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SMART WASTE MANAGEMENT SYSTEM FOR RESIDENTIAL AREA

Nazihah Alway[1], Asmat Ismail[1*]

[1]Department of Built Environment Studies and Technology,
College of Built Environment,
Universiti Teknologi MARA, Perak Branch,
32610 Seri Iskandar,Perak, Malaysia

nazihahalway@gmail.com, *asmat926@uitm.edu.my

ABSTRACT

A growing population, ongoing economic progress, and a greater quality of living have resulted in an unavoidable increase in demand and consumption, resulting in a rise in waste generation. Most researchers concentrated primarily on the final treatment, but few paying attentions to the collection and transportation. Besides, people are confronted with the challenge of waste categorization on MSW, which people must first learn about various forms of waste in order to properly identify them. Without modern waste detection technologies, effective waste sorting and categorization takes longer. The objective of this research is to develop smart waste management system design ideas, to assemble the proposed smart waste management system, to demonstrate the performance of smart waste management system and to suggest the marketability potential of proposed smart waste management system in Malaysia. The research design was quantitative methodology and the data collection method adopted for this study would be based on the document analysis, review the previousliterature, design thinking method and 3D modelling. The proposed innovation product for this study was improvised from existing innovation products and various innovation techniques approach which the speciality is for the landed houses with the separation of wastes inside the house. The recommendations for the further studies are the maintenance measure for the underground piping system by using the advance technology and how to ensure the life expectancy of the system for longest time.

Keywords: *MSW, Waste management, Residential, Smart waste, Malaysia"*

INTRODUCTION

Municipal solid waste (MSW) generation is rising in direct proportion to population increase, and it is expected to reach 49,670 tonnes per day by 2030 (Tang et al., 2021). As referred to Kaza et al. (2018), every year, the world creates 2.01 billion tonnes of MSW, with at least 33% of that not being managed in an ecologically safe manner. In recent years, the pace and volume of waste creation have increased day by day especially in Malaysia. Malaysia is a growing country with fast urbanisation and population expansion. Tang et al. (2021) pointed out in their research that the average MSW created in Malaysia has now become 0.5 – 0.8 kg/person/day,however this may vary according on the development condition of the states in the country. New Straits Times (2022), a media statement, stated on Malaysia's waste collection data, waste creation has increased significantly in recent years. Accordingto their data, in 2018, around 36,843 tonnes of waste were created each day, followedby 2019 (37,462 tonnes), 2020 (38,081 tonnes), 2021 (38,699 tonnes), and 2022 (39,936 tonnes). In light of this, this study is significant for the implementation of 12thMalaysia Special Plan (RMK-12) goals which is 3R program and the enforcement ofwaste segregation at the source of waste, and creating facilities for waste collection, segregation, and recycling (Prime Minister's Department, 2021). Besides, it is significant as mentioned in Green Technology Master Plan Malaysia 2017 – 2030 (GTMP 2017 – 2030) to implementation of the waste collection and transportation such as automatic waste collection and the plan encourage the use of technology like internet of thinking (IoT) to manage waste from households (Ministry of Energy, Green Technology and Water, 2017). This research also contribute to the achievement of the Sustainable Development Goals (SDGs) which was introduced by United Nations (UN). The SDGs that contribute to the achievement of waste management in this research are SDG 11 (sustainable cities and communities) and SDG 12 (responsible consumption and production). Another contribution is Shared Prosperity 2030 which aims to promote green growth, places an emphasis on low- carbon development, and resource efficiency (Ministry of Economic Affairs, 2019). Therefore, the aim of this research is to develop a smart waste management systemfor residential area that can separate waste from inside the house.

LITERATURE REVIEW

Definition of Wastes

In recent years, various waste definitions have been put suggested. Based on the Mubaslat (2021), a waste is considered as any material that is being disposed of by disposal, recycling, burning, or incineration whether it be solid, liquid, or confined gaseous. He also added that it may be a waste product from production or a commercial item that has outlived its useful life and needs to be thrown away. Besides, according to Wiprächtiger et al. (2021), waste is any moveable item that is tossed in a waste can, given to a waste collector, and then recycled, burned, or dumped. It also includes any moveable item that is required by law to be discarded

or disposed of in order to reduce risks to public safety, the environment, or health (Wiprächtiger et al., 2021). Meanwhile, based on the Official Department of Environment (DOE), Ministry of Environment and Water Malaysia (2022), defines waste as any substance prescribed to be scheduled waste or any matter, whether in solid, semi-solid, or liquid form, or in the form of a gas or vapour, which is released into the atmosphere, discharged, or deposited in the environment in such volume, composition, or manner as to cause pollution.

Classifications of Wastes

According to Mubaslat (2021) waste can be classified into several types as shown in Table 1. Basically, based on physical properties, effects etc., waste can be found in three forms which are solid wastes, liquid wastes, and gaseous wastes. Solid wastes consists of solid materials including glass bottles, crockery, plastic containers, metals, and radioactive wastes, among several others. Meanwhile, liquid wastes comprises industrial effluents, fertiliser, and pesticide solutions from agricultural fields, and so on. The majority of gaseous wastes is caused by human activity such as carbon dioxide (CO_2), methane (CH_4), chlorofluorocarbons (CFC), oxides of nitrogen (NO_x), carbon monoxide (CO), and other gaseous wastes.

Table 1: Classifications of wastes (Source: Mubaslat ,2021)

Classifications	Types of wastes
Based on physical properties, effects etc.	a) Solid wastes: Wastes in the form of solid i.e. local, commercial, and industrial waste. b) Liquid wastes: Wastes in the form of liquid or water i.e. oils, chemicals, polluted water from ponds or rivers etc. c) Gaseous wastes: Wastes in the form of gaseous i.e. Carbon dioxide (CO_2), methane (CH_4), chlorofluorocarbons (CFC), oxides of nitrogen (NO_x) and carbon monoxide (CO).
Based on the biological properties of wastes.	a) Biodegradable wastes: Can and will be decomposed by natural forces. b) Non-biodegradable wastes: Unable to degraded or dissolved by natural means.
Based on the effects of waste on human health and environment.	a) Hazardous wastes: Dangerous substances emitted from commercial, industrial and agriculture or economical use, which are unsafe to use for further purpose. b) Non- hazardous wastes: Safe wastes emitted from commercial, industrial and agriculture or economical use, considered harmless to use for further purpose.

)

Furthermore, there are two types of waste according to the biological properties' biodegradable wastes and non-biodegradable wastes. Biodegradable wastes or also known as wet wastes are waste materials that can and will be decomposed by natural

forces such as microorganisms (e.g. bacteria, fungus, and a few others) and abiotic elements such as temperature, ultraviolet (UV), oxygen (O_2), and so on (Mubaslat, 2021). The entire procedure is natural and might be fast or sluggish and as a result, the environmental difficulties and hazards posed by biodegradable wastes are minimal (Chàfer et al., 2019). While, non-biodegradable wastes, in contrast to biodegradable wastes, cannot be easily managed, are those that are unable to degraded or dissolved by natural means (Mubaslat, 2021). They last for countless generations without degrading and consequently, the threat posed by them is considerably more severe (Mubaslat, 2021). Plastics, for example, are a widely utilised material in practically every sector and improved grade plastics are being used to provide these polymers a longer lifespan which this made it more temperature resistant and robust even after usage (Michel Devadoss et al., 2021). Other examples include cans, metals, and agricultural and industrial chemicals and they are the primary sources of air, water, and soil pollutions, as well as illnesses such as cancer (Mubaslat, 2021).

Above and beyond, based on the effects of waste on human health and environment, types of waste are hazardous waste and non-hazardous waste. The Organization Economic Cooperation and Development (OECD) (2022) mentioned that waste has the potential to harm the environment or human health is referred to as hazardous waste and requires special or separate handling. The organisations added that hazardous waste mostly exhibits flammability, corrosiveness, toxicity, ecotoxicity, and explosiveness. Radioactive waste, industrial waste, electronic waste, medical waste as example of hazardous waste. In the meantime, all waste that has not been labelled as hazardous is considered as non-hazardous. This waste is not dangerous, but if it is not collected and processed properly, it can have a negative influence on the environment and health (Shadbahr et al., 2022). While a considerable amount of non-hazardous waste might potentially reused or recycled, one of the most difficult waste management difficulties is waste collection by type of waste, which is require for reuse and recycling (OECD, 2022). The example to this waste are municipal waste (organic waste, packaging waste, other material), and other non-hazardous (industrial).

Sources of Wastes

Residential homes, as well as the agricultural, commercial, construction, industrial, and institutional sectors, and others are the primary sources of solid wastes (Saleh & Koller, 2019). Table 2 provides a breakdown of solid waste sources according to types and typical waste generators. These sources are defined as producing four principal types of waste: municipal solid wastes (MSW), industrial wastes, agricultural wastes, and hazardous wastes (Saleh & Koller, 2019). MSW is the most well-known sort of waste that will be discussed in this research since it accounts for the majority of waste output to dumpsites and has enormous potential for management. The term “municipal solid waste” (MSW) refers to waste generated inside a municipality (Saleh & Koller, 2019). MSW is popularly known as garbage, junk, scrap, and debris is includes of everyday goods that people discard after use (Mubaslat, 2021).

Table 2: Sources of solid wastes (Source: Saleh & Koller, 2019)

Source	Typical waste generators	Types of solid wastes
Residential (private sector)	Single and multifamily habitations.	Paper, cardboard, food wastes, plastics, textile rags, leather, yard waste, glass, lignocelluloses, metals, ashes, special wastes, and diverse types of precarious household waste.
Industrial sector	Light and heavy manufacturing companies, fabrication, power and chemical plants, construction sites.	Housekeeping waste, different packaging materials, food waste, construction and demolition materials, ashes, hazardous waste, and special waste.
Commercial sector	Stores, markets, gastronomy, hotels, office buildings, etc.	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, and hazardous wastes.
Institutional Sector	Schools, universities, kindergartens, hospitals and other health and medical institutions, penitentiaries, government centers.	Same as for the commercial sector.
Construction and demolition sector	New construction sites, renovation sites, road rehabilitation, demolition of buildings.	Wood, steel, asphalt, cement, insulation materials, dirt, dust, etc.
Municipal services	Street cleaning, landscaping, playgrounds, sport facilities, other recreational areas, and wastewater treatment plants.	Street sweepings, landscape, tree- and bush trimmings, different waste accruing in parks, riversides, and other recreational area.
Processing sector	Heavy and light manufacturing, chemical plants, refineries, mineral extraction and processing, and veneer works.	Industrial process waste, saw dust, scrap materials, off specification products, slag, and tailings.
All of the above should be included as “municipal solid waste”.		
Agriculture sector	Farms, dairies, feedlots, distilleries, rendering and animal processing industry, biodiesel industry, and bioethanol production .	Agricultural wastes, spoiled food wastes, animal residues (slaughterhouse waste),hazardous wastes (e.g., pesticides, antibiotic residues), and crude glycerol.

Current Waste Management Techniques

Waste management refers to the process of managing waste (Murugesan, 2020). Mubaslat (2021) pointed out in his research that waste management refers to the many systems and procedures developed and put in place to detect, control, and handle various forms of waste from creation through disposal. Meanwhile, Adipah & Kwame (2018) stated that waste management entails the collection, segregation,

transportation, treatment, and disposal of solid waste. Waste management is described by Haji Ali et al. (2018) as the regulation of waste creation, storage, collection, transfer and transport, processing, and disposal in accordance with best practices, while taking public health, economical, legal, and environmental repercussions into account. Overall, the main purpose of waste management is to collect and properly dispose of waste with minimum system costs, and environmental pollution (Haji Ali et al., 2018). One method of reducing the amount of solid waste for final disposal is the 3R idea (Figure 1). In the hierarchy of solid waste management, waste reduction comes first and is a more challenging option than recycling (Mubaslat, 2021). For example, households must cut back on the production of municipal solid waste in the housing area and they must adopt behaviors like bringing their own bags when they go shopping, adopting tool replenishment by purchasing new containers, using cloth diapers, substituting rags for tissue paper, and other behaviors that can cut down on waste in the waste stream (Haji Ali et al., 2018).

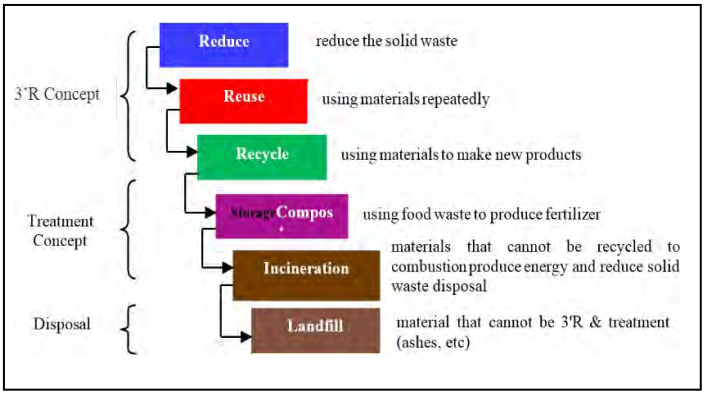

Figure 1: Pyramid of waste minimization (Source: Haji Ali et al.,2018)

In addition, when materials are reused, it signifies that they may still be put to use and have value for several purposes as opposed to being thrown away (Haji Ali et al., 2018). Haji Ali et al. (2018) stated again instead of throwing things out in the trash stream, households can reuse them or distribute them to others in need to cut down on waste production. The last R is recycling which is the process of separating waste products that can be recycled from the rest of the solid waste so that they may be collected separately (Mubaslat, 2021). Murugesan (2020) stated that glass, plastic, paper, cardboard, and other recyclable materials can be utilised to create new items. The final option for removing solid waste from the waste stream is treatment. One of the treatment ideas for volume reduction that can redirect big volumes is composting (Bhat et al., 2018). The authors added that only food and household waste are the subject of composting. The procedure of controlled combustion known as incineration is used to burn solid waste (Bhat et al., 2018). In this process, waste materials' carbon, hydrogen, and other components react with O_2 in the combustion air to produce heat (Murugesan, 2020).

Various Research Related to Wastes Management Issues

MSW may be dangerous if not properly controlled and managed from separation, collection, transfer, treatment, and disposal or recycling and reuse (Vinti et al., 2021). There are various research related to wastes management issues. Those are:

Previous research on smart waste management system conducted worldwide

As pointed out by Vinti & Vaccari (2022), waste collection and management are particularly difficult in rural locations due to restrictions brought on by poor road links to metropolitan areas. They mentioned that large waste trucks can sometimes struggle to drive for long distances on dirt roads. Because of this, common waste management techniques at the local level include uncontrolled waste burning, waste dumping, waste burial, and the repurposing of unsorted waste as fertiliser (Vinti & Vaccari, 2022). Gómez-Sanabria et al. (2022), support that the uncollected percentage accounts for around 80% of waste burning in rural regions. Besides, based on the Tsheleza et al. (2022) waste mismanagement is becoming increasingly common issues in most developing nations, particularly in rapidly growing cities because waste creation is inescapable. According to estimates, nearly 80% of solid waste in African cities is deposited in open areas, lake areas, and surface drains due to limited infrastructure and knowledge (Tsheleza et al., 2022). They also included that this is also due to a lack of a planned system or general discipline involved with efficiently regulating waste creation, storage, collection, transportation, processing, and disposal. Managing solid waste is a difficult chore all over the world, and the main reason for this is a lack of societal awareness, responsibilities, and creative solutions (Nimita Jebaranjitham et al., 2022).

Next, Yamekeh et al. (2021) stated in their research the problem of waste management has gotten worse as consumer habits have changed, as has the availability of waste handling services. One evident result of increased urbanisation is an increase in solid waste output, which presents many municipal authorities with unprecedented hurdles in management, including problems with collection and disposal (Yamekeh et al., 2021). In most poor and middle-income nations, one-third to half of solid waste generated within cities is not collected (Debrah et al., 2021). They frequently wind up as illegal dumps on streets, open spaces, and wastelands (Murugesan, 2020). In Ghana, the difficulties confronting municipal solid waste management are indiscriminate waste disposal, irregular waste collection, and insufficient resources. In addition, a lack of equipment and a lack of properly constructed ultimate disposal sites impede the emptying of containers positioned at strategic spots (Yamekeh et al., 2021). Ferronato & Torretta (2019) had pointed out that the major waste treatment and ultimate disposal procedures used in low-income nations are open dumping and open burning. They added unsustainable methods that increase environmental degradation and disease transmission exacerbate solid waste management in poor nations. The primary difficulties observable are open dumping in unmanaged sites, open burning of waste fractions, and mishandling of

leachate produced in final disposal sites (Ferronato & Torretta, 2019). In underdeveloped nations, open dumping is the most typical way of household waste disposal. Open dumping is the cheapest alternative for low-income nations; however it is an unregulated and insufficient disposal method since waste pickers and animals may reach the material, and pollutant creation is not monitored (Ferronato & Torretta, 2019). As example, in Cambodia, particularly in the capital city of Phnom Penh, where the MSW management system is unregulated, homeowners regularly burn, bury, or dump around 361,000 tonnes of MSW (Ferronato & Torretta, 2019).

According to Ahluwalia & Patel (2018), they had agreed that rapid economic expansion, unplanned urbanisation, and changing lifestyles have resulted in increased volumes and a shift in composition (a greater use of paper, plastic, and other inorganic materials) of municipal solid waste in India. Untreated waste (a mixture of biodegradable or wet waste and non-biodegradable waste) from Indian towns has been accumulating for months and years at dumpsites where land was initially set aside for the development of landfills for the safe disposal of just the residual waste (Ahluwalia & Patel, 2018). The authors said this is has led to global warming which the situation is made worse since the current generation of waste is likewise not managed adequately.

Previous research on smart waste management system conducted in Malaysia

Due to reduced capital, operating, and maintenance costs compared to other disposal methods, open dumping dominates MSW in the majority of developing nations, including Malaysia. As said by Fadhullah et al. (2022), in Kelantan, waste is commonly disposed of in rural and isolated locations by burying and burning rubbish, however in urban or semi-urban areas, fixed waste storage containers are primarily supplied along key roads. The Kota Bharu Municipal Council (KBMC) is the local authority in charge of providing stationary waste storage containers at waste collection sites within the Kota Bharu district, collecting solid waste approximately three times a week by compactor vehicles, and transporting waste to the dumpsite in Beris Lalang, Bachok (Fadhullah et al., 2022). They added however, the shortcomings of MSW in Kelantan are mostly due to insufficient waste and waste collection given by local authorities, principally due to financial constraints. House-to-house waste pickup is particularly difficult to accomplish due to tiny lanes and alleyways that are mainly inaccessible due to the state's development practices and geographical location (Saat et al., 2018). As a result, the resident's resort to burying and burning their waste within their house, as has been the practice for decades.

Afterwards, despite the fact that 100,000 free dustbins were sent to each household in many Malaysian cities, the populace continued to dispose of their waste improperly (Wong et al., 2023). According to them again, only 24% of the waste was recycled or sorted, and 76% was disposed of in landfills. Furthermore, waste overflow occurs frequently as a result of uncollected waste, which causes air pollution, wild insects and animals will consume and collect the overexposed waste, which includes various

types of organic and inorganic waste that are potentially hazardous to the environment and public health (Ivan, 2021). Another, separating waste is one of Malaysia's issues in waste disposal decisions. Waste collection is critical to avoiding contamination, and its efficiency is dependent on behavior, which requires education and development. Furthermore, people confront the challenge of waste categorization on municipal solid waste, which is one of the primary sources of environmental difficulties (Wong et al., 2023). People must study the many sorts of waste in order to properly classify them. However, without sophisticated technology to detect waste disposal items, attaining effective waste sorting and classification takes longer (Wong et al., 2023). Sustainable waste management necessitates a long-term commitment from the public to develop appropriate waste disposal habits.

Only 70% of Malaysia's daily 18, 000 tonnes of solid waste is collected and disposed of and the remaining 30% is recycled or discarded illegally . However, it is estimated that just 3 – 5% of waste is recycled, implying that at least 25% of waste is disposed of at unauthorized landfills (Zabidi et al., 2023). According to them, Malaysians general lack of care for adequate waste management, as well as the lack of a MSW program, are to blame for this deplorable state of things. In actuality, there is a pressing need to educate the public about the devastating effects of irresponsible solid waste disposal on the environment. Based on the Shakil et al., (2023), Malaysia has a major MSW challenge since the country generates a lot of rubbish every day. Malaysia's MSW system now presents several issues which is the lack of proper waste management infrastructure, such as landfills and waste treatment facilities (Shakil et al., 2023). This has resulted in a vast number of illegal dumpsites, which may cause environmental contamination and pose health hazards to the surrounding people. Another impediment is a lack of public education and understanding about trash management (Shakil et al., 2023). Many Malaysians are still unaware of the need of waste reduction, recycling, and proper waste disposal practices.

Table 3: Summary of various research conducted on waste management

No.	Citation	Country	Summary
1.	Vinti & Vaccari (2022)	Italy	Inappropriate road connections make large waste trucks cannot enter in the rural areas.
2.	Tsheleza et al. (2022)	South Africa	The inability to effectively control waste generation, storage, collection, transportation, processing, and disposal results in waste mismanagement. This is due to a lack of a planned system or general discipline.
3.	Nimita Jebaranjitham et al. (2022)	Worldwide	Managing solid waste is a challenging task because of a lack of society knowledge, obligations, and innovative solutions. Lack of waste collection coverage is another factor contributing to the waste heap.
4.	Yamekeh et al. (2021)	Ghana	MSW management has challenges such as indiscriminate trash disposal, irregular waste

			collection, and a lack of resources, equipment, and adequately designed final disposal sites.
5.	Ferronato & Torretta (2019)	Worldwide	Open dumping and open burning are the most common waste management and disposal methods in low-income countries. The main issues include open dumping at unmanaged sites, open burning of waste fractions, and mismanagement of leachate produced in final disposal sites.
6.	Ahluwalia & Patel (2018)	India	Rapid economic growth, unplanned urbanisation, and changing lifestyles have led in higher quantities and a shift in composition of municipal solid trash in India.
7.	Fadhullah et al. (2022)	Malaysia (Kelantan)	House-to-house waste pickup is especially challenging due to the state's development practices and geographical position, which make narrow roads and alleyways mostly inaccessible.
8.	Wong et al. (2023)	Malaysia	Separating waste is one of Malaysia's waste disposal difficulties. People face the waste categorization problem on MSW, since people must study the many types of waste in order to appropriately identify it.
9.	Zabidi et al. (2023)	Malaysia	Malaysians' widespread disregard for proper waste management, as well as the absence of a MSW program, are to blame for this dreadful state of affairs.
10.	Shakil et al. (2023)	Malaysia	One of the most serious problems is a lack of effective waste management infrastructure, such as landfills and waste treatment plants. Another barrier is a lack of public awareness and comprehension of disposal of waste.

MATERIALS AND METHODS

In this research, the research design was quantitative methodology. It employs the use of 3D simulation video. The data collection method adopted for this study would be based on the document analysis, review the previous literature, design thinking method and 3D modelling distributed by used the SketchUp Software version 2022, and this serves as the primary instrument. The 3D simulation video would bedesigned in order to accumulate enough information pertained to the objectives of the study. The data collection of the study would be analyses which includes the result achieved by simulation video results.

RESULTS AND DISCUSSIONS

There are a few existing innovation products of waste management worldwide. Those are Stream Automated Waste Collection System (AWCS), Binology Smart City Bin

and Envac Underground Vacuum Waste Collection. The proposed innovation product for this study is a Smart Waste Management System For Residential Area. The design idea of smart waste management system for residential area for this innovation project was improvised from existing innovation products and various innovation techniques approach. The main components of the products are wall mounted smart bins, underground piping system, air intake valve discharging valves connect with automatic shutter door, vacuum fans with filtration, waste storage container with roller, control panel and central waste handling facility (CWHF). The specialty of this product is that it was created for a type of landed residential houses.

The features of smart bin that was installed in kitchen area is fixed and wasdesignated as a wall mounted with 5 separation types of bins (plastic, glass, metal, paper, and food waste). The advantage of these wall-mounted bins is to make morespace inside and cleanliness in the house. Another superiority of this innovative product which make it different from the other three products is it was installed with a self-cleaning system attached with compactor inside the smart bins. The functionsof the cleaning systems is to ensure the cleanliness of the smart bins so that the smallinsects like cockroaches from the underground can be reduced from entering the smart bins. While the functions of the compactor is to compact the wastes inside thebins so that it will compresses the waste when it expands and provide more capacityof wastes inside the smart bins. Besides, the smart bins also are attached to shutterdoor that is set by technology sensor of IoT to ensure that the smart bins is always closed from the bottom. It will automatic open every 4 hours or 6 times per day.

Air filtration that was installed at the smart bins and discharging valve is function to filter the smelly odour from the wastes so that there is no issue of smell pollution in the residential area. The advantages of this system are the data for every waste that move underground can be seen by municipal local authority so that they will be eased to make schedule for waste truck collector to collect the waste at the Central Waste Handling Facility that was installed in every residential area. Table 4 show the comparison matrix of the previous waste management system developed by three companies.

Table 4: The comparison matrix of existing innovation products

Products / Features	 **Automated Waste Collection System**	 **Binology Smart City Bin**	 **Underground Vacuum Waste Collection**	 **Smart Waste Management System For Residential Area**
Company	Stream Environment Sdn. Bhd.	Binology	Envac Group	Innovation Project

Smart bins (fixed/unfixed)	x	(unfixed)	(fixed)	(fixed)
Compactor	x	/	x	/
Sensor	x	/	/	/
Solar panel	x	/	x	x
Screen display	x	/	x	/
The data able to access	x	/	/	/
Foot pedal	x	/	/	x
Underground piping system	/	x	/	/
Vacuum fans	/	x	/	/
Waste separate	x	/	/	/
Shutter doors	x	x	x	/
Waste storage	/	x	/	/
CWFH	/	x	/	/
Air compressor	/	x	/	/
Air intake valve	/	x	/	/
Sealed refuse container	/	x	/	/
Air filtration	/	/	/	/
Cleaning system	x	x	x	/
Control system	/	x	/	/
Air pipe	/	x	/	/
Truck collector	/	/	/	/
Location of the products use	Every floor for high rise building	Streets and inside	Outside the building (streets)	Inside the house (landed houses)

CONCLUSION AND RECOMMENDATIONS

Based on this study, it found that innovation product is important in waste management. MSW can be hazardous if not adequately monitored and managed throughout the separation, collection, transfer, treatment, disposal, recycling, and reuse processes. If waste is not properly kept, collected, and disposed of, it endangers public health and the environment. The separation of the wastes from thesources make it easy to ensure the wastes is manage properly in the sorting center or recycling depots. This indirectly also can teach people to start do recycling in theirdaily life. A few of recommendations for the future purpose of other researchers are the maintenance measure for the underground piping system by using the advance technology which does not require human to enter underground and how to ensure the life expectancy of the system for longest time.

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