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Impacts of solid waste management strategies in urban high density suburbs: a case of Amaveni suburb, Kwekwe, Zimbabwe

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Abstract
Improper solid waste management is one of the causes of environmental and health problems in many cities worldwide. It is in this context that the study aimed to determine the solid waste management strategies used in Amaveni suburbs in Kwekwe, Zimbabwe and assess the health and environmental problems associated with the solid waste management strategies used in Amaveni. Researchers used a mixed method design in which quantitative and qualitative data was collected at the same time. Semi –structured interviews, field observations and questionnaires were used to collect data. The sample comprised 380 Amaveni residents, 3 Kwekwe City employees and one Environmental Management Agency (EMA) official. Qualitative data was analyzed thematically while quantitative data was analyzed using inferential statistics. Open dumping and open burning were the dominant solid waste management strategies in Amaveni. The main health problems identified were cholera and malaria. Air pollution, water pollution and loss of urban beauty were the main environmental problems identified. From the findings it can be concluded that solid waste management strategies used in Amaveni were associated with many health and environmental problems and as a result sustainable solid waste management was proposed.

Keywords Solid waste · Management strategies · Impacts · Kwekwe

1 Introduction

Solid waste management is one of the most challenging environmental issues that urban areas face globally [1, 2]. This presents that solid waste management is a problem in developed and developing nations, particularly in high density suburbs in urban areas. The continued population growth in cities, need for goods and services coupled with increased urbanization has resulted in a surge of waste production which pose significant challenges to sustainable development [3, 4]. In many urban areas, the volume of solid waste generated overwhelms the waste collection and disposal systems, resulting in adverse environmental and public health outcomes [3, 5]. Owing to various anthropogenic activities, generation of solid is projected to rise to 3.4 billion tonnes by 2050 [2]. Generation of solid waste is increasing in the United Kingdom, Canada, Germany and the United States of America among other developed countries [6, 7]. Although solid waste is increasing in developed countries, management of solid waste is more sophisticated due to availability of resources. As a result, application of approaches which support turning waste into useful resources is common, thus limiting the quantity of disposed solid waste. Solid waste management strategies refer to approaches adopted by

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individuals, governments, organizations and communities to effectively handle and dispose solid waste [8]. Solid waste management generally encompasses activities encompassing generation, treatment, storage, transportation, waste reduction approaches, disposal as well as monitoring of disposal sites. Reference [9] argued that solid waste management strategies should include various practices and techniques aimed at minimising the adverse impact of solid waste on the environment and public health. This suggests that management of solid waste, particularly disposal strategies like landfills must take into account demands of sustainability.

Landfilling is a method of solid waste management which involves compacting and covering solid waste with soil [10]. Reference [7] argued that out of all the solid waste that the municipalities collect, over 70% is disposed in landfills and dumpsites, 19% is recycled and 11% is utilised for energy recovery. However, studies by [11] highlighted that 59% of global solid waste is disposed in landfills. In developed countries like Australia and Japan environmental health problems associated with landfilling are low since landfills are equipped with gas and leachate control systems while waste is compacted and covered after disposal [12]. However, the scenario differs with issues in most developing countries like Zimbabwe, Botswana, Zambia where a number of landfills are operated like open dumpsites [5, 13, 14]. This clearly signifies that in developing countries solid waste is openly dumped on landfills and is not compacted or covered, therefore averting of environmental health risks associated with landfills is difficult. As a result, a number of landfills used in developing countries encompassing Zimbabwe can generate gases like methane which cause air pollution while leachates have potential to reach groundwater since most landfills are unlined. Composting is emerging among significant solid waste disposal approaches in developing and developed regions in the world [15, 16]. Organic solid waste including food waste, garden waste and yard waste is disposed through composting since they are biodegradable materials which naturally degrade. In developed countries like France, Sweden and Italy composting is present to be more practical since residents are equipped with enough storage receptacles to practice proper segregation [17]. Composting enables conversion of biodegradable solid waste into organic manure, thus minimizing the need for synthetic fertilizers [18, 19]. Recovery of organic fertilizer from composting is limited by poor waste segregation in Sub-Saharan African countries [20–22]. Moreover, indiscriminate composting reduces the effectiveness of composting, since decomposition is minimized and the compost acts as breeding sites for various pests and organisms which propel transmission of diseases. This is also articulated by [5, 23] that co-disposal of solid waste limits efficiency of composting and effectiveness of incinerators.

An incinerator is a waste treatment facility that uses combustion to convert waste materials into ash, flue gas and heat [24, 25]. During the incineration process, solid waste is combusted at high temperatures typically between 850 and 1200 °C which results in the conversion of the organic materials into ash, flue gas and heat [18, 25, 26]. Considering this, incineration Solid waste incineration is a waste treatment process that involves the burning of solid waste in specialised facilities known as incinerators and incineration has the potential to reduce the quantity of solid waste. Incinerators used in development to be more sophisticated since they allow energy to be recovered during incineration [27, 28]. In developed nations in Northern America and Europe, utilise incinerators with emission scrubbers and energy recovery systems [27, 28]. This suggests that characteristics of incinerators used in developed countries advocate for air pollution reduction while supporting a circular economy. The situation is different in developing countries in Asia and Africa where most of the incinerators are almost of sub-standard since they lack energy recovery and emission control systems [29, 30]. Considering their characteristics, it implies that these incinerators have potential to cause various environmental health risks. This reduces the ability of developing countries to meet demands of sustainable development goals namely goal 13 of Climate Action and 3 of good health and well-being. To worsen the scenario, efficiency of incinerators is lessened by utilisation of incinerators with cracked combustion chambers in developing nations like Zimbabwe [31, 32]. These incinerators produce partially burned materials and numerous gases and particulate matter namely carbon dioxide, monoxide, Sulphur dioxide, dioxins and furans. This implies that management of solid waste through the incineration process is among factors contributing to high occurrence of respiratory diseases as well as cancer since dioxins and furans are carcinogenic. This is supported by studies which illustrated that incinerators used in other developed and developing countries release pollutants such as dioxins, heavy metals, and particulates which pose health risks to people [18, 33]. Exposure to compounds emitted from incinerators may occur by inhalation of contaminated air, consumption of local agricultural produce or contact with contaminated ashes.

Furthermore, in developing countries like Botswana and Namibia collection of solid waste is described as insufficient [34, 35]. This goes in line with [36] that collection of solid waste from point of generation to official disposal sites is approximately 40 to 70% in most developing countries. This is ascribed to shortage of resources particularly finance to purchase enough waste collection trucks, fuel as well as finance to pay workers. In Sub Saharan Africa insufficient solid waste collection by municipalities leave residents with no option but they resort to illegal dumping [37, 38]. Illegally disposed solid waste is found along road edges, on open spaces, in drains as well as buildings under construction among

other undesignated sites. Continuous accumulation of unmonitored solid waste on these sites result in land, water, soil pollution while acting as breeding sites for mosquitoes, rats, rodents in cities like Masvingo in Zimbabwe [39], in informal settlements in South Africa [40] and in cities in Nigeria [41]. This suggests that disposal of solid waste on non-regulated sites is associated with various forms of pollution, disturbing aesthetic value of the land while accelerating outbreak of intestinal diseases, malaria and rat bite fever. According to [39, 42, 43] besides illegal dumping of solid waste, people always apply open combustion as well as discarding in open pits at household level. Although these methods are of low cost, therefore easy to apply in developing countries [23, 43, 44], open air burning of solid waste releases various toxic gases with potential to manipulate air quality negatively while causing numerous ailments to people. Backyard solid waste burning coupled by use of backyard shallow open pits is highly practiced in Zimbabwe, although solid waste is also buried but at a lower rate.

In Zimbabwe, approximately 90% of solid waste is disposed through landfilling, open dumping, open burning and into open pits although a certain proportion of solid waste is illegally disposed [21, 45]. This asserts that application of recycling, reuse, recovery, repair and refurbishment is limited in the Zimbabwean context. This goes in line with [32] that adoption of solid waste management which supports the circular economy in Zimbabwe is at infancy stage. A view supported by studies which indicated that about 63% of all waste generated in developed countries is recycled while less than 10% of generated waste is recycled in developing countries [46]. Although recycling advocates turning solid waste into useful resources, in developing countries in Southern Africa like Zimbabwe, non-segregated solid waste is transported and indiscriminately disposed [45, 47]. In Zimbabwe, management of solid waste from urban residential areas is highly pinned on the lower base of the waste management hierarchy focusing on landfilling, open dumping and incineration [39, 48]. These approaches which are least prioritized by the hierarchy have potential to trigger occurrence of a number of environmental health problems. Thus hindering progress towards attainment of various global Sustainable Development Goals and Zimbabwe Vision 2030 targets particularly those related to environmental protection and human health. Inadequate management of solid waste in Zimbabwean urban suburbs, particularly high density suburbs is attributed to population increase which accelerates generation of solid waste [49, 50]. This exceeds the capacity of municipalities which are already struggling due to lack of resources due to economic problems experienced by Zimbabwe since the beginning of twenty-first century. Municipalities responsible for supporting high density suburbs are struggling to offer enough services and Amaveni high density suburb in Kwekwe city is also among residential areas impacted by waste management problems.

The problem at hand revolves around the challenges and consequences associated with solid waste management in densely populated urban areas such as Amaveni. The suburb is among other high densities experiencing high population growth, expansion and infrastructure deterioration translating to difficulties in waste management. The lack of proper waste management infrastructure and practices in this high-density suburb exacerbates challenges experienced by people who are already vulnerable to deteriorating living conditions. This creates a pressing need for sustainable solid waste management approaches tailored to the specific context of high density suburbs. Therefore, in order to deal with the matter meticulously this study focuses on understanding the effects of various solid waste management strategies in an urban high-density suburb, specifically focusing on the Amaveni suburb in Kwekwe, Zimbabwe. Results of the research are essential since they pave route to achieve various environmental health goals advocated for by Sustainable Development Goals (SDGs) namely good health and well-being (3), clean water and sanitation (6), life below water (14), life on land (15), sustainable cities and communities (11), responsible consumption (12) among others, Zimbabwe's second republic Vision 2030 targets and Agenda 21, Chapter 21 which calls for proper management of waste including solid waste. Moreover, urban high-density suburbs face unique challenges when it comes to waste management due to the concentration of population and limited space [49, 50]. Understanding the specific issues faced by these areas such as inadequate infrastructure, limited resources and high waste generation rates is essential for developing targeted interventions. Moreover, the choice of Amaveni suburb in Kwekwe, Zimbabwe as a case study provides valuable insights into the practical implications of waste management strategies in a real world setting. Consequently, by focusing on a specific location, the study can assess the effectiveness of existing strategies, identify local constraints and propose context specific recommendations. Unearthing issues surrounding solid waste management in Amaveni enable the Zimbabwean government to formulate policies directed to management of solid waste in high density suburbs. Findings from this study can serve as a model to develop proper solid waste management for other similar urban areas particularly high density residential areas facing comparable challenges in waste management. In the Zimbabwean context, studies related to impacts of solid waste management always cover whole cities, therefore, in-depth information linked to high density suburbs only is scarce. As a result, besides enabling sustainable management of solid waste, this research also covers the literature gap. The research was guided by objectives namely to assess the current solid waste management

practices in the Amaveni suburb, to evaluate the environmental and health impacts of existing waste management strategies and to propose possible recommendations to enhance solid waste management approaches and suppress environmental health problems that emanate from the management techniques.

2 Materials and methods

2.1 Location of the study area

The study area is illustrated in Fig. 1 in Kwekwe town. Kwekwe is a town in the Midlands province of Zimbabwe and has a population of about 119,863. Kwekwe is made up of low, medium and high-density suburbs. Amaveni is one of the high-density suburbs in Kwekwe situated in the northern side of the Kwekwe Central Business District (CBD). A Central Business District (CBD**)** is generally a commercial center within a city that typically contains a high concentration of commercial spaces, offices and financial institutions [51, 52]. Mostly, large volumes of specialised goods and services are exchanged within the CBD. Amaveni is about 5 km from the CBD. Its geographical coordinates are 18 55 30° south, 29 46 54° east from the CBD. Amaveni is one of the oldest suburbs in Zimbabwe which was established during the colonial era as a racially segregated dormitory for African male laborers. Today Amaveni is made up of people from different professional backgrounds. Amaveni suburb in Kwekwe, Zimbabwe, represents a high-density urban area facing specific challenges related to solid waste management. Therefore, by focusing on this particular suburb, the research can delve deep into the intricacies of waste management strategies within a densely populated urban setting. Utilisation of Amaveni as a case study provides local relevance. Hence, the choice of Amaveni suburb allows the study to address issues that are directly relevant to the local community and policymakers. Understanding the impacts of solid waste management strategies in this specific context can lead to more targeted and effective solutions tailored to the needs of the residents.

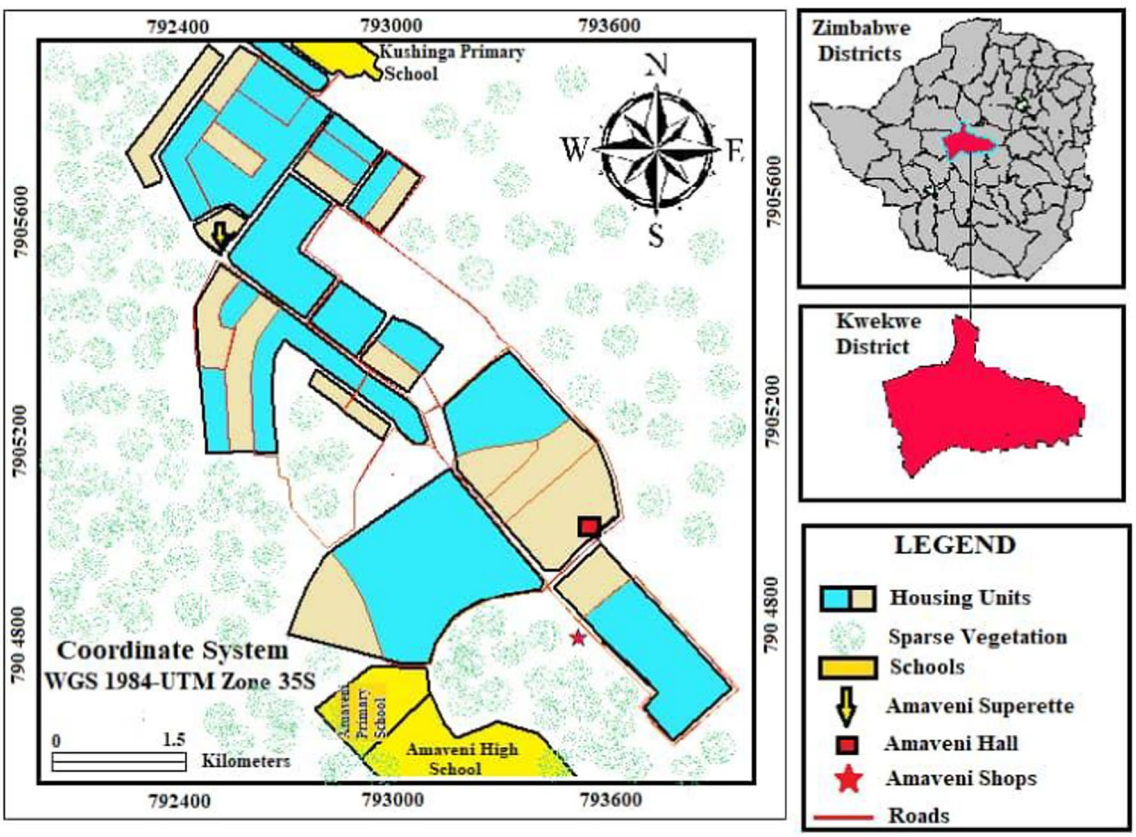

Fig. 1 Amaveni suburb, Kwekwe, Zimbabwe

2.2 Method of data collection

During the research triangulation method was employed during data collection, analysis and presentation. According to [53] triangulation refers to research that combines quantitative and qualitative methods within a single study. The mixed-methods approach was suitable for this study as it allowed a deeper understanding of the complexities and nuances of solid waste management practices in residential areas [54]. By combining qualitative and quantitative data more accurate and contextually rich information is obtained resulting in findings that can be generalized to other settings or populations [55]. Furthermore, mixed research design enabled the researchers to triangulate quantitative data from questionnaires and qualitative data from semi-structured interviews and observation thereby increasing the validity of the findings [56].

The target population for this study comprises residents of Amaveni suburb in Kwekwe, Zimbabwe. Amaveni suburb had approximately 2000 houses with a population of around 20,000 people. Cochran's formula was used to determine sample size:

$n = \frac{z^2 * p(1-p)}{e^2}$ where p is standard deviation = 0.5, z is standard normal deviate at 95% confidence interval which is set at 1.96, e is margin of error = 5%

n is sample size

$$= \frac{1.96^2 * 0.5(1 - 0.5)}{0.05^2}$$

$$= \frac{3.8416 * 0.25}{0.0025}$$

$$= \frac{0.9604}{0.0025}$$

$$= 384.16$$

Thus 384 participants took part in this study.

Stratified random sampling was used to select Amaveni residents who took part in the study. Stratified random sampling ensured that a diverse representation of households across different sections of Amaveni were included in the study. It also ensured that there was no bias in the selection of the population sample and every member of Amaveni suburb had an equal chance of being selected. The suburb was sub-divided into 20 sections based on geographical locations. From each section 19 residents were randomly selected thereby having a total of 380 residents. Questionnaires with both open ended and closed ended questions were self-administered to collect data regarding objectives of the study. The questionnaire consists of questions related to demographic data of the respondents, solid waste management strategies including waste disposal methods, environmental health risks associated with existing management strategies as well as possible strategies to minimize impacts of solid waste.

Purposive sampling was used to select three key informants from the Kwekwe city council and one from the Environmental Management Agency. Two council officials from the department of waste management were selected and these included the director of waste management services and one waste collection worker because they had information on solid waste management. One environmental health technician (EHT) from the department of health within the city council was also selected to provide reliable insights on health impacts associated with solid waste management. The EMA official was selected to provide reliable information on environmental impacts associated with solid waste. Interview guides were used to collect data from purposively selected interviewees. The key informants were expected to provide in-depth knowledge related to solid waste management methods, impacts of solid waste on human health and the natural environment. Interviews were also used to solicit data on strategies to curb detrimental impacts that emanate from inadequately managed and disposed solid waste. Furthermore, an observation checklist was prepared and used to collect data during the study, therefore the nature of disposed solid waste, areas with undesignated dumpsites and possible environmental impacts were observed. A digital camera was used to capture images during field observations. Secondary data sources were also used as sources of already existing literature. This assists in understanding the past and current trends in solid waste management strategies and their impacts. Figure 2 presents a brief structure of the research methodology.

2.3 Data analysis and presentation

The collected quantitative data was analyzed using statistical software for social sciences (SPSS) and thematic analysis. Quantitative data obtained from the survey questionnaire was analyzed using descriptive statistics, such as frequencies, percentages, and Chi-square, to identify patterns, trends, and relationships. Qualitative data from interviews and observations was transcribed, coded, and subjected to thematic analysis to identify recurring themes and patterns. The themes used in the description were derived from the research objectives. The themes include solid waste management strategies used in Amaveni, health and environmental impacts associated with solid waste management. Findings of this research were presented on graphs, tables and pie charts for easy interpretation.

2.4 Research ethics

Research ethics play a crucial role in ensuring the integrity and validity of a research study. The research ethics followed during the study plays a vital role in ensuring that research upholds the interests of the public, research subjects and researchers themselves by establishing guidelines for responsible conduct throughout all stages of the research process. Research ethics followed during the study encompass informed consent, confidentiality as well as seeking permission to conduct the study from responsible authorities.

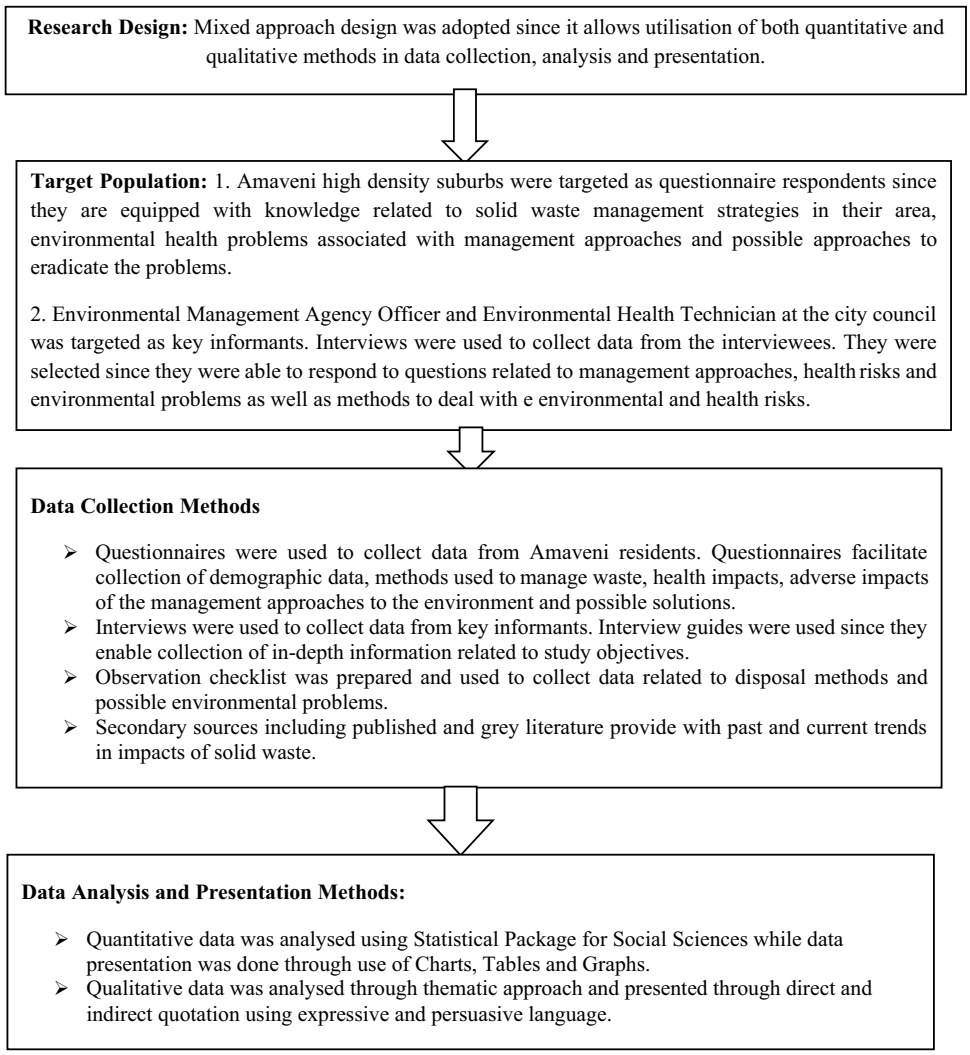

Fig. 2 A brief structure of the research methodology

3 Research results

3.1 Solid waste management strategies

3.1.1 Bin provision

All respondents (100%) unanimously reported that the Kwekwe city council is failing to provide enough bins to store household solid waste, hence each household found their own container to store solid waste before collection. Most of the participants used 50 kg sacks (70%), 15% used black polythene bags, 8% had plastic bins, 2% used metal bins and 1% used cardboard boxes to store solid household waste. This was supported by observations which demonstrated that people in Amaveni suburbs used different types of solid waste storage receptacles. This information concurs with information obtained through interviews. Interviewee A revealed that "Kwekwe city council used to provide bins to residents long back; however they have stopped providing bins to residents due to financial constraints." (Excerpt from interview Kwekwe, 2023).

3.1.2 Waste disposal

A significant number of people who answered questionnaires (52%) dispose their solid waste through open burning while 22% of those who responded dispose waste through open dumping as shown in Fig. 3. Twenty-five percent of questionnaire respondents dispose waste through land filling and only 1% of waste is recycled.

Interviewee D revealed that:

"Open burning and dumping of solid waste is rampant in Amaveni suburb due to erratic collection of waste by the Kwekwe city council." (Excerpt from interview, Kwekwe, 2023).

Interviewee C said "Household solid waste collected from Amaveni suburb is landfilled at the outskirts of the suburb however there is a lot of waste dumped in open spaces". (Excerpt from interview, Kwekwe, 2023).

Observations point out that some waste dumps within the suburb as well as on the unsanitary landfill near the suburb. Observations indicated that solid waste was also disposed on non-designated sites including road sides, open spaces and in drains. Figure 4 is evidence of solid waste dumped on non-designated open space.

3.2 Health impacts

3.2.1 Water borne diseases

Responding to the question on water borne diseases, Interviewee C said:

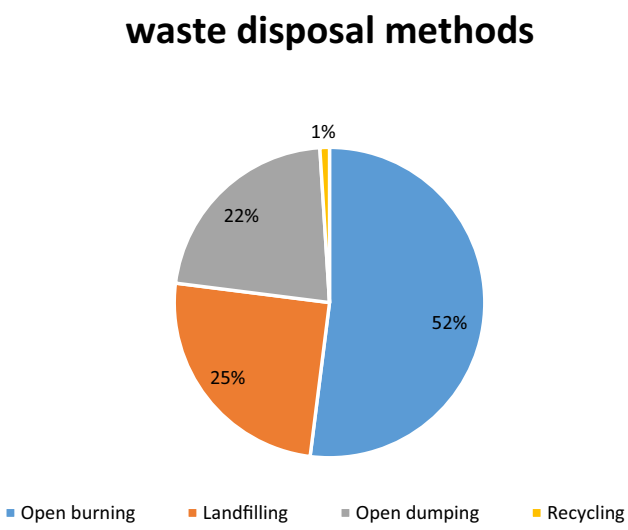

Fig. 3 Waste disposal methods (Fieldwork, 2023)

Fig. 4 Dump waste in Amaveni suburb (Fieldwork, 2023)

"Increasing illegal solid waste disposal in Amaveni is posing risks to people's health as more and more flies breed in the dumpsites increasing the chances of cholera outbreak."

Interviewee D also revealed that "Dumping of solid waste has polluted water sources in Amaveni and this has increased the risk of cholera in Amaveni suburb."(Excerpt from interview, Kwekwe, 2023).

Results from interviews were supported by questionnaire respondents since residents indicated that improperly managed waste is facilitating outbreak of water borne diseases namely cholera (64%), typhoid (15%), dysentery and diarrhea (21%).

3.2.2 Vector borne diseases

Interviewee C's response on the question regarding health risks associated with solid waste management was:

"Mosquitoes are breeding on decomposing solid waste dumped in open spaces increasing the risk of malaria in Amaveni suburb". (Excerpt from interview, Kwekwe, 2023).

Vectors observed on dumpsites mosquitoes, houseflies, rats and cockroaches. All these have potential to cause vector borne ailments. Questionnaire participants (100%) highlighted that improperly managed solid waste offer breeding sites for vectors with potential to cause vector borne diseases including malaria, sleeping sickness and rat bites fever.

3.2.3 Respiratory diseases

In response to the question relating to respiratory diseases Interviewee C revealed that:

'Many residents burn solid waste in the suburb which produces a lot of smoke and this has caused many people to experience coughing problems.'(Except from interview, Amaveni suburb, 2023).

Interviewee D shared the same sentiments and said:

"A lot of smoke is produced in the suburb from burning of solid waste and many people are exposed to the risk of breathing the smoke resulting in coughs" (Excerpt from interview, Kwekwe, 2023).

Key informants argued that toxic gases from solid decomposition and open burning cause various respiratory diseases encompassing asthma, tuberculosis, bronchitis and lung cancer. Information from questionnaire participants suggested that existing solid waste management approaches like open burning are associated with tuberculosis (13%), asthma (55%) and persistent coughing (32%) (Fig. 5).

3.2.4 Injury problems

Responding to a question on injury problems, interviewee C stated that:

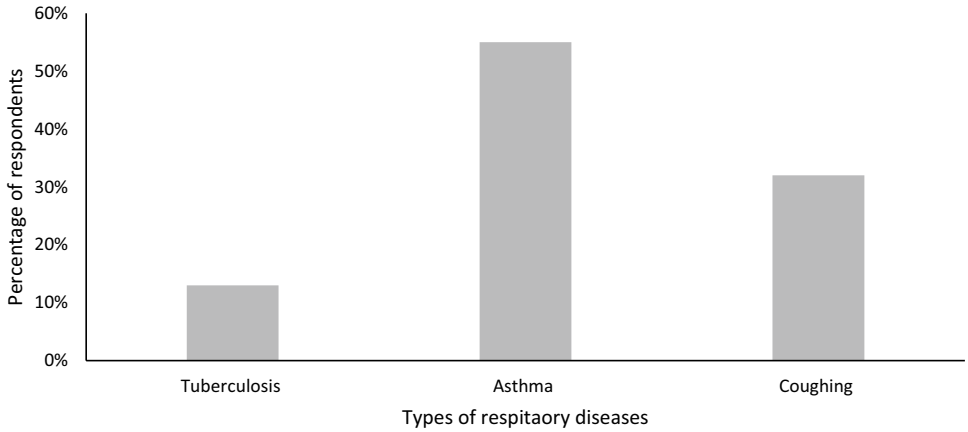

Fig. 5 Nature of respiratory diseases highlighted by respondents (Fieldwork, 2023)

"Waste pickers and many waste workers are cut by sharp objects at dump sites" (Excerpt from interview, Kwekwe, 2023).

Interviewee A concurred with the view above and said:

"Waste workers often request for safety shoes and gloves to protect themselves from cuts from broken glass and scrap metal." (Excerpt from interview, Kwekwe, 2023).

Broken glass, scraps of metal and tins were observed within dumpsites during field observation (Fig. 6). Information above confirms that injuries are associated with improper solid waste management in Amaveni suburb. Questionnaire respondents argued that scraps of metal and broken glass are sharp objects; hence, they increase the risk of cuts (82%), pricks (12%) and piercing (6%) among waste scavengers and children who consider illegal dumpsites as playgrounds (Fig. 7).

3.3 Environmental impacts

3.3.1 Air pollution

Most of the questionnaire respondents (80%) agreed that solid waste strategies used in Amaveni were associated with air pollution, although 15% were not sure while not agreeing was indicated by 5% (Table 1). Moreover, during field survey

Fig. 6 Scraps of metal within unsanitary landfill (Fieldwork, 2023)

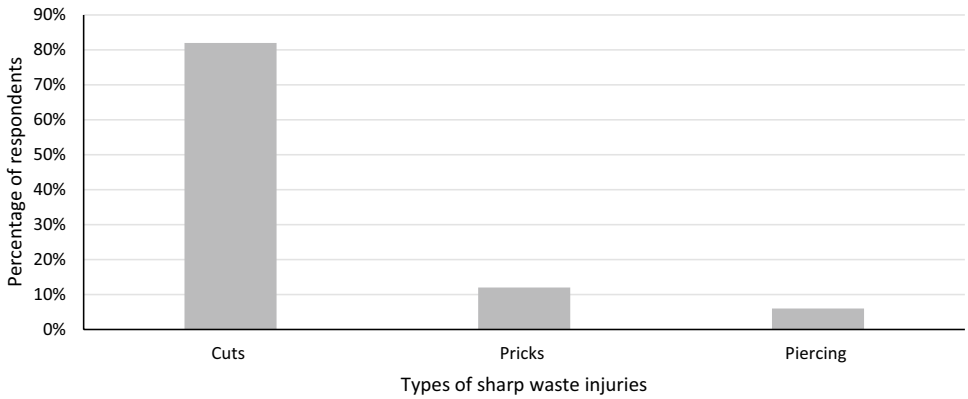

Fig. 7 Types of injuries caused by sharp waste (Fieldwork, 2023)

Table 1 Environmental problems that emanate from existing solid waste management approaches

Environmental risk	Agree	Not agree	Not sure
Air pollution	80%	5%	15%
Water pollution	90%	2%	8%
Soil pollution	97%	1%	2%
Loss of urban beauty	86%	3%	11%

Fig. 8 Burning waste emitting smoke into the air (Fieldwork, 2023)

smoke from solid waste open burning was observed at a dumpsite used to dispose solid waste collected from Amaveni suburb (Fig. 8).

The information from questionnaires concurred with information obtained through interviews. Interviewee D noted that:

> "Air pollution is one environmental risk associated with solid waste management strategies used in Amaveni since burning of solid waste is common" (Excerpt from interview, Kwekwe, 2023).

3.3.2 Water pollution

The majority of people who responded to questionnaire questions (90%) agreed that water pollution was associated with illegal solid waste disposal (Table 1). However, 8% of the respondents were not sure while 2% of the questionnaire participants failed to agree. Solid waste was observed in surface water sources as shown by plastics floating on water (Fig. 9).

Information from interviews was in harmony with information obtained through questionnaires. Interviewee D said:

Fig. 9 Solid waste in water sources (Fieldwork, 2023)

"The streams are clogged with plastics that are being thrown all over in Amaveni suburb" (Excerpt from interview, Kwekwe, 2023).

3.3.3 Loss of urban beauty

The majority of questionnaire participants (86%) agreed that poor solid waste management is associated with loss of urban beauty. Responses from questionnaires were in harmony with interviews. Interviewee D noted that:

"The general outlook of Amaveni suburb is dirty due to illegal dumping of solid waste in open spaces." (Excerpt from interview, Kwekwe, 2023).

The researchers observed solid waste illegally disposed on open spaces and this has reduced the aesthetic value of Amaveni suburb as shown in Fig. 10. This means solid waste management strategies used in Amaveni suburb were associated with loss of urban beauty.

Fig. 10 Dumpsite near houses making the area lose beauty (Fieldwork, 2023)

4 Discussion

In this study, all questionnaire respondents (100%) unanimously reported that the Kwekwe city council failed to provide bins for storing household solid waste. Consequently, each household had to procure their own containers for solid waste storage before collection, although the city council sometimes provided. Approximately 70% of the study's participants utilised 50 kg sacks for storing their solid household waste while around 15% opted for black polythene bags. This clearly illustrates that most of the storage receptacles used by residents in this high density suburb are temporary, not durable and can be easily torned by stray dogs. A view upheld by [45] and [57] that sometimes receptacles such as plastics and cardboard boxes are torned by dogs before waste collection or by waste collectors during collection. This increases littering in residential areas like Amaveni high density suburbs. In the past, the Kwekwe City Council used to provide bins to residents as part of their waste management services but due to financial constraints, they have made the decision to discontinue this service. This is supported with studies which indicated that currently most of the city councils in Zimbabwe are incapacitated to provide sufficient services to residential areas of their jurisdiction [58, 59]. Nevertheless, owing to lack of enough storage receptacles, residents fail to manage their waste effectively from storage to disposal, translating to littering, environmental pollution and public health concerns. This generally points out that lack of adequate resources among responsible city councils is widening the gap to achieve Sustainable Development Goal 11 which advocates for sustainable cities and communities.

This study allows us to understand that various methods are used to dispose of solid waste generated from Amaveni suburb, which conforms with a study by [49] indicating that solid waste collected from Bulawayo suburbs is discarded through several approaches, namely landfilling, open pits, open dumping, and burning' in the in discussion. Collected data revealed that 52% of the participants opt for open burning as a means of waste disposal, while 45% resort to open dumping. Open burning and open dumping are two common but highly unsustainable methods used to dispose waste from Amaveni. These approaches are less sustainable since burning of solid waste generates various air pollutants with potential to cause serious health risks to vulnerable individuals while adding greenhouse gasses into the atmosphere. Therefore, reliance on open burning among other disposal methods limit the ability of the Zimbabwean government to attain requirements of Sustainable Development Goal 3 and 13 of good health and well-being and climate action respectively. Toxic gases and fumes from solid waste combustion are increasing the prevalence of respiratory diseases, headache and nose irritation among people [32, 60]. Similarly, highly used open dumping not only leads to unsightly and unhygienic conditions but also contaminates soil and water sources while impacting both human health. Therefore, besides affecting soil quality, these contaminants hinder achievement of universal and equitable access to safe and affordable water as highlighted by Sustainable Development Goal 6 and Zimbabwe Vision 2030. Results indicated that solid waste was also disposed on non-designated sites including road sides, open spaces and in drains. These results state that while many countries have made progress in increasing their coverage of formal waste management systems, there are still gaps in Zimbabwe since illegal dumping of waste is still common. A view upheld by [30, 47, 49] that attaining proper solid waste disposal in developing countries, particularly those in Southern Africa is difficult due to numerous socio-economic and political challenges.

Results from interviews were supported by questionnaire respondents since residents indicated that improperly managed waste is facilitating outbreak of water borne diseases namely cholera (64%), typhoid (15%), dysentery and diarrhea (21%). This entails that improperly managed waste is a major contributor to the outbreak of waterborne diseases such as cholera, typhoid, dysentery and diarrhea. Mismanagement of solid waste in high density suburbs of Zimbabwe is adding burden to health services which are almost failing to serve their purpose. Zimbabwe always experiences high cholera outbreaks which mostly affects high density suburbs and add burden to hospitals and clinics [61, 62]. This suggests the significance of investing in effective waste management systems as key interventions for preventing solid waste related diseases. This is because improper waste management is almost against the Sustainable Development Goal 3, target 3.9 target of reducing the number of illnesses and deaths related to air, water and soil contamination in Zimbabwe. Vectors observed on dumpsites such as mosquitoes, houseflies, rats and cockroaches are significant public health concerns due to their potential to transmit diseases or cause discomfort and injury to humans. These findings tally very well with [63]'s view in Botswana and Ethiopia that improperly monitored dumpsites act as suitable breeding sites for vectors. The presence of these vectors on dumpsites poses a serious risk to public health as they can spread diseases within communities and contaminate the environment. Questionnaire respondents (100%) highlighted that improperly managed solid waste offer breeding sites for vectors with potential to cause vector borne diseases including malaria, sleeping sickness and rat bites fever. This illustrates that when solid

waste is not managed effectively, particularly on disposal sites, it can create environments that attract and support the proliferation of disease carrying vectors. This is supported by [43] and [64] that improperly managed solid waste can indeed serve as breeding sites for vectors, which are organisms that can transmit diseases to humans. Proper methods to spray and control breeding of vectors at designated and non-designated disposal is crucial to safeguard health of people especially those who reside in areas which are less than 500 m from disposal sites.

Key informants supported by questionnaire participants suggested that existing solid waste management approaches like open burning are associated with tuberculosis, asthma and persistent coughing. The evidence presented the detrimental impact of burning solid waste on respiratory health in suburban areas. The findings correspond very well with [39] that toxic gasses from solid waste burning and decomposition increase prevalence of respiratory diseases among people. Furthermore, the majority (82%) identified cuts as a common type of injury resulting from sharp objects in dumpsites, followed by pricks (12%) and piercing (6%). The sharp edges of broken glass and metal pieces can easily cause injuries when handled or stepped on, leading to various types of wounds such as cuts, pricks and piercing [5, 30]. The presence of broken glass, scraps of metal, and other sharp objects in dumpsites within Amaveni suburb poses a serious threat to the health and safety of waste scavengers and children. As waste pickers and workers scavenge through these piles of garbage to collect recyclable materials or items of value, they are exposed to the danger of getting cut by these sharp objects. The lack of proper protective gear like boots, gloves and safety measures further increases the risk for waste pickers and workers to sharp injuries which expose them to tetanus, Hepatitis as well as HIV and AIDS. Similarly, in Latin America and Sudan apart from the immediate pain and discomfort caused by cuts and lacerations, there is also a risk of infection due to exposure to contaminated sharp materials [65, 66].

In the context provided, it is evident that there is a concern regarding the association between solid waste strategies in Amaveni and air pollution. The questionnaire results indicate that a significant majority of respondents, 80%, agreed that the solid waste management strategies employed in Amaveni are linked to air pollution. This suggests a widespread perception among the community that the management of solid waste in the area has implications for air quality. Furthermore, during a field survey, smoke from open burning of solid waste was observed at a dumpsite where solid waste collected from the Amaveni suburb is disposed. Less sustainable waste management practices including open air burning leads to air pollution through the release of harmful emissions into the atmosphere [4, 19]. This implies that when materials such as paper, cardboard, plastics, textile waste and electronic waste are burned they release pollutants like particulate matter, carbon monoxide and volatile organic compounds into the air. These pollutants have detrimental effects on human health and the environment since particulate matter emitted from open burning can penetrate deep into the lungs and cause respiratory issues [44, 67]. Carbon monoxide interferes with the blood's ability to carry oxygen potentially causing headaches, dizziness and in severe cases, death while volatile organic compounds can harm lung function and aggravate respiratory diseases [68, 69]. This signifies the importance of resorting to other solid waste disposal since open burning is cheap while capable of reducing the volume of waste but it speeds up lives of people to graves. In the study conducted in Kwekwe, it was found that a significant majority of questionnaire respondents, amounting to 86%, agreed that poor solid waste management is directly linked to the loss of urban beauty. This sentiment was further reinforced by insights gathered from interviews and observations. This simply highlights that the presence of illegally disposed solid waste in open areas not only poses environmental and health hazards but also significantly diminishes the aesthetic appeal of urban spaces. In the case of Amaveni suburb, the inadequacies in waste disposal mechanisms have directly contributed to a decline in the visual attractiveness of the area. According to [70, 71] ineffective solid waste management strategies are among aspects which disturbs urban aesthetics in Kenya. Addressing various environmental health problems that emanate from improperly managed solid waste from Amaveni is paramount in the efforts towards achieving Sustainable Development Goals, and Zimbabwe Vision 2030 targets.

5 Conclusion

Solid waste management is a critical issue in urban high-density suburbs due to the large population concentration, poor infrastructure and limited space for waste disposal. The problem is more pervasive in high density suburbs of developing countries since most of the municipalities responsible to offer services are almost incapacitated. Therefore, this study put much emphasis on impacts of solid waste management strategies in urban high density suburbs: a case of Amaveni suburb, Kwekwe, Zimbabwe". The research was guided by objectives namely to assess the current solid waste management practices, to evaluate the environmental and health impacts of existing waste management strategies and propose possible recommendations to suppress environmental health problems. This paper has examined various

solid waste management strategies utilised in Amaveni high density suburbs and their impacts on human health as well as the environment. Management of solid waste in Amaveni is characterized by a traditional linear approach where solid waste is generated, indiscriminately stored, transported and finally disposed. Solid waste was disposed through open burning, illegal dumping and unsanitary landfilling. Insignificant amount of waste was composted and recycled. Findings illustrated that most of the existing management approaches offer little attention to aspects which support circular economy and the upper part of the waste management hierarchy. Consequently, a large proportion of solid waste is disposed, thus adding pressure to poorly monitored dump sites. Moreover, in order to free solid waste receptacles, residents resort to illegal solid waste disposal along road verges, drains, open spaces and backyard dumping. Verdicts of the study illustrated that improperly dumped solid waste and monitored dumpsites act as breeding sites for pests, vermin and pathogens which trigger occurrence of various health problems. Diseases such as cholera and malaria were health problems identified in Amaveni suburb. The main environmental problems identified included air pollution, water pollution and loss of urban beauty. Solid waste management in Amaveni was far from sustainable since it failed to promote Sustainable Development Goal 3 of good health and wellbeing and Sustainable Development Goal 6 of clean water and sanitation. Existing solid waste management strategies in Amaveni suburb reduce the capacity of Zimbabwe to reach demands of National Development Strategy 1 goals particularly those related to environmental protection while safeguarding human health. The impacts of solid waste management strategies in urban high density suburbs are multifaceted and are presenting far-reaching detrimental impacts to the environment and people. Therefore, effective waste management is essential for preserving the environment, safeguarding public health and promoting sustainable development in these densely populated areas.

6 Study limitations

One significant limitation is the narrow scope of the study since it solely focuses on the Amaveni suburb in Kwekwe. While this specificity allows for an in-depth analysis of a particular area, it limits the generalisability of the findings to other urban high-density suburbs in Zimbabwe or different regions with distinct socio-economic and infrastructural characteristics. Research on solid waste management often faces challenges related to data collection. In this case, limitations may arise from inaccurate or incomplete data provided by interviewees or residents. Another common limitation in the research project may be ascribed to resource constraints. Lack of adequate finance, time constraints and access to necessary equipment may hinder the researchers' ability to conduct comprehensive fieldwork or analyse data effectively translating to proposing of recommendations with various gaps. However, to minimize limitations of the study various data collection and analysis tools were utilised while secondary data was also used to support the findings.

7 Recommendations

Analysis of the findings demonstrates almost enough evidence which illustrates that impacts of solid waste in Amaveni high density suburbs require attention. The city council should provide enough bins to promote segregation of waste at source. This minimizes transportation and disposal of non-segregated solid waste. Source separation, which is generally a practice of separating waste at its source before it is collected, facilitates easy application of recycling, composting and reuse approaches at household level. Segregation of solid waste minimizes challenges experienced during application of waste reduction approaches in Asian cities [72]. Promoting waste reduction initiatives which support a circular economy minimize the quantity of disposed solid waste, thus lessening the burden of monitoring disposal sites as well as environmental health problems that emanate from improperly managed dumpsites. Households in Amaveni suburb must be educated and encouraged to compost organic waste. This reduces the quantity of organic waste destined in landfills, therefore lowering greenhouse gasses emissions released into the atmosphere. Composting is among effective solid waste management approaches in Bangladesh [73, 74]. Additionally, there is a need to adopt public–private partnership in solid waste management. Public–private partnerships have the potential to facilitate sharing of resources and expertise of both public and private sectors to effectively manage solid waste and construct properly engineered dumpsites. This implies that the city council must collaborate with residents, non-governmental organizations, research institutes and the Environmental Management Agency in suppressing environmental health problems associated with solid waste. The city council, Environmental Management Agency and Zimbabwe Republic Police should work hand in hand to deal with individuals, industries, business among other stakeholders who violate solid waste management

legal framework and standards. This improves compliance to recommended standards, translating to reduction of illegally dumped solid waste, thus reducing cropping of diseases linked to inappropriately dumped waste. Additionally, residents should be encouraged by city council and Environmental Management to participate in community initiatives which support clean-up campaigns, recycling, refurbishment, repairing and reuse programs. In order to inject a sense of circular economy in residents, awareness campaigns and training must be conducted by private and public sectors. Most importantly, the city council responsible for offering waste management services to Amaveni suburb must adopt an integrated solid waste management system. Integrated approach presented to be effective in managing solid some parts of India [75]. Integrated solid waste management systems combine various techniques such as source separation, recycling, composting, landfilling and energy recovery to effectively manage solid waste in a sustainable manner. Such systems can help to reduce the negative impacts of solid waste management on the environment while also providing economic benefits through resource recovery and energy generation. Furthermore, the Government of Zimbabwe must channel enough resources to city councils so that they pin advanced technologies in management of solid waste. Advanced technologies such as anaerobic digestion, gasification, pyrolysis and gasification support conversion of waste into valuable resources such as energy, fertilizer among other resources. These technologies assist to reduce the amount of waste that ends up in landfills or incinerators, thereby reducing the environmental impact. Application of advanced technologies in solid waste management demonstrated to be effective in countries like Canada [76].

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Declarations

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