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Situation Analysis of Municipal Solid Waste Management Practices in Mthatha Central Business District, South Africa

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ABSTRACT

Managing municipal solid waste is one of the most crucial services municipal authorities provide in developing nations to maintain clean cities. However, in many cities in the Eastern Cape, the municipal solid waste is still not managed properly. Thus, this study compared the distribution of dustbins in Mthatha's Central Business District between 2012 and 2023. In addition, this study investigated the strategies the municipality employs to manage its solid waste. The distribution of dustbins was recorded using the Global Positioning System. Additionally, questionnaires were distributed to investigate the strategies that the town employs to manage its waste. The findings revealed statistically significant variations in the frequency of operational and non-functional dustbins in 2023 and 2012. The study also showed that Mthatha has issues in managing solid waste, which include a lack of compliance by urban dwellers, population growth, and financial constraints among others. We conclude that for waste management in Mthatha to be successful, technologies like geographic information systems must be used when distributing dustbins. Finally, this study demonstrated that urban dweller collaboration is essential for good municipal solid waste management, which depends on more than just government officials.

1. INTRODUCTION

A greater amount of waste that goes untreated contaminates the ecosystem. Municipal solid waste (MSW), also known as trash or garbage, refers to the solid waste generated by residences and other places of employment outside factories. Paper, cardboard, food waste, cans, bottles, garden waste, plastics, metals, glass, and electronic waste (e-waste) are some types of MSW. A large portion of this waste is managed improperly and ends up in lakes, rivers, and open landfills. While MSW is safely disposed in landfills or burned in incinerators in first-world nations, it ends up in open dumps in less developed nations, where the impoverished scratch out a living by scavenging for items, they can sell for reuse or recycling [1].

Ahmed and Ali [2] indicated that the annual global production of solid waste is approximately 1.6 billion metric tons. Unmanaged solid waste is an environmental hazard that has resulted in a long list of public health problems in numerous nations. For instance, Thakur et al. [3] estimated that India's waste generation is rising at a rate of 1% to 1.33% annually. Furthermore, Nyika et al. [4] reported that in South Africa, waste generation has been on the rise. In addition, Nyika et al. [4] further reported that in 2017, South Africa generated 121 million tons of waste. Lastly, Nyika et al. [4] also noted that these projections are greater than those reported in 2011, which predicted a total waste generation of 108 million tons. As the world's population continues to grow, so does the amount of waste generated. For example, in 2015, the world generated 2 billion metric tons of solid waste, which is expected to grow to 3.4 billion metric tons by 2050 [5].

According to Singh et al. [6], solid waste is produced every day in residential and commercial sectors, and it is crucial to store this waste properly at the source before collection to prevent environmental pollution. As specified by Breukelman et al. [7], municipalities in many developing countries struggle to complete waste management due to insufficient infrastructure. Furthermore, inconvenient locations for solid waste storage facilities, inadequate coverage services, and bad transportation routes from inadequate home awareness-raising efforts, insufficient recycling efforts, and inadequate landfill disposal methods are some of the challenges affecting waste management [7]. Serge Kubanza and Simatele [8] argue that municipal solid waste management is frequently identified in developing countries as a problem that threatens the environment and public health. For example, open dumping damages nearby ecosystems by contaminating the air, soil, and water [9]. Research indicates that particulate matter from landfills degrades air quality [10].

Furthermore, it appears that municipal solid waste management is not a top priority in developing nations, where the primary issues are unemployment, starvation, water scarcity, and civil war. As a result, millions of people in developing nations lack access to efficient waste management system, which causes a variety of problems [8]. For example, inadequate waste management exacerbates the effects of urban

flooding by obstructing drainage, raising debris, and harboring disease vectors [11, 12]. In addition, poorly managed waste poses serious risk to the environment and population due to the contamination of water and soil [8, 9, 13]. For example, poorly managed MSW impacts the environment in terms of the water, soil, and air [14]. The production of leachate, resulting from the interaction between MSW and water, poses a significant risk of contaminating groundwater resources. Consequently, the hazardous nature of waste has an impact on the land where it is dumped [14]. Sociologically speaking, this negatively impacts the environment's aesthetics as well as the health of those who live nearby, work at the site, and engage in waste picking [15].

Hangulu [16] pointed out that, there are several laws that govern how the environment and waste management are handled in South Africa. The South African constitution is one of the laws, and it emphasizes the close ties between pollution control and waste management. For example, the constitution of the Republic of South Africa assures its adherence to sustainable development principles, supports environmental preservation, and provides information to stakeholders. In addition, sustainable development focuses on addressing current demands without compromising the capacity of future generations to address their own needs [16]. Furthermore, the Municipal Systems Act (Act No. 32 of 2000), the National Environmental Management Waste Act (Act No. 59 of 2008), and National Environmental Management Act (Act No. 107 of 1998) (NEMA) are significant regulators of waste management in South Africa. Lastly, the eleventh Sustainable Development Goal emphasizes the need for cities and human settlements that are inclusive, safe, resilient, and sustainable. Goal 11.6 says by 2030, cities must take steps to lessen their harmful environmental impacts, particularly on-air quality, and municipal and other waste management (The 2030 Agenda for Sustainable Development). Local authorities must adopt systems for the delivery of waste collection services, including collection, storage, and disposal, in accordance with the NEM: WA (Act No 59 of 2008).

The O.R. Tambo District Municipality's Integrated Waste Management Plan (IWMP) [17] recognised that unlawful dumping occurs in the area, and King Sabata Dalindyebo Local Municipality (KSDLM) is not an exception given the efforts being made to address this issue. For instance, the Thuma Mina Green Deeds initiative, which uses employees from the Extended Public Works Program (EPWP) to clean up unlawful dump sites, aims to deal with illegal dumping within local municipalities (LM), published by O.R. Tambo IDP in 2022.

According to Aremu et al. [18], cities distribute dustbins at designated service stations along the highways to handle MSW and temporarily store it there. This method accepts joint accountability. One need is for the waste generator to deposit the created solid waste at the designated location into the dustbin provided by the municipality. The second requirement is for the municipality authorities to assign dustbins to various city neighbourhoods, collect the waste, and dispose of it. Yet, the municipal authority faces two difficulties in this role: distributing dustbins effectively and figuring out how many dustbins are needed to provide the best possible service. According to Leeabai et al. [19], selecting the right dustbin and positioning it in the appropriate location are both essential components of solid waste management. Most people are likely to select the closest site, just like choosing a store or hospital nearby. The location of dustbins, which influences the volume of waste transported into the system and the amount of waste that flows through the reverse logistic chain, has a substantial impact on the overall effectiveness of the MSW system [20]. Low volume of waste is properly disposed because people are less able to use the MSW system because of a sparse or unevenly dispersed collection network. Since the dustbin collection network and waste transportation from dustbins to transfer sites can account for about 70% of the system's overall cost, the quantity, distribution, and kind of dustbins are also important [5]. Insufficient funding is another reason why local governments struggle to fulfill their mandate for waste collection [21, 22]. Due to the thousands of tons of MSW that must be managed every day in cities, which are centers of rapid economic expansion, these hurdles cause additional issues like littering and unlawful dumping.

The current study was motivated by some factors observed in Mthatha. For example, filthy streets, which included unmanaged waste piles, obstructed drainage channels, open areas that had turned into impromptu dumping grounds, and a lack of dustbins along the Central Business District (CBD) edge. Because of this, MSW is a problem that impacts several sustainable development issues across the three sustainability domains, that is ecology, economy, and society. Living circumstances, sanitation, public health, terrestrial and aquatic ecosystems, and the sustainable use of natural resources are among the affected areas by MSW. At least 12 of the 17 Sustainable Development Goals (SDGs) and related targets of the 2030 Agenda for Sustainable Development (SD), which was agreed upon by the 193 UN member states in September 2015, have a direct bearing on solid waste management [23]. This study's objective is to find geographical trends and coverage gaps by analysing the dustbin distribution throughout the city of Mthatha. Furthermore, to evaluate the overall efficacy of waste management infrastructure, the study compares the number of functioning and non-functional dustbins in the city. The results will help to guide recommendations for dustbin installation and upkeep that will enhance cleaning and public health.

The study hypothesises as follows: H_0: The number of dustbins distributed in Mthatha CBD is the same across categories of years (i.e., 2012 and 2023). H_a: The number of dustbins distributed in Mthatha CBD differs across categories of the year (i.e., 2012 and 2023). The second hypothesis is H_0: The number of functional and non-functional dustbins in Mthatha CBD is the same across years (i.e., 2012 and 2023). H_a: The number of functional and non-functional dustbins in Mthatha CBD differs across years (i.e., 2012 and 2023).

2. MATERIALS AND METHODS

2.1 Study area

The study was conducted at Mthatha, Eastern Cape Province, South Africa (Figure 1). Mthatha had 96,114 people in 2011 (Statistics South Africa). The only town in the former Transkei region with a 230 km radius is Mthatha, the third-largest town in the Eastern Cape Province of South Africa. It serves as an economic and social hub for the area's eight functionally lower-ranked towns and the nearby rural villages, shown by O.R. Tambo DM IDP in 2013. Layers of both commercial and residential settlement patterns can be seen in Mthatha, and these patterns include varied residential types, densities, spaces, and distinct spatial features. On both the east

and western sides of the city center, high-density communities dominate Mthatha's overall structure. There are also several low and moderate-density villages, and roomy peri-urban settlements.

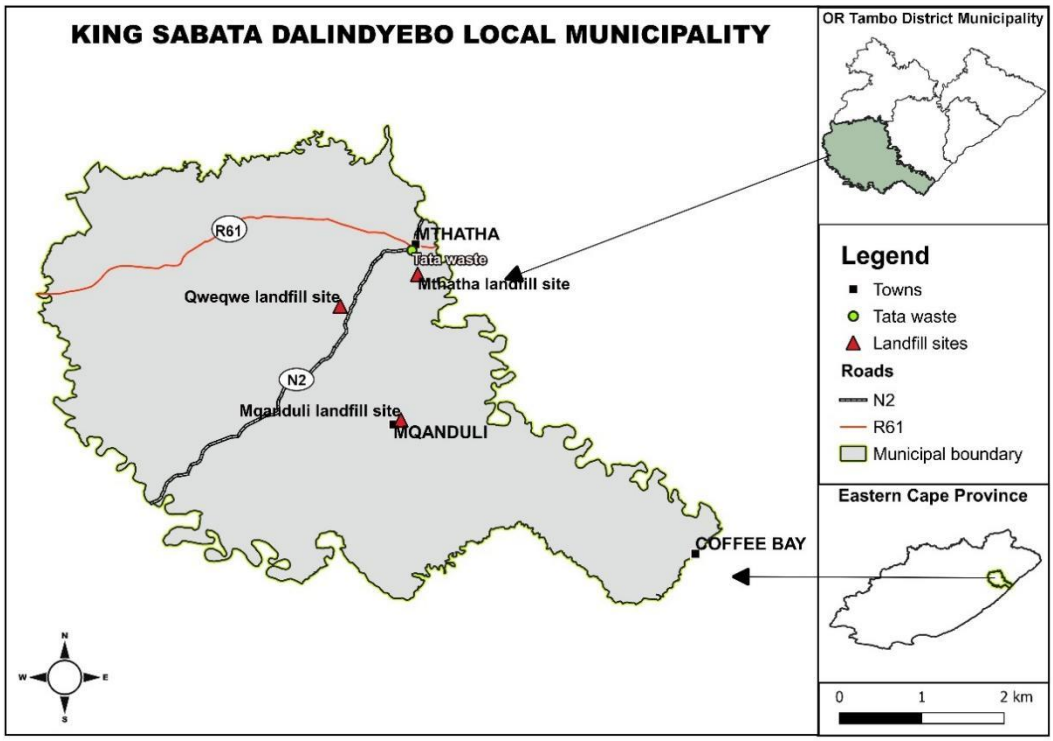

Figure 1. Map of KSDLM showing waste management facilities

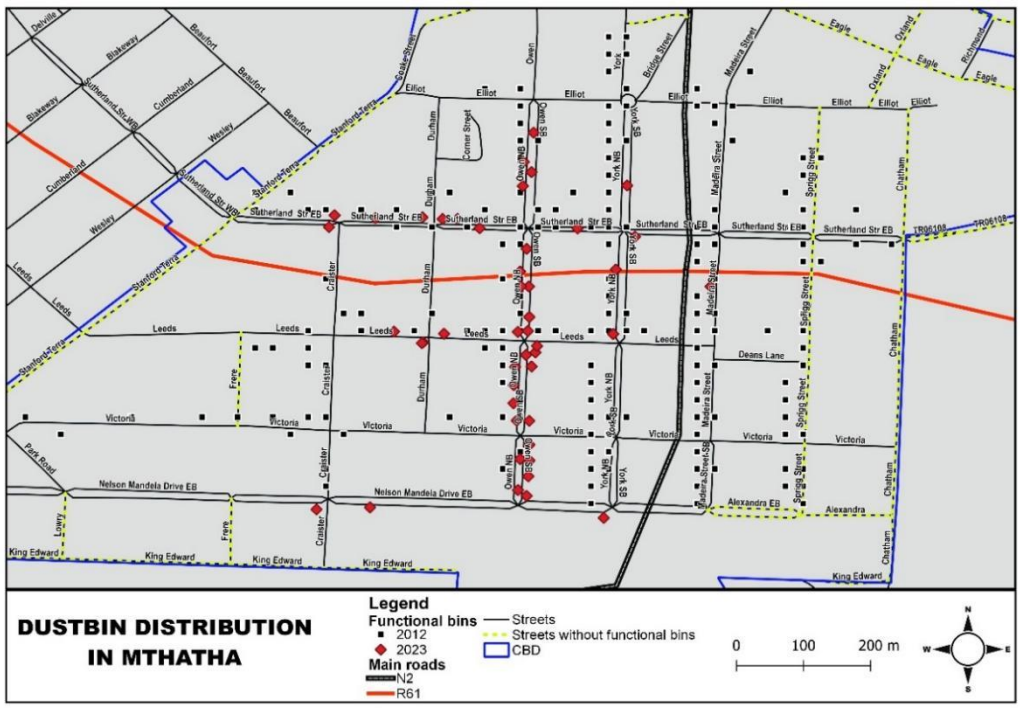

Figure 2. Comparison of functional dustbin which were found in Mthatha between 2012 and 2023

2.2 Sampling design

This study used a diagnostic research design to assess the reasons behind residual waste in the Mthatha CBD. This included identifying the problem, diagnosing it, and offering a workable solution for a solid waste management strategy that is sustainable. The study was conducted in eleven streets that are found within the CBD of Mthatha. These include York Road, Craister, Victoria, Leeds, Spring, Owen, Madeira, Sutherland, Durham, Elliot, and Nelson Mandela Drive. All these streets form the CBD of Mthatha.

2.3 Data collection

An ambulatory Global Positioning System (GPS) was used to collect data on each of the eleven streets that comprise the

Mthatha CBD. The locations of the dustbins were determined using GPS [24] in both 2012 and 2023, and each dustbin's functional and non-functional condition was noted on an information data sheet located in each of the eleven streets. The dustbin coordinates were recorded in an Excel spreadsheet, transformed into a CSV comma-delaminated format that is compatible with GIS software, and then uploaded to Arc GIS 10.8. As a result, shapefiles were created using the acquired coordinates, and maps displaying the locations of dustbins were produced (see Figure 2).

Interviews were held in order to solicit information about the challenges faced by the municipality in achieving its obligation of waste management as stipulated by section 9 (1) of National Environmental Management: Waste Act (Act No. 59 of 2008) which stipulates that "A municipality must exercise its executive authority to deliver waste management services, including waste removal, waste storage and waste disposal services, in a manner that does not conflict with section 7 or 8 of this Act". Interviews were conducted with ten officials who oversee waste management in both the local and district municipalities. These included senior managers, managers, and officials in charge of waste management in the local and district municipalities in the study area. These were specifically chosen because they have the expertise and an understanding of the obstacles the municipality has in carrying out its duty. These make up 100% of the entire number of officials in charge of waste management in the two municipalities.

2.4 Data analyses

The Shapiro-Wilk test provided by SPSS software version 29, which has good power qualities was used to test data normality. The Shapiro-Wilk test revealed that the datasets for functionality and the number of dustbins found within the Mthatha CBD edge in 2012 and 2023 were not normally distributed. The non-normality of data necessitated the use of a non-parametric test (Mann Whitney U test) which is the alternative to the independent samples t-test [25, 26]. To determine if there were statistically significant differences between observed and expected frequencies [27] of dustbins in the Mthatha CBD edge, the chi-square test was employed, providing insight into the relationships between the years 2012 and 2023.

3. RESULTS

A total of 217 functional dustbins from the 11 streets within the Mthatha CBD edge were recorded in 2012 as opposed to 46 functional dustbins recorded in 2023. The study findings show that the street with the most functioning dustbins in 2012 was Madeira Street, with 46 dustbins, followed by York Road, with 43 dustbins (Figure 2). However, Owen Street had the most functioning dustbins in 2023 (22 dustbins), followed by Leeds and Sutherland Streets, each with 8 functional dustbins (Figures 2-4). In addition, Durham Street and Nelson Mandela Drive, had functioning dustbins in 2023, although they did not have any in 2012 (Figures 2 and 3). Additionally, the results show that in 2023, 28.57% of dustbins were functional in Mthatha CBD as opposed to the 100% functional dustbins that were found in 2012 (Figure 5).

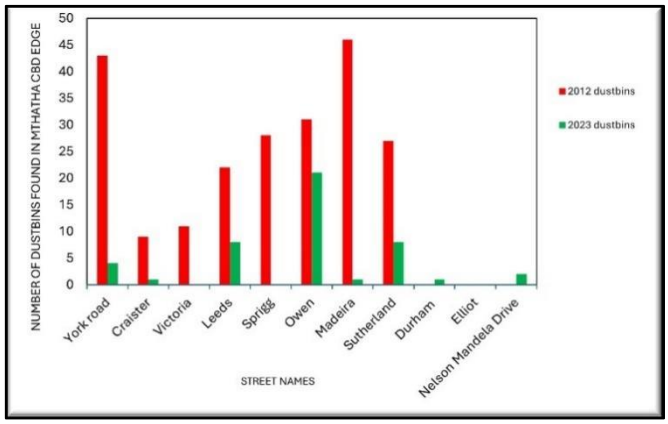

Figure 3. The number of functional dustbins that were found in Mthatha CBD in 2012 and those that are there in 2023

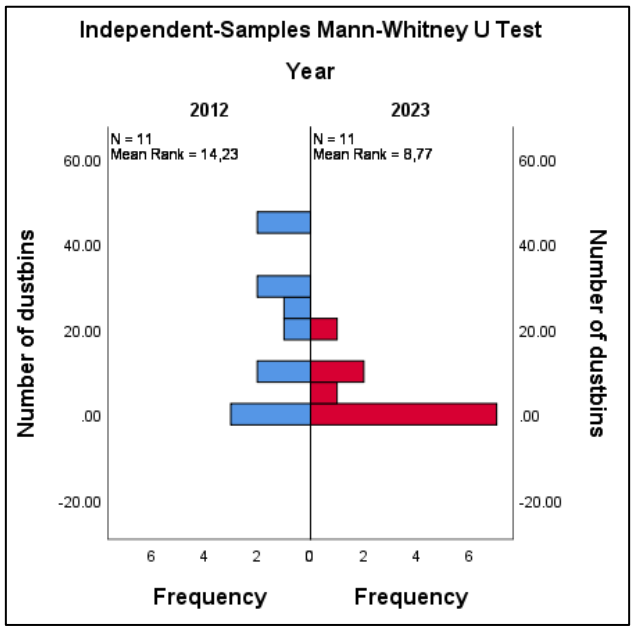

Figure 4. Mann Whitney U test output results for functional dustbins found in Mthatha CBD between 2012 (in blue colour) and 2023 (in red colour)

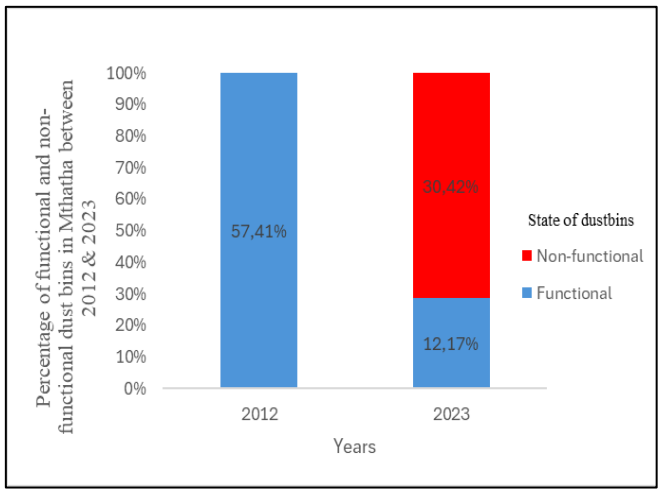

Figure 5. Bar chart showing state of dustbins in Mthatha between 2012 and 2023

The study showed statistically significant differences in the mean rank of dustbin distribution in 2012 (N = 11, Mean Rank = 14.23) and 2023 (N = 11, Mean Rank = 8.72), p = 0.047. Therefore, we reject the null hypothesis and accept the alternate hypothesis i.e., the mean rank of dustbins distributed in Mthatha CBD is different between 2012 and 2023. In addition, the Pearson chi-square results revealed a statistically significant difference between the frequency of functional and non-functional dustbins between years in Mthatha CBD (χ^2 = 222.776, df = 1, p = 0.001).

4. DISCUSSION

4.1 Distribution of dustbins in Mthatha CBD edge

Given that the human population is growing, we had expected a rise in the number of dustbins distributed in the study area. Nevertheless, the findings showed that this was not the case (Figure 6). The significant variations in the mean rank dustbin distribution between 2012 and 2023 are attributed to vandalism of dustbins, particularly by mentally ill individuals, high-speed cars, and a lack of enforcement of regulations. These findings are consistent with those studies made by Mudzengerere and Chigwenya [22] and Buso et al. [28], who found that dustbin numbers decline over time due to theft, vandalism, and a lack of enforcement of municipal bylaws. Unfortunately, when dustbins are broken or vandalised, the municipality does not prioritize buying new dustbins, instead, it hires extra street cleaners each year to keep the city clean. We assume that politics contribute to maintaining this MSW management strategy since hiring more people increases support for the ruling party. Furthermore, there are no agencies to hold those responsible for illegal dumping and littering in Mthatha.

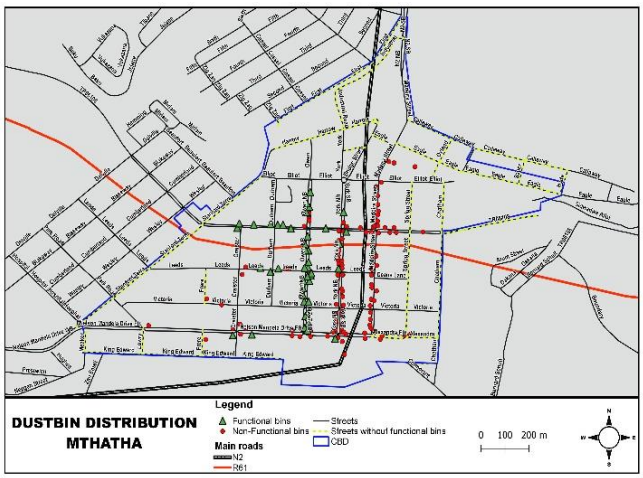

Figure 6. Functional & non-functional dustbins found in Mthatha in 2023

4.2 Condition of dustbins within Mthatha CBD edge

Only 28.57% of the dustbins identified in Mthatha CBD in 2023 were functioning, while in 2012, every dustbin was operational. Additionally, these findings show that while there were no non-functional dustbins in 2012, there were 115 non-functional dustbins in Mthatha in 2023, making up 71.43% of the total number of non-functional dustbins thereof. Dustbins are essential for waste management since they provide a place for proper disposal, facilitate waste collection, and create a more hygienic environment [29]. Mthatha is likely to flood due to clogged drainage caused by lingering waste, which is caused by absence of functional dustbins in the city [11, 30].

It is concerning to see so many non-functional dustbins since, according to Tembani et al. [31], a community's shortage of dustbins reflects its level of waste. Figure 7 shows a non-functional dustbin, which is overflowing from a lack of waste collection. Furthermore, we show that one reason for the non-functional dustbins in Mthatha city is dustbin cementation. Non-collection of waste results in the cementation of solid waste in dustbins creating a sludge-like mixture that dries and hardens into a cement-like substance.

Given the volume of waste produced in the city Tembani et al. [31] and the number of functional dustbins discovered, the state of poor waste management is not surprising, which clearly shows that one cause of the poor waste management experienced in Mthatha is the diminishing number of functional dustbins. These results corroborate those of Teshome et al. [32] who revealed that lack of proper dustbins contributes to an increase in solid waste, which in turn negatively affects human health and the environment.

Non-functional dustbins are dustbins that have lost their utility. They may be strategically placed, but these bins are no longer helpful because they have been vandalized or are simply too small. These findings are corroborated by those made by Zhou et al. [33], who discovered that most locations lacked dustbins large enough to hold waste, leading people to leave waste outside of dustbins. Buso et al. [28], in their study, conducted in the O.R. Tambo District Municipality, remove and they also found that some dustbins were tiny, causing waste to overflow.

Figure 7. A cemented dustbin found in Mthatha

4.3 Implications of non-functional dustbins

Urban residents are dissuaded from dumping at designated and approved locations by the lack of dustbins and the distance between functional dustbins, which forces them to dump anywhere indiscriminately. Similar to studies conducted by Kinemo [34] as well as Mbwilo and Mahenge [35], which showed that the absence of dustbins leads to unattended waste that is dispersed and disseminated around the neighbourhood. Consequently, the urban area without dustbins becomes vulnerable to unhygienic environments, infectious diseases, and ineffective waste management [36-38].

The dispersed waste could cause health issues for the nearby communities. Moreover, homeless individuals frequently

utilize the waste that has spread to start fires to stay warm, particularly during the chilly winter months. The spread of fire also adds to the destruction of dustbins and the release of greenhouse gases into the environment.

In Mthatha city, a lack of dustbins leads to illicit waste disposal, especially of paper and plastics, which clogs drainage lines. These findings support other researches [39-43] that found plastic waste leads to drain obstruction in urban areas. Localized flooding results from the city's inability to absorb runoff, particularly during periods of high rainfall, due to congested drainage systems. Floods have the potential to destroy companies, highways, and pipelines, resulting in large financial losses. In addition, floods influence infrastructure and force expensive maintenance and repairs [44]. Cities are compelled to set aside money in order to unclog and fix clogged drains. These consist of labour and sophisticated machinery. Furthermore, the obstruction of drains may cause harm to the drainage system, requiring the replacement or repair of pipes and drains.

4.4 Waste management challenges experienced in Mthatha

The results of the study showed that one of the problems experienced in Mthatha is the constantly growing population, which results in waste production. Since Mthatha is the center of the O.R. Tambo District's economy, residents of the nearby small towns frequently travel to Mthatha in search of employment, education, and other possibilities, which results in waste production. These findings are comparable to previous studies which also emphasized that rising solid waste creation is a result of the expanding population, quickening urbanization rates, developing economy, and generally rising standard of life [45-48].

The low budget that Mthatha has is another issue. The available resources are under extreme pressure because there is a limited budget to meet the needs of city dwellers despite the ever-increasing human population. These results concur with those of different authors such as Viljoen et al. [49-52], who discovered that municipalities are operating on inadequate funds. Inadequate municipal funding makes it difficult to replace dustbins that have been vandalized and provide dustbins for every street. As a result, municipal authorities are forced to devise solutions like renting skipper bins to company owners in order to handle their waste effectively.

Numerous unlawful dumps also plague the town of Mthatha. Business owners who frequently forget to leave their waste at the collection point at the right time for pickup are typically to blame for illegal dumping. The business owners end up illegally dumping the waste after realizing that the collection time has long passed, which leaves the town dirty. Moreover, the incessant malfunctioning of municipal vehicles exacerbates the challenges associated with timely waste collection. This predicament compels both business proprietors and local residents to seek alternative methods for the disposal of refuse. These results support those researches [53-56].

Urban dwellers, especially the homeless and truck drivers, burn the illegally discarded waste on cold days in order to warm themselves, adding to the city's air pollution [57]. Consequently, numerous dangerous pollutants, such as particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NOx), and volatile organic compounds (VOCs), are released into the atmosphere because of such fires. Toxic byproducts like dioxins and polycyclic aromatic hydrocarbons (PAHs), which are known to be carcinogenic and can cause serious health problems like respiratory diseases and cardiovascular problems, are specifically produced when materials like plastics and textiles burn [57-59]. In addition to lowering the quality of the local air, the smoke from these fires puts communities' long-term health at danger, especially for the elderly and other vulnerable groups like children [58].

5. CONCLUSION

The study aimed to examine the methods used to manage MSW in the Mthatha CBD. The study concentrated primarily on the accessibility, usability, and environmental effects of dustbins and their availability. The study's findings showed that between 2012 and 2023, the number of dustbins in Mthatha CBD significantly decreased. The investigation also revealed that there are numerous vandalised dustbins in the study area. According to the study's findings, insufficient dustbins cause waste to be dispersed around the area and clog sewer drainage pipes. The study's findings also reveal that the town of Mthatha faces a number of difficulties, including an ever-growing population that increases waste production, a limited budget that makes it difficult to replace broken dustbins, illegal dumping that business owners bring on, or a lack of waste collection vehicles. In an effort to handle the waste produced by the continuously expanding human population, it is advised that King Sabata Dalindyebo Local Municipality officials take reasonable measures to replace the dustbins that have been vandalised, increase the budget, and collect waste frequently. Dustbins should be placed in each of the eleven streets that form the Mthatha CBD to accommodate both urban dwellers and hawkers while also improving the management of solid waste in the area and preventing indiscriminate waste dumping practices. This will lessen the frustration of having to carry waste for a longer period only to throw it away or engage in unlawful dumping. Municipal ordinances should be followed to stop unlawful waste dumping.

Furthermore, the city needs to engage members of the public in programs that aim to educate residents about waste management, waste reduction, waste separation at source, and sustainable waste practices. Additionally, local government representatives ought to start community-led projects that explore cleanup campaigns as a means of encouraging a sense of accountability and ownership among the populace, including the incorporation of unofficial garbage collectors into the municipal waste collection system by helping cooperatives gather and process waste.

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