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REVIEW

Safety and health risks associated with illegal municipal solid waste disposal in urban Zimbabwe. "A case of Masvingo City"

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Abstract

Municipal solid waste management (MSWM) is a worldwide problem as most local authorities are unable to dispose MSW safely. The study sought to evaluate safety and health risks associated with illegal MSW disposal in Masvingo City. Descriptive cross-sectional design was employed in which quantitative and qualitative data were collected concurrently. Questionnaires with both close and open-ended questions, semi-structured interviews, observations and secondary data sources were used during data collection. The study population comprised participants from Masvingo City's residential areas, Masvingo City Council employees and Environmental Management Agency (EMA) officials. A sample of 406 participants, comprising 354 residents from high-density, 16 residents from medium-density, 24 residents from low-density suburbs. Six interviewees were included during the study. Interviewees were selected purposively. Quantitative data was entered into Microsoft Excel Spreadsheet for analysis and content analysis was used to analyse qualitative data. Results showed that Cholera, skin problems, injuries and malaria were the main health problems. Based on the findings of the study, it can be concluded that MSW disposal in Masvingo was a threat to safety and human health. The study recommends that Masvingo City council provide receptacles and collect waste frequently.

Keywords Municipal Solid Waste · Illegal Disposal · Safety Risks · And Health Risks · Urban Zimbabwe · Safety and Health

Introduction

Municipal solid waste management (MSWM) has remained a thorn in the flesh for local authorities worldwide (Mbue et al. 2015; Hettiarachchi et al. 2018; Yukalang et al. 2017). The global nature of the problem is revealed in Bangladesh (Das et al. 2014), India (Saikia and Nath 2015), Pakistan (Mahar 2014) and Ghana (Ampofo et al. 2016), among others. The above scholars pointed out that MSWM was of great concern for many local authorities. Measures have been in place to improve the management of municipal solid waste after world leaders agreed in 1992, at the Conference on Environment and Development in Brazil, that MSWM was a global problem. However, strategies have been negatively affected by high rates of urbanisation and population growth which make it difficult for local authorities to manage solid waste safely (Samwire et al. 2017; Makarichi et al. 2018; Li Zhou 2020). The information above implies that management of municipal solid waste is a challenge to local authorities, especially in low-income countries experiencing faster rates of urbanisation than high-income countries. Illegal MSW disposal is dominant in developing countries, so local authorities in these countries should be innovative in managing increasing municipal solid waste (MSW) under their jurisdictions.

Fire is associated with disposal sites due to bacterial degradation of municipal solid waste producing flammable gases (Zohoori and Ghani 2017). Reporting on the situation in Asia, Das et al. (2014) revealed that methane gas from uncontrolled landfill sites in urban Bangladesh was causing fires. Similar studies in India, for example in New Delhi (Times of India 2017), revealed outbreak of fire at Deonar

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landfill in 2016 and at Ghazipur in October 2017. Fire is fuelled by the presence of numerous scrap tyres. Lagos, Nigeria, is a case in point (Maton et al. 2016). Studies in Zimbabwe also revealed that improper municipal solid waste management was associated with fire. For example, Shabani and Jerie (2023a, b) and Shabani et al. (2023) established that the Golden Quarry dump in Harare burned in August 2000 due to methane gas generated by anaerobic decomposition of MSW.

The indiscriminate disposal of Municipal Solid Waste can be a threat to the environment if not properly managed because it can cause floods in urban areas (Kaburu et al. 2019; Van Niekerk and Weighmann 2019). Several studies conducted in different countries, including Rawalpindi, Pakistan (Hina et al. 2020), Mexico, and Indonesia (Nanda and Berruti 2021), as well as Chandigarh City, India (Rana et al. 2015), have provided insights into the management of municipal solid waste (MSW). These studies have revealed a common issue related to the illegal disposal of MSW in drainage channels, which significantly hampers the flow of water and consequently leads to flooding. According to Butu and Mshelia (2014) and flooding was common in Kano and Abeokuta, Nigeria, as a result of municipal solid waste in drains. Mutemani et al. (2022) and Ndebele-Murisa et al. (2020) reporting on Zimbabwe, indicates that Harare, Bulawayo and Chitungwiza were affected by municipal solid-waste-induced floods. The information above shows that illegal solid waste disposal causes floods by disturbing the movement of water in drains and in rivers, thereby threatening human safety. The problem is not limited to Africa but affects other developing countries worldwide.

The way municipal solid waste is managed could pose health risks (Nyanzou and Jerie 2014; Mouhoun-Chouaki et al. 2019). Municipal solid waste management can be associated with waterborne diseases, depending on how the waste is disposed of (Lethbridge 2017). A study conducted in Juba, Sudan, (Namara Beamanya 2021) noted that there was risk of typhoid and cholera due to illegal municipal solid waste disposal. In Harare, Zimbabwe, municipal solid waste related cholera caused deaths of over 3500 people between 2008 and 2009 (Mandevere 2015; Mukandavire et al. 2020). The preceding literature suggests that if one functional element (disposal) of municipal solid waste management is not properly implemented, human health is threatened because of waterborne diseases such as cholera, typhoid and diarrhoea. The indiscriminate disposal of municipal solid waste can contribute to the outbreak of diseases such as cholera through various mechanisms. Cholera is a waterborne disease caused by the bacterium Vibrio cholerae, and improper waste management practices can create favorable conditions for its transmission. One of the primary ways in which indiscriminate waste disposal contributes to the outbreak of diseases like typhoid is through water contamination. Improperly disposed solid waste often ends up in water bodies such as rivers, lakes, and groundwater sources. When waste decomposes, it releases harmful substances and pathogens into the water, making it unsafe for human consumption. If contaminated water is used for drinking, cooking, or washing food, it can lead to the transmission of diseases like typhoid. Municipal solid waste can be a threat to human health as it provides breeding grounds for vectors (Atalia et al. 2015; Nor Faiza et al. 2019). Cases of vector borne diseases have increased greatly worldwide as a result of poor municipal solid waste disposal, with malaria having the highest number of deaths (Wilson et al. 2020; WHO 2019). Therefore, malaria is the deadliest MSW induced vector borne disease worldwide.

In a study on municipal solid waste management in Butwal, Nepal, (Bhusal et al. 2020) established that disposal sites promoted the breeding of mosquitoes, implying that there was risk of malaria in Nepal. Related studies in India (Atalia et al. 2015) and in Latin America (Lethbridge 2017) concluded that yellow fever and bubonic plague were among vectorborne diseases emanating from municipal solid waste disposal sites. In relation to Zimbabwe, Shabani and Jerie (2023a, b) noted that malaria and fever were common in Harare due to open space waste dumps. The nature of diseases can vary with location. The present study sought to assess vector borne diseases associated with illegal MSW in Masvingo City. In a study on MSWM and related health risks in China, Wang et al. (2019) noted that exposure to e-waste was associated with slow childhood growth and cognitive development. Studies in Africa, for example in Ghana (Van Viekerk and Weighmann 2019) and in South Africa (Ncube et al. 2017) established that exposure to e-waste resulted in damage to the urogenital system and kidney problems. In Gweru, Zimbabwe, Jerie (2016) reported high risks of kidney and liver damages due to cadmium from e-waste.

In addition, municipal solid waste illegal disposal was associated with respiratory problems. Respiratory problems are a result of emissions from burning plastic and rubber. Studies on MSWM and health in India, for example in Chennai (Balasubramanian 2018) and in Kalimpong (Khati 2015), revealed that uncontrolled burning of solid waste resulted in breathing difficulties among solid waste workers. The majority of residents in South Africa were suffering from respiratory diseases as a result of nearby illegal disposal sites (Mangoro and Kubanza 2023). In Zimbabwe, Jerie (2016) concluded that there were respiratory risks in Gweru due to burning of MSW. The extent of respiratory risks depends on how solid waste is dealt with at disposal sites and nearness of residents to dump sites. Literature in Latin America (Lethbridge 2017; Cruvinel et al. 2019) shows that informal waste workers were at risk of injury from sharp material within mixed residential waste on illegal disposal sites. Lack of personal protective equipment (PPE) increased the probability of cuts on waste workers

on disposal sites in Chitungwiza and Bindura, Zimbabwe (Zvobgo and Do 2020; Chikombe 2017). Thus, municipal solid waste workers, especially informal in developing countries, are the most affected as a result of lack of awareness and PPE. Therefore, the risks can be reduced by improving their awareness and providing protective clothing.

In Zimbabwe studies carried by researchers notably Jerie (2016); Shabani and Jerie (2023a, b); Shabani et al. (2023) most of them focus on waste produced by sectors such as informal sectors and institutions such as healthcare facilities neglecting Municipal Solid waste. Therefore, this study put much attention on Municipal Solid Waste in order to examine environmental, safety and health risks caused by indiscriminate disposal of MSW. The results of the study would help to attain Sustainable Development Goals for example Sustainable Development Goal 3 on Health and Well-being and Sustainable Development Goal 3.9 which put much attention on reducing number of illness and deaths hazardous materials. The results of the study ought to support ecosystem protection, hence promoting attainment of SDGs 14 and 15 of life below water and on land respectively.

Materials and methods

Study area

The study was conducted in Masvingo City (Fig. 1). Masvingo City is located in the southern part of Zimbabwe ($20^0 4^l 28^{ll}$S and $30^0 49^l 58^{ll}$E). It is 288 km north of Beitbridge, 290 km east of Bulawayo and is 292 km south of Harare. Masvingo is 1098 m above sea level. In terms of climate, its annual rainfall is 615 mm and the average temperature is between 17.5 and 20 °C. The geology of Masvingo City is made up of resistant (strong) and non-resistant (weak) metamorphic rocks implying moderate chances of groundwater pollution from solid waste leachate. Masvingo had a total population of 87 886 (ZIMSTAT 2022). Currently, the city has a population of 100 000 (ZIMSTAT 2022) indicating a growth rate of about 1.3% per annum. This growth rate has implications on municipal solid waste management because an increase in urban population is associated with an increase in MSW generation rate, which makes it difficult for local authorities to collect and dispose waste sustainably. Masvingo is associated with high informal traders which are increasing everyday due to high unemployment rate (Gambe et al. 2023). However, toomuch informal trading is associated with poor disposal of waste which expose humans to risks. Given the high unemployment rate in Masvingo City, the majority of waste generators fail to pay rates (Chitongo et al. 2023. Thus, a rapid increase in urban population has a negative impact on MSWM.

Study design

A descriptive cross-sectional design was applied during the study. It was applied because it applied both quantitative and qualitative methods in data collection and analysis in addressing the objectives of the study.

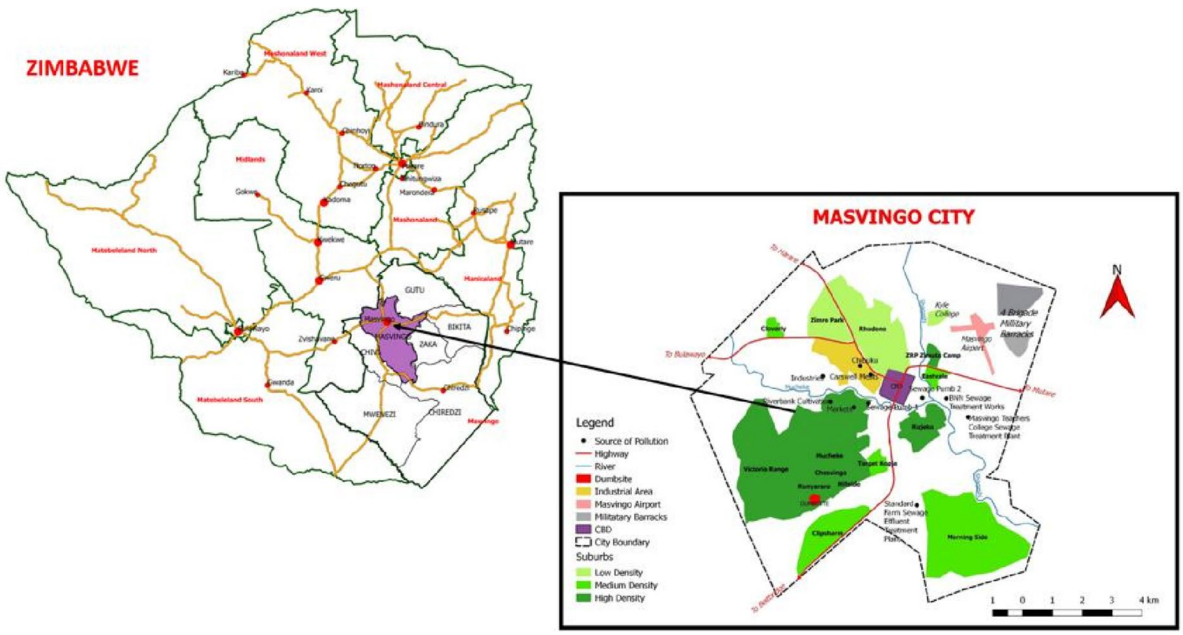

Fig. 1 Masvingo City map and relative location of Masvingo City in Zimbabwe. Source: ZIMSTAT (2022)

Study population

The study consists target residents in Masvingo City and workers of Masvingo City Council as well as workers from the Environmental Management Agency. Residents participated as questionnaire respondents. The study encompass interviewees notably City Council Director, Environmental Management Officer, Environmental Health Technician, Nurse in Charge and Environmental Quality Officer.

Sampling techniques

The appropriate sample size for residents who participated as questionnaire respondents was calculated using Cochran 1963's formula. As a result after calculations were done a sample of 354 participants was derived from 12 980 residents in High Density Suburb, a sample of 16 questionnaire respondents was derived from 615 residents in Medium Density Suburb and a sample of 24 participants was derived from 779 residents in Low Density Suburb. Random sampling was used to select questionnaire respondents from the randomly selected Suburbs. Respondents for interviews were purposely selected.

Data collection

A questionnaire with both closed and open-ended questions was used for the study. The questionnaire was self-administered to reduce margin of error. The questionnaire collected information on demographic data, environmental risks caused by indiscriminate disposal of Municipal Solid Waste as well as safety and health risks caused by improper disposal of MSW. A pilot study was done using 10% of the study participants. This was significant because it helps the researcher to correct errors related to the questionnaire. This conformed to Nyariki (2009)'s assertion that pilot survey of a questionnaire requires 10% from the target population before the questionnaire is used for the main study. After the pilot survey alterations were made following recommendations provided during the pilot survey and finally the questionnaire was administered to the residents of Masvingo City.

In addition, semi-structured interview guides were prepared. The interviews were done with key informant interviewees who were selected purposively including City Council Director, Environmental Management Officer, Environmental Health Technician, Nurse in Charge and Environmental Quality Officer. The semi-structured interview guides collect information on environmental risks and safety and health risks which are caused by indiscriminate disposal of Municipal Solid Waste. Furthermore, observations were carried out to observe tasks performed by waste scavengers which expose them to risks and type of waste which expose people to risks for example improperly disposed sharp waste. An observational checklist was drafted to be used during the survey. More so, secondary data was also used during the survey. Data regarded as secondary was collected from textbooks, review papers, journals and reports.

Data analysis and presentation

Returned questionnaires were screened for quantitative data analysis. The data was cleaned coded and summarised based on objectives of the study before it was entered into the Microsoft Excel Spreadsheet for analysis. The data was presented in form of Pie charts. Content analysis was used to analyse qualitative data.

Ethical considerations

Ethical clearance certificate was obtained from the CAES Health Research Ethics Committee before collecting any data from Masvingo City. Prior to entering the research sites, permission was sought and granted from Masvingo Municipality and Environmental Management Agency. Permission from individual respondents was obtained through consent forms.

Results and discussion

Environmental safety and health risks

Flooding

The majority of participants (95%) as shown in Fig. 2 agreed that flooding was a risk associated with indiscriminate disposal of MSW. During the interview the City Council Director stated that "Human life is under threat from flooding during the rainy season as a result of illegal solid waste disposal in drains. The reason for the agreement among the majority of participants regarding the risk of flooding associated with indiscriminate disposal of MSW can be attributed to several factors. Firstly, when solid waste is disposed of improperly, such as being dumped into drains or water bodies, it can obstruct the natural flow of water. This obstruction leads to the accumulation of water, increasing the likelihood of flooding during periods of heavy rainfall.

Additionally, solid waste can clog drainage systems and reduce their capacity to handle excess water. When drains are filled with waste materials, they become less effective in channelling water away from residential areas and other vulnerable locations. As a result, even moderate rainfall can cause flooding in areas where waste has accumulated. Furthermore, solid waste disposed of inappropriately can contribute to the deterioration of drainage infrastructure.

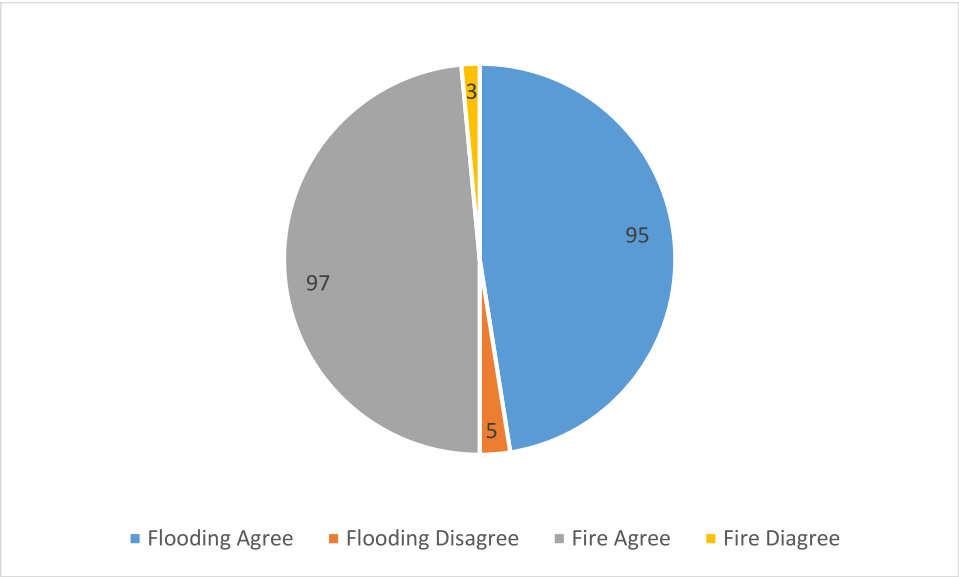

Fig. 2 Statistics on flooding and fire. Source: Field Survey (2023)

The presence of waste materials in drains can lead to blockages and damage to pipes and culverts. Over time, this degradation weakens the overall drainage system's ability to function efficiently and increases the risk of flooding. Solid waste was observed in and around drains during data collection as illustrated in Plate 1. This visual representation reinforces the concerns raised by participants about the connection between indiscriminate MSW disposal and flooding risks. During periods of heavy rainfall, there is a reasonable likelihood that localized flooding may occur as a result of the improper disposal of municipal solid waste (MSW) in drains. This observation is consistent with findings from various studies conducted in different countries. For instance, in Mexico, Mseleku (2021) noted that the disposal of MSW in drains contributes to flooding incidents. Similarly, Rana et al. (2015) found evidence of unlawful waste disposal blocking drains and causing floods in urban areas of India. In Nigeria, both Butu and Mshelia (2014) and observed that the improper disposal of municipal solid waste obstructs drains and other waterways, leading to flooding in urban regions.

Fire

Figure 2 illustrates that the majority of respondents (97%) were in agreement with the fact that fire was a risk. There are several reasons why respondents may have expressed agreement with the notion that fire is a risk associated with the indiscriminate disposal of MSW. Firstly, when waste is disposed of in an uncontrolled manner, it can accumulate in large quantities, creating potential fuel sources for fires. MSW often contains flammable materials such as paper, cardboard, plastics, and organic waste, which can easily ignite and spread fire if not properly managed. Secondly, improper disposal practices such as open burning or dumping waste in unauthorized areas can lead to the ignition of fires. Open burning of waste releases harmful pollutants into the air and poses a significant fire hazard. Furthermore, the presence of hazardous materials in MSW can contribute to the risk of fire. Many household and industrial products contain chemicals that are flammable or reactive when exposed to heat or other ignition sources. If these materials are not handled correctly during disposal, they can ignite and escalate fires, posing a threat to both human health and the environment. The findings of the current study that fire was a safety risk caused by illegal municipal solid waste disposal is consistent with studies conducted in Bangladesh (Das et al. 2014) and in India (Times of India 2017), which revealed that fire was a result of flammable gases like methane produced by anaerobic decomposition and informal waste collectors who start fires when recovering recyclable materials on illegal disposal sites.

Plate 1 Solid waste in and around drains. Source: Authors (2023)

Waterborne diseases

During the study majority (72%) reported that illegal disposal of waste expose humans to water borne diseases however, minority (28%) of the participants did not indicate that water borne diseases occur as a result of illegal disposal of waste. This was supported by the Environmental Health Technician that cases of cholera have increased with increasing in urban areas due to indiscriminate disposal of waste. The discrepancy in opinions can be attributed to various factors. Firstly, individuals may have different levels of awareness and understanding regarding the link between waste disposal and waterborne diseases. Those who acknowledged the connection may have been more informed about the potential health hazards posed by contaminated water sources resulting from improper waste disposal.

Secondly, cultural and societal factors could influence people's perceptions. In some communities, there may be a lack of awareness or acknowledgment of the impact of waste disposal on public health. This could explain why a portion of the participants did not recognize the association between illegal waste disposal and waterborne diseases. The study mentions that a third interviewee supported the notion that cases of cholera have increased in urban areas due to indiscriminate waste disposal. This suggests that there are instances where individuals have witnessed or experienced firsthand the consequences of improper waste management leading to waterborne diseases. The finding of the current study on waterborne diseases is consistent with findings from studies conducted in Kaye, Burkina Faso (Cissé 2019), in Ghana (Ashitey 2014), in Tanzania (Palfreman 2014) and in Harare, Zimbabwe (Mbereko et al. 2020), that poor collection and improper disposal of municipal solid waste create conditions for outbreaks of disease like cholera when the faecal material in such disposal areas provide conducive environment for bacteria growth. Surface runoff from illegal disposal sites may cause contamination of water sources as noted by Sarker et al. (2021). Contaminated water that is used without adequate treatment increase the risk of cholera. Many illegal disposal sites were observed in Masvingo City and there was probability of cholera in the city as indicated by interviewees eleven and twelve. The probability of cholera was high during the rainy season due to run off and stagnation of water leading to exposure to Cholera vibrio. The finding on MSWM and waterborne diseases is also in harmony with the ISWM model which states that infrequent collection and illegal disposal of municipal solid waste can cause diseases. To solve the problem of waterborne diseases, generated solid waste should be collected regularly and disposed of properly.

Vector borne diseases

During the study questionnaire respondents were asked to if they were exposed to vector borne diseases due to indiscriminate disposal of MSW. Most (83%) specified that they are exposed to vector borne diseases due to poor disposal of municipal solid waste and very few (17%) indicated they were not exposed to vector borne diseases due to improper disposal of waste. During the interview the Environmental Management Officer indicated that Mosquitos have increased in Masvingo as illegal disposal sites as breeding grounds and this has increased cases of malaria. There are several reasons why improper disposal of municipal solid waste can contribute to the spread of vector-borne diseases. Firstly, when waste is not disposed of properly, it can accumulate and create ideal breeding grounds for disease-carrying vectors such as mosquitoes. These vectors thrive in stagnant water and areas with poorly dumped organic waste. The presence of uncontrolled waste attracts various pests and rodents that can act as carriers for diseases. These pests can come into contact with the waste and then transmit pathogens to humans through bites or contamination of food and water sources. For example, rats are known carriers of diseases such as leptospirosis and Hantavirus, which can be transmitted to humans through direct contact or inhalation of contaminated particles. The finding supports literature and observations in Latin America (Lethbridge 2017), in Uganda (Kinobe 2015), and Sudan that show that if MSW is poorly handled, it can promote breeding of mosquitoes thereby increasing cases of malaria. Thus, to reduce the risk of malaria, MSW should be collected frequently and disposed of in ways expected by law and the ISWM model which promotes sustainability.

Respiratory risks

During the study on safety and health risks associated with illegal MSW disposal majority (64%) of the study participants indicated that they are exposed to respiratory risks due to indiscriminate disposal of Municipal Solid Waste. Only some (36%) indicated they were exposed to respiratory risks due to poor disposal of Municipal Solid Waste. In response to a question on respiratory risks, Nurse in Charge noted that, there is bad odour from illegal waste disposal sites and that those who burn solid waste often experience breathing difficulties and coughing. There are several reasons why the study participants indicated their exposure to respiratory risks in relation to MSW disposal. Firstly, the indiscriminate disposal of MSW often leads to the release of harmful pollutants into the air. When waste is disposed of in an uncontrolled manner, it can emit various gases and particulate matter that can be detrimental to human health

when inhaled. These pollutants may include volatile organic compounds (VOCs), sulfur dioxide (SO2), nitrogen oxides (NOx), and particulate matter (PM), among others. Prolonged exposure to such pollutants can result in respiratory issues such as asthma, bronchitis, and other respiratory infections. These findings of the present study corroborate findings from studies in India (Kumari et al. 2019), which concluded that municipal solid waste workers and residents living near dump sites were at risk of breathing problems and coughing due smoke from burning solid waste. According to the ISWM model which informed the present study, MSW must be disposed of appropriately so that it does not cause health problems. Thus, to reduce health risks associated with MSWM, solid waste should be handled properly. Below is a discussion on health risks associated with heavy metals and e-waste.

Reproductive and developmental disorders

During the study most (89%) of the questionnaire respondents designated that reproductive and developmental disorders occur as a result of indiscriminate disposal of Municipal Solid Waste and a small percentage (11%) reported that they were not exposed to reproductive and developmental disorders. This was supported by the Environmental Quality Officer that indiscriminate dumping of waste containing heavy metals can pose significant risks to human health which disturbs the development of the foetus hence reproductive is affected. There are several reasons why indiscriminate disposal of MSW can lead to reproductive disorders. Firstly, when waste is disposed of in an uncontrolled manner, it can contaminate the surrounding environment, including water sources and soil. This contamination can result in the accumulation of harmful substances such as heavy metals, pesticides, and other toxic chemicals. When these substances enter the human body through various pathways such as ingestion, inhalation, or dermal contact, they can disrupt normal reproductive processes. Heavy metals, in particular, have been linked to reproductive disorders. For example, exposure to lead has been associated with decreased fertility in both men and women. Lead can interfere with hormone production and disrupt sperm production in men, while in women it can affect ovulation and increase the risk of miscarriage. Similarly, exposure to mercury has been shown to impair fertility and increase the risk of birth defects.

Furthermore, the presence of toxic chemicals in MSW can also have indirect effects on reproductive health. For instance, certain chemicals found in MSW have been identified as endocrine disruptors. These substances can mimic or interfere with natural hormones in the body, leading to hormonal imbalances and reproductive dysfunction. Endocrine disruptors have been linked to conditions such as infertility, menstrual irregularities, and developmental abnormalities in offspring. The study findings concur with findings from previous studies conducted in South Africa (Ncube et al. 2017) and in Gweru, Zimbabwe (Jerie 2016), which showed that improper management of heavy metals and e-waste caused skin problems and damage to kidneys. However, the finding of the present study on heavy metals and e-waste is inconsistent with literature in China (Li and Achal 2020) which suggests that besides causing skin and kidney problems, illegal disposal of heavy metals and e-waste also caused slow cognitive development and childhood growth in China. The differences in health risks associated with heavy metals and e-waste could be due to differences in the nature of heavy waste.

Injury risks

Majority (83%) specified that illegally disposed waste expose humans and animals to injuries such as sharp injuries and minority (17%) reported that they were not affected with injuries related to improper disposal of waste. This Nurse in Charge designated that, waste scavengers are exposed to sharp injuries when they try to retrieve some of the waste such as zinc scaps which can be reused from the illegally dumped Municipal Solid Waste. Interviewee Twelve go on to say the rate of sharp injuries among waste scavengers is increased by shortage of PPE/C among waste scavengers. The exposure to sharp injuries during waste scavenging activities can be attributed to several reasons. Firstly, when waste is illegally disposed of, it often ends up in uncontrolled and hazardous environments. This increases the likelihood of encountering sharp objects such as broken glass, metal fragments, or needles, which can cause injuries if not handled properly. Additionally, waste scavengers often have limited visibility and may not be able to identify potential hazards hidden within the waste. Secondly, the nature of waste scavenging work itself poses risks for injuries. Waste scavengers typically have to rummage through piles of waste in search of valuable or recyclable materials. This process involves physically handling and sorting through various types of waste, increasing the chances of coming into contact with sharp objects. Moreover, waste scavengers often work in unsanitary conditions where proper hygiene practices may not be followed, further increasing the risk of infections or injuries. PPE, such as gloves and protective clothing, plays a crucial role in minimizing the risk of injuries during waste handling (Jerie 2016). However, due to financial constraints or lack of awareness about the importance of PPE, many waste scavengers do not have access to adequate protective gear. This leaves them vulnerable to sharp injuries and other health hazards associated with waste handling.

Plate 2 Broken glass within waste dump. Source: Authors (2023)

The finding of the current study on MSWM and injury risks concurs with findings from studies carried out in Seri-Kembangan, Malaysia (Mohammed and Latif 2014) in Latin America (Cruvinel et al. 2019), in South Africa (Nkosi 2014; Ncube et al. 2017) and in Sudan that municipal solid workers and those playing on dump sites experienced cuts from sharp objects. The above finding of the current study is in line with the ISWM model which informed the present study, which states that generated solid waste should be collected regularly and disposed properly to prevent negative effects on public health. By causing injuries, MSW disposal in Masvingo was not promoting public health. To reduce injury risks, MSW should be collected frequently and disposed of in a sustainable manner as required by the ISWM model (Plate 2). Sharp objects were observed during observations as indicated by plate 2. This sharps expose people to sharp injuries.

Conclusion and recommendations

In conclusion, the paper titled "Safety and Health Risks Associated with Illegal Municipal Solid Waste Disposal in Urban Zimbabwe: A Case of Masvingo City" sheds light on the significant safety and health hazards posed by illegal waste disposal practices in urban areas of Zimbabwe, with a specific focus on Masvingo City. The study highlights the detrimental effects of improper waste management on both the environment and human well-being.

The research findings indicate that illegal municipal solid waste disposal in Masvingo City has led to various safety risks. One of the primary concerns is the contamination of water sources due to leachate seepage from improperly managed waste sites. This contamination poses a severe threat to public health, as it can lead to the spread of waterborne diseases such as cholera, typhoid, and dysentery. Additionally, the accumulation of solid waste in unauthorized dumping sites increases the risk of fire outbreaks, which can cause extensive damage to property and endanger lives.

Furthermore, the paper highlights the adverse environmental impacts resulting from illegal waste disposal practices. Improperly managed waste sites contribute to air pollution through the release of toxic gases and the emission of greenhouse gases such as methane. These pollutants not only degrade air quality but also contribute to climate change. Moreover, the indiscriminate dumping of waste in open spaces and water bodies leads to soil degradation, loss of biodiversity, and contamination of ecosystems.

The study also emphasizes the socioeconomic implications of illegal waste disposal in Masvingo City. The presence of unsightly dumpsites negatively affects property values and tourism potential, hindering economic development in the area. Additionally, the financial burden associated with cleaning up and mitigating the consequences of illegal waste disposal falls on local authorities and taxpayers.

Recommendations

To improve municipal solid waste management, the following recommendations are proposed.

1. *Provision of suitable waste receptacles including colour coded waste bins for all waste generators by local authority, NGOs and donor agencies:* Availability of suitable receptacles would reduce littering and promote separation at source. Lack of bins and equipment for separation were noted by respondents as challenges hindering MSWM. Separation at source is crucial for recycling, composting and reuse of solid waste. The 4Rs are a key component of the integrated sustainable waste management, which is the theoretical framework of this study. If the 4Rs are promoted because of separation at source, sustained municipal solid waste management would be achieved and this would reduce environmental and health risks of municipal solid waste management.
2. *Regular collection of solid waste from all areas by local authority*: Only 40% of municipal solid waste generated in Masvingo was collected. According to the integrated sustainable waste management, collection of solid waste should promote public health. Illegal disposal was caused by infrequent collection. By collecting solid waste frequently from all waste generators, illegal disposal would be reduced. This would reduce environmental and health risks associated with municipal solid waste management.

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Data availability The data used in this study are available upon request from the corresponding author.

Declarations

Ethics approval Approval was granted by Midlands State University to carry out the research as well as to publish under its name. All sources were properly cited to avoid plagiarism.

Consent to participate All authors participated and agreed to participate up to final revision of the manuscript.

Consent for publication Authors agreed to let the paper published when considered for publication.

Conflicts of interest This manuscript has not been submitted to, nor is under review at, another journal or other publishing venue.

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