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**Muhamad Azahar Abas, Nor Hizami Hassin, Amal Najihah Muhamad Nor, et al.**

# Technology Adoption for Municipal Solid Waste Management (MSWM) in Malaysia

Muhamad Azahar Abas[1, a)], Nor Hizami Hassin[1, b)], Amal Najihah Muhamad Nor[1, c)], Kamarul Ariffin Kambali[1, d)] and Nurullia Fitriani[2, e)]

[1]*Faculty of Earth Science, University Malaysia Kelantan, 17600 Jeli, Malaysia*
[2]*Faculty of Mathematics and Natural Sciences, Universiti Padjadjaran, Indonesia*

[a)]Corresponding author: azahar.a@umk.edu.my
[b)]hizami.h@umk.edu.my
[c)]amalnajihah@umk.edu.my
[d)]kamarul@umk.edu.my
[e)]nurullia.fitriani@unpad.ac.id

**Abstract.** The concept of sustainable municipal solid waste management is a ground-breaking new concept for resolving the dilemma of rapidly increasing waste generation, with technology adoption at the forefront. Therefore, this manuscript will explore the technology adoption in Malaysia's municipal solid waste management (MSWM). Besides that, this article also investigates the challenges of MSWM technology adoption in Malaysia. A focus group discussion (FGD) and an in-depth interview were conducted. Purposive sampling was used to select respondents from government agencies and private industries in Malaysia directly involved with MSWM. The study's findings show the type of technology Malaysia uses for MSWM based on phases (collection, transportation, segregation, treatment, disposal). Aside from that, the study discovered two (2) significant barriers to adopting technology for MSWM, such as lack of provision and expertise. The findings of this study could provide insight and opportunities in Malaysia's solid waste sector for sustainable municipal solid waste management.

## INTRODUCTION

The generation of municipal solid waste (MSW) has increased dramatically in recent years [1]. Management of MSW should be effective, safe, and, most importantly, environmentally friendly. The significant steps of integrated waste management are reduction, reuse, recycling, sorting, segregation, processing, and disposal [2]. In developing countries such as Malaysia, improper waste management is currently causing a slew of health and environmental problems [3]. The emission of greenhouse and other toxic gases from treatment and disposal procedures is one of the most common issues with old waste management methods. As a result, other Municipal Solid Waste Management (MSWM) options are required. Excessive resource use in the industrial sector and households produce massive amounts of solid waste, posing a threat to global sustainability. It has been observed that as developed countries' economies improve, the amount of waste produced increases dramatically [4].

MSW can now be found in every nook and cranny, owing to insufficient collection and transportation in developing countries like Malaysia where the solid waste management is a low priority. According to the World Bank's global review, world cities generate about 1.3 billion tons of MSW each year, with that figure expected to rise to 2.2 billion tons by 2025 [5]. Local governments are responsible for solid waste management, and a reasonable portion of the budget is set aside for this purpose. Poor waste collection causes environmental degradation, local flooding, and land, air, and water pollution. These effects result in serious human health risks, which can only be reduced by implementing cost-effective technical and policy solutions [6].

Many new technologies have recently been introduced to combat the severe consequences of poor waste management, which are more efficient and environmentally friendly. While the choice and application of such

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technology are influenced by various factors, including the country's economic situation, priorities, and waste types generated [7]. As a result, this manuscript will investigate the use of technology in Malaysia for MSWM, including storage, collection, recycling, processing, energy recovery, and final disposal.

# MATERIALS AND METHODS

## Data Collection

For data collection, a qualitative approach was used in this study, which included focus group discussions and in-depth interviews. The most appropriate respondents for this study were chosen using a targeted as well as purposive sampling technique. This study includes 10 respondents from related government agencies such as the Department of National Solid Waste Management, Solid Waste Corporation, local governments, and the private sector who are involved in MSWM in Malaysia. The criteria of respondent's selection are based on their position and experience in MSWM.

## Data Analysis

The data were analyzed using thematic and content analysis, as well as an interpretation and reflection procedure. The data gathered from focus group discussions and interviews were used to interpret the technology adoption in MSWM, including waste collection, transportation, segregation, treatment, and disposal. In addition, reflection was carried out to generalize the information gathered, and it was crucial to avoid bias (8).

# RESULTS AND DISCUSSION

Table 1, 2 and 3 shows the summary of finding based on the feedback from the respondent. There are two (2) main findings of this study: the technology adopted by Malaysia based on the MSWM system (collection, transportation, segregation, treatment, disposal) and its challenges.

**TABLE 1.** Summary of adopting technology for MSWM in Malaysia

| Technology Adopted | Highlighted by Respondents |
|---|---|
| Collection & Transport: | |
| • Web-based GIS technology | R1, R6, R7, R9, R10 |
| • GSM-based bin monitoring system | R3, R5, R6, R7, R10 |
| • Waste compactors technology | R3, R4, R5, R7, R8, R9 |
| Segregation, Sorting & Treatment | |
| • Multi-compartment bins | R1, R2, R3, R5, R9, R10 |
| • Sensor-based sorting systems at MRF | R6, R7, R8, R9, R10 |
| Disposal | |
| • Sanitary landfill | R1, R2, R3, R4, R5, R8, R9, R10 |
| • Incinerator | R1, R2, R3, R4, R5, R6, R8, R9, R10 |

*R1-R10 represent code number of respondents

**TABLE 2.** Summary of challenges in adopting technology for MSWM in Malaysia

| Challenges | Highlighted by Respondents |
|---|---|
| Lack of provision | R3, R4, R5, R6, R7, R8, R9, R10 |
| Lack of expertise | R1, R2, R3, R4, R5, R7, R8, R9, R10 |

*R1-R10 represent code number of respondents

## Technology Adoption in MSW Collection and Transport

According to the findings of this study, solid waste collection in Malaysia varies depending on the area and situation. For example, waste collection is done at commercial areas and apartments every day except Sunday. Waste collection is done every day, including Sunday, in the public market. Waste collection at landed property owners is

only done three times a week on alternate days. Solid waste collection and transportation are increased on special occasion days, such as festivals, compared to regular days. Furthermore, garden waste collection is only available in a few areas, such as Penang, and is considered a specialized service. This service is available only once a week or as needed.

According to most respondents, in Malaysia's integrated waste management system, the collection and transportation of municipal solid waste involve many technical steps and emerging technologies. The convergence of information technology and waste management systems has resulted in a slew of new sustainable development technologies. Web-based GIS technology, a GSM-based waste bin monitoring system and waste compactors are among the most recent technologies.

Local governments in Malaysia have implemented GIS technology in their MSWM. However, due to a lack of expertise, the number is minimal. According to previous research, using web-based GIS technology to optimize waste collection and source separation for recycling increased efficiency by up to 80% [9]. Because GIS can model world landmarks and streets, it can be helpful in the waste collection industry. When used in conjunction with other software, GIS can provide data on the most reliable routes, the number of residents, the number of contracts, their validity, and potential fraud [10].

Aside from that, due to Malaysia's narrow and congested roads, small garbage collection trucks are used. Garbage compactors have been installed in collector trucks in recent years to increase the vehicle's collection capacity. With constant modification, these trucks now have a high compression rate, allowing them to carry 1.5 times more waste than flat pile trucks. Not only does the technology improve collection capacity, but it also improves fuel efficiency, making it more environmentally and economically viable. Furthermore, respondents state that they are working to introduce electric motor drive and hybrid collection trucks to address greenhouse gas emissions and air pollution issues.

## Technology Adoption in MSW Segregation, Sorting and Treatment

In Malaysia, multi-compartment bins are currently used for source segregation of municipal waste. Separate compartments for different types of waste are found in these waste bins. Paper waste and recyclables can be separated on the spot of generation using this organic method, and recyclables can be recycled or reused, avoiding contamination [11]. However, respondents have mentioned many issues maintaining the multi-compartment bins, including the high cost and vandalism by the unresponsible community.

Furthermore, private-sector respondents stated that modern sorting plants are transitioning to sensor-based sorting systems at Material Recovery Facilities (MRF) to improve sorting efficiency. This technology exempted low-tech or manual sorting options. This technology is advantageous because of its high recovery rate, low operating costs, and high reorganization capability. This process can convert waste into a beneficial product, lowering carbon emissions and reducing carbon footprint [12]. Furthermore, transfer station technology is used to treat and compact waste before being disposed of at a landfill. In Malaysia, there are a few transfer stations, including those in Jinjang Hill (Kuala Lumpur), Ampang Jajar (Penang), and Batu Maung (Penang) (Penang).

## Technology Adoption in MSW Disposal Facilities

For decades, landfilling has been the primary method of waste disposal in Malaysia. However, most respondents are concerned that Malaysia is experiencing serious landfill issues, such as overflowing landfill sites, no facility for venting gas, no leachate treatment, unsuitable landfill sites, and a lack of land. Some initiatives, such as the privatization of landfill operations, are being pursued to improve and streamline management. Some landfill facilities have been upgraded to level 3 and level 4 as a result of this privatization. Level 3 landfills have a leachate circulation system, while level 4 landfills have leachate treatment facilities and are referred to as sanitary landfills [13].

Furthermore, incinerator technology is used to dispose of municipal waste on the island. However, most respondents pointed out that the cost of operation is relatively high, costing more than MYR 600 per day, and each incinerator costs about MYR 2.5 million. An incinerator can burn between 5 and 10 tons of solid waste per day. The Malaysian government is committed to adopting incinerator technology as an alternative to solid waste disposal. There is a plan to develop an incinerator in suburban areas of Kuala Lumpur. Although the Department of Environment has approved the development plan, there are protests from Malaysian citizens and environmental activists. As a result, the incinerator program has yet to be completed.

## The Challenges in Adopting Technology for MSWM in Malaysia

In Malaysia, the main impediment to technology adoption is a lack of adequate provision. The majority of respondents agreed that most local governments could not afford to fund advanced MSWM technology. The federal government solely funds the current technology used in Malaysia's MSWM. It strains the federal government because many priorities, such as socioeconomic, health, and educational issues, remain unaddressed [14].

These findings were consistent with previous research that found that local and national policymakers and planners do not always allocate adequate resources to solid waste management in most developing countries [15, 16]. Other issues of greater social and political importance may take precedence, leaving a smaller budget for waste management. As a result, each stakeholder must address the problem by finding the best solution, such as collaborating with the private sector and being proactive in generating revenue, such as trading recyclable materials.

Besides that, this study identifies the lack of expertise in adopting advanced technology in Malaysia. The majority of Malaysia's current technologies are imported from Europe. Malaysia must develop its MSWM technology that is appropriate and based on local expertise. The government should promote private sector participation in waste management. The government should also invest in appropriate technologies that can generate revenue, create jobs, and protect public health and the environment. Municipalities must show that they are capable of implementing and managing these technologies. Appropriate technologies will aid resource recovery.

## CONCLUSION

The high volume of solid waste generated in Malaysia can be put to good use, such as creating new products or converting waste to energy to produce a cleaner form of energy. Waste that can be recycled for a profit should be prioritized over the waste that is dumped. Malaysia's large amount of organic waste materials must be efficiently managed through composting and bio gasification to produce a by-product that can be used in agriculture and generate revenue. Municipal solid waste management that is sustainable can help to reduce environmental and human health risks in the short and long term. This manuscript concluded that proper implementation of cutting-edge technologies in the MSWM sector could play a critical role in ensuring a pollution-free and long-term environment. Besides that, the government and all stakeholders must fully participate in waste management for more significant goals. Further study required to explore the technology usage and challenges on the ground, which could provide a comprehensive perspective.

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