, they were destroyed. Most liquor outlets are facing the challenge of disposing of glass bottles, such as castle lights, which are non-returnable. The shop owner will be left with no option but to dump in any place he/she thinks is suitable. This will lead to improper dumping of waste around the city. Even the recycling company faces difficulties in locating this product because it is being dumped far away. For example, the green bottle was dumped 3 kilometres away from town along the Zimuto road just after Kyle College. Some recycling companies in South Africa have once extended their hands into Zimbabwe to import these green bottles from Zimbabwe. However, this has failed.

4.20 Urban Recycling Company

The recycling company produces several products from the waste collected. Firstly, the methods they use are melting plastics and mixing them with sand to mold pavement bricks. The company highlighted that engineers have tried and tested the strength of the bricks, and they agree that the brick can last for 8 years on pavement surfaces used by heavy vehicles compared to cement bricks, which last for 4 years. The bricks are sold at 1 USD per piece, and as a result, the community is surviving very well due to this recycling process. Currently, the company is at an advanced stage in molding plastic roof tiles. As time goes on, the company will import plastics from other towns and cities.

Figure 7: Bricks that Have Been Moldedat Urban Recycling

4.21 Metal Recycling Company

A recycling cooperative company has been melting used cans to make cooking pots. The type of implements that can be melted include Coca-Cola cans, dragon cans, and any aluminium product that can be melted to form a new product.

Figure 8: Waste and some Metals for Recycling

Figure 9: Cooking Pots from RecycledAluminum Waste

4.22 Strategies that Can Be Used to Mitigate the Environmental Impacts of Waste Dumpsites

The waste management hierarchy identifies favourable solutions for waste before sending them to dumpsites. They are also known as solid waste management strategies.

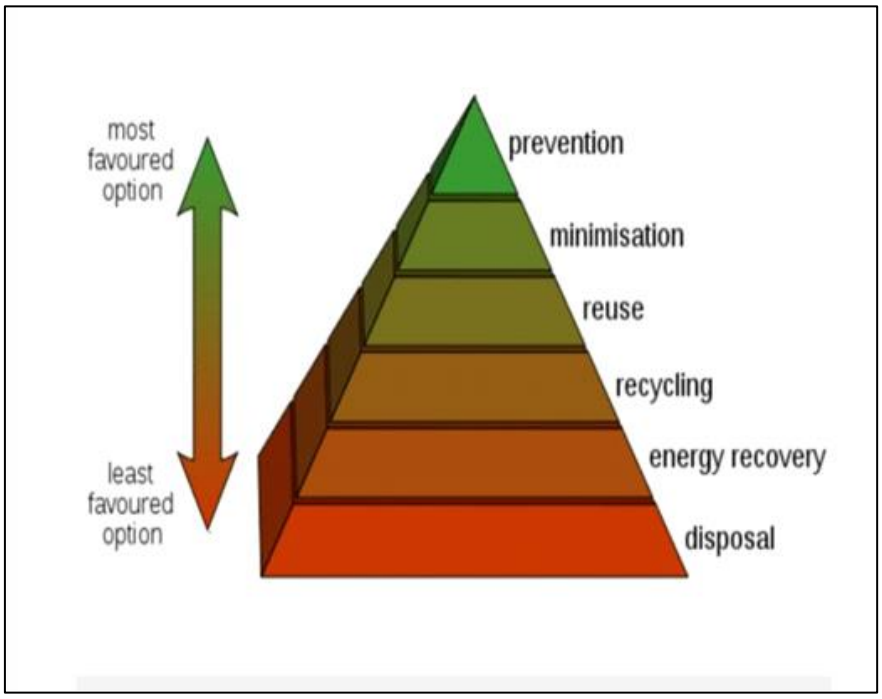


Figure 10: Waste Management Hierarchy

4.23 Waste Prevention

This is the basic goal of all strategies. Numerous technologies can be employed throughout the product life cycle to eliminate waste and, in turn, reduce or prevent pollution, such as environmentally conscious manufacturing methods that incorporate less hazardous or harmful materials storage as well as chemical neutralization techniques to reduce reactivity (Mangizvo, 2010).

4.24 Improve Waste Management System

Improving waste management system means improving recycling systems in order to lower the amount of trash buried in landfills and dumpsites. Thus, waste will be treated more efficiently, and the adverse effects of landfills will be mitigated to a certain extent.

4.25 Improve Landfill Structure

Proper installation and maintenance of dumpsites are crucial to avoid environmental issues at these sites. However, in most developing countries, regulatory standards for dumpsites are quite low; hence, setup often leads to weaknesses, which results in pollution and other environmental issues. Therefore, improving the structure will significantly reduce dumpsite issues.

4.26 Environmental Education

According to the research conducted, no educational campaign on waste management has been conducted since 2020. This shows that people lack knowledge of waste management. Only EMA conducted an educational campaign on waste management. Educational awareness is a crucial part that can be used in order to educate people on the importance of recycling. Educational awareness of waste production and its negative

consequences on environmental systems should start in primary schools so that children can integrate this knowledge into their daily behaviour. Also, children are likely to convince their parents that reducing trash will benefit the environment and the future generation, thus mitigating the dumpsite problem. Also, the media could play a role in raising awareness of the waste problem in communities. Television, radio, and press can be used to disseminate information about waste. The municipal public relations department should engage the media as much as possible on the subject. Various messages will run on different themes and target various audiences. This education will be used to sensitize the public to appreciate that littering is shameful. Zero litter adverts will be created and featured on television as often as possible. Also, billboards along major highways can be used to educate travellers as well as the local people.

4.27 Implementation of Policies

The Department of EMA points out that they have several penalties applied to solid waste management offenders, such as littering up to level, dumping of general waste level 4, and waste receptacle level 3. Another important measure is to invoke policies, regulations, and laws that are meant to implement the polluter pays principle. A legislative framework to manage waste is in place, but there is no enforcement. Also, fines that are prescribed are too low, rendering effective enforcement difficult. The country needs to develop a national management policy with a complete vision, mission, strategy, and action plan. This strategy should be result-driven. This, therefore, promotes sustainable waste management. Thus, if fully implemented, environmental tools such as polluter pay are vital in reducing the environmental impacts of waste.

A shift from conventional waste management to integrated solid waste management (ISWM) should be done. This is another strategy for sustainable urban solid waste management. The latter include waste prevention, recycling, compositing, and disposal methods that promote human health and the environment. It promotes multi-stakeholder participation in decision-making and the implementation process, whilst the former includes the treatment of compositing, incineration, and disposal of that waste. Also, it just focuses on the local authority and other government ministries and neglects other stakeholders in decision-making.

4.28 Conformity to Waste Handling by Laws

Health Hazards Identified in Waste Disposal Residents were reported to be resorting to the burning of solid domestic wastes. A visit to the dump site also revealed that due to people scavenging for reusable waste, there were fires on site. The dangers posed by the fires include the destruction of biodiversity, air pollution, and the emission of ozone-depleting gases, such as carbon monoxide, nitrogen dioxide, and sulfur dioxide. These gases also pose a threat to human health. The country has laws, such as Statutory Instrument No. 7 of 2007, which criminalized the lighting of fires, failure to put out fires on one's property, and failure to put in place adequate fire prevention measures on one's property. The Environmental Management Agency is empowered to enforce regulations and court rulings concerning a lack of control of fires within residential areas and

dumpsites. However, the Environmental Management Act provides for the issuance of orders to the Council to ensure that the municipality does not contribute to the damage to the environment due to intermittent fires at the dump site under its jurisdiction.

4.29 Opportunities for Solid Waste Reduction and Recycling

A visit to the dumping disposal site indicated that the site will soon be abandoned to a new site, due to the unavailability of space to continue dumping the waste and its expansion of the residential area of Victoria range. The Cambria landfill is also relatively small to service the whole of Masvingo; hence, in a few years to come, they will soon look for another area. Therefore, a long-lasting solution is needed to have a permanent solution.

4.30 Composting of Bio-degradable Domestic Waste

The vegetable component of domestic waste varies from city to city and country to country. Manyanhaire, Sigauke, and Munasirei (2009) cited 15.62% of low-income cities of India, while for Chirundu, Zambia, food waste accounted for 72%. Muniafu and Otiato (2010) found 75% of the waste in Kenya to be compostable waste. The residential area of Sakubva in Mutare was 32% (Manyanhaire *et al.*, 2009). The Intermediate Technology Consultants (1998) observed a range of 15- 28% (Chimhowu, 1998) to 43% in Marondera, a town similar to Masvingo in terms of population and size. Recycling bio-degradable domestic waste into nutrient-stable compost can result in both the reduction of waste and the reduction in water pollution through the substitution of chemical fertilizers for compost in urban agriculture. In a case study of urban agriculture farmers in Harare, Kisner (2008) recommended that the current farming practices of using chemical fertilizers, were leading to underground water pollution through eutrophication and leaching. The composting of MSW and availing of such compost to urban agriculture farmers could assist in pollution mitigation. As the bio-degradable component of domestic constitutes 47.1% of waste generated, the composting of this component, if done at the household level, will result in a corresponding reduction of solid waste generated by households needing disposal by municipalities. Supriyadi, Kriwoken, and Birley (2000) also advocated for source separations and large-scale composting as a means to deal with the solid waste problem. Studies in Israel indicated that the waste sector may contribute as much as 25% of greenhouse gas emissions over 20 years. Ayalon, Avnimelech, and Shecter (2002) further stated that mitigating options showed that the most cost-effective means to treat the biodegradable organic component is the use of aerobic composting. The use of vermiculture (earthworm farming) technology to recycle bio-degradable solid waste is also an option worth evaluating and pursuing. Masvingo town is surrounded by dams with high fishing activities. The town is located on the Harare-Beitbridge highway. There are numerous entrepreneurs selling fishing worms (earthworms) along this highway. Training in earthworm farming technology using bio-degradable domestic wastes can be a way of waste reduction and recycling while, at the same time, creating employment opportunities.

5. Production of Energy

5.1 Waste to Energy Conversion Options

The over 3000 tons of bio-degradable MSW generated by residents and potentially more from businesses offer a large quantity of bio-stock for energy production. Energy recovery from MSW offers one way to reduce and recycle waste. Thorough tests have to be conducted to determine the actual physical and chemical characteristics of the waste (Johri &Rajeshwari, 2008). The conversion of bio-degradable MSW to energy can be done in three possible ways: thermo-chemical; biochemical; and physicochemical processes. The thermo-chemical conversion process can be characterized by higher temperatures and conversion rates. The process is best suited for lower moisture feedstock and is generally less selective for products. Thermo-chemical methods, such as pyrolysis (Hoffman & Fitz, 1968), biomass gasification, and incineration, require infrastructure setup. These processes resulted in the production of heat that can be used to generate steam that drives a turbine for electric power generation.

Biomass gasification produces combustible gases, which can be further cleaned and utilized to run water pumps at the municipality water works, saving on electricity expenses. Biochemical MSW processes (Fulford, 1998) used a bio-digester to anaerobically digest and ferment organic biodegradable wastes with high moisture content. Anaerobic digestion can be used to recover both nutrients and energy contained in organic waste products. The process generated gases with high methane content (55-70%), as well as bio-fertilizers. The gas produced was purified before feeding into internal combustion engines or gas turbines to generate heat and power. The production of bio-fertilizers can be an opportunity for farmers to access this alternative source of crop nutrients. MSW of high lingo-cellulosic biomass can be converted to bio-ethanol by a series of biochemical reactions using specialized micro-organisms (Kadam *et al.,* 2000). A micro-ethanol plant, which blends ethanol with petrol, was feasible and could positively impact Zimbabwe's fuel needs as a 100% importer of fuel. This can lead to a reduction of Masvingo's carbon footprint.

Physically, physicochemical technology, such as co-processing (Pandey, 2008), can also be utilized. This is a process of using the cement-manufacturing process to recycle, reuse, or treat wastes while simultaneously manufacturing cement in a single combined operation. The waste required to be used as fuel at the cement kiln is evaluated for its physical, chemical, and thermodynamic properties to ascertain its energy value and compatibility with the cement-making process (Pandey, 2008).

The co-processing method is one ideal method for recycling wastes by recovering their energy value. Much of the waste burned as fuel and recycled in cement-making contains high-energy contents. Pandey (2008) reported on an Indian company that developed an indigenous technology for the conversion of MSW into a Refuse Derived Fuel (RDF). The RDF can cost-effectively replace domestic fuels, such as firewood and kerosene, and has been claimed to be a good substitute for production processes in local industries. If Masvingo City were to espouse such a technology, it would, in a way,

generate some form of revenue and, at the same time, help mitigate greenhouse gas (GHG) emissions.

5.2 Potential Impact of Waste to Energy Conversion Technologies

Technologies are available that can recuperate the thermal power contained in the garbage, consequently supplanting restricted petroleum derivatives, like coal, oil, or flammable gas, utilized by regular power plants, thereby adding to the decrease of CO2 discharges. The technologies can efficiently harness the unused energy capability of organic waste by changing the biodegradable part of the waste into high calorific worth gases, similar to methane, through bio-methanation processes. The processed bits of the waste are profoundly wealthy in supplements and are broadly utilized as bio-compost (fertilizer) in many regions of the planet (Fulford, 1998). The waste changed over completely to energy would somehow be shipped off to landfill sites, consequently decreasing the reliance on landfilling and petroleum derivatives. Oliveira and Rosa (2000) demonstrate that networks that utilize waste-to-energy innovations have higher reusing rates than those that do not use waste-to-energy. Today, different strategies for the treatment of MSW have been effectively evolved and executed all around the world. Researchers have accomplished new advancements by which people will not just confine their insight for discarding squanders but additionally foster a few substitute items produced from similar squanders, which can be exceptionally helpful to society (Banwari & Reddy, 2008).

6. Conclusions and Recommendations

The Zimbabwe National Waste Management Strategy objectives include the following: to ensure the involvement and participation of all stakeholders in waste management; to develop waste management enterprises among Central Business Organizations and Industries; to develop a sound policy on all types of waste in Zimbabwe, with the aim to improve and safeguard public technical National Waste Management Strategy for the collection, transportation, treatment, and final disposal health and welfare; and to further promote resource recovery and environmental protection, among other objectives. The municipality of Masvingo City is failing to collect refuse from high-density residential suburbs. Access to municipality services should not be dictated by the area or suburb where one resides. All poor people have the right to live in a clean and healthy environment that is not harmful to their health, as stated by the Environmental Management Act (EMA) (2007). This study has revealed that in Masvingo city, there was poor management of waste in all five aspects of waste management, ranging from the storage, collection, and transportation to the disposal of waste. This is evidenced by the accumulation of waste and illegal dumps that were observed. Residents are increasingly made vulnerable to diseases such as cholera and diarrhoea. Although different sectors of society have tried to solve the problem through various initiatives, such as clean-up campaigns, the piecemeal approach does not manage to address the endemic waste management problem. Resource challenges for small cities, such as Masvingo, with

highly unemployed residents, offer opportunities to create volunteer refuse cleaners and waste sorters to periodically clean up residential areas, which has been done, with success, in Cape Town, South Africa (Miraftab, 2004). For waste management to be effective, there have to be activities to reduce and recycle it so as to reduce environmental pollution and prevent health hazards. MSW is an important raw material for sustainable energy and bio-fertilizer production.

7. Recommendations

Several recommendations can be suggested in order to avert the solid waste management crisis in the city. They include:

- Multi-stakeholder engagement and developing partnerships are crucial in adopting and implementing policies and strategies that promote a clean environment.
- Standardisation: This will allow for accurate benchmarking and target setting for stakeholders concerned.
- There is a need for the central and local governments to invest in a concerted and enduring effort to support recycling and create an enabling policy and legal framework that promotes multi-stakeholder participation and development incentives for organizations that are implementing recycling strategies
- Review regulatory frameworks to support recycling markets and promote waste recycling through enforcement of existing Statutory Instruments on industrial waste management.
- Introduce incentives and subsidies that promote investment in solid waste recycling enterprises and facilities.
- Create a green fund in which the banks, private sector, and development partners can contribute funds towards solid waste recycling and provide innovative funds and seed money for developing innovative waste recycling ideas.
- An integrated solid waste management strategy must be fully implemented to ensure a radical change in solid waste management in Victoria Ranch. Masvingo City Council (MCC) should engage and integrate with other stakeholders and private companies on the best ways to manage the dump site.
- Dumpsites should be properly located and managed to minimize their effects on the environment.
- The government and municipalities should revise laws regarding the locations of dumpsites. These laws should include properly managed sites, that are well fenced in and away from human settlements.
- The government should include laws that see to it that dumpsites are located properly and if it is not then action should be taken according to the law.
- There should be a follow-up in the functioning of the dumpsites to avoid pollution of the environment and health hazards.

- Municipalities should open dumpsites in remote areas with no residents closer to them to avoid the effect of the dumpsite on the nearby residents and monitor the dumpsite properly. They also have to control the litter and monitor their volume.
- People need to be educated by health motivators about the effects of dumpsites on their health. This will limit the effect of the dumpsite on the residents and hands should be joined in managing waste. This environmental education and awareness must target at changing human attitudes and thinking of solid waste as the basis of solid waste management.
- There should also be a follow-up to make sure that what they teach the residents is applied. Thus, the council and other relevant stakeholders should try and assist as well as monitor the well-being of the residents who live close to the dumpsites.
- The important stakeholders should also try and follow international standards recommended for the type of waste disposal method they use in a particular city or town so as to provide a healthy living environment to everyone.
- For improved health status of the populace living less than 500 meters within from the dumpsites, it is a matter of must for Masvingo City Council to resettle these residents as these people are the most vulnerable.
- Masvingo City should be commended for its shift from open dumpsites to landfills which are less damaging to both the environment and human health.

The study concludes that the land is a precious commodity and by reducing the amount of waste we produce, reusing items more than once, recycling items correctly, and complying with other waste management strategies, avoid the creation of open dumpsites and help maintain a unique environment thereby reducing the number of pests in an ecosystem, saving land and reducing biodiversity loss as the sites will be maintained for longer periods. Also, landfills should be properly located and managed to minimize their effects on the environment. There is a need to work towards a sustainable waste management system, which requires environmental, institutional, financial, economic, and social sustainability.

Conflict of Interest Statement

The authors declare no conflicts of interest.

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