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Solid Waste Management in Akkaraipattu Municipality Area in Sri Lanka

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ABSTRACT

Akkaraipattu Municipal Council (AMC) disposes more than twenty-six tons of solid waste daily. The concerning issues pertaining the solid waste disposal are the increasing quantity of debris, landfill obstacles, unavailability of proper collection, interrupted waste transportation, inadequate waste treatments, and improper disposal methods. No scientific research has been carried out regarding the Municipal Solid Waste (MSW) and disposal methods at AMC. However, it was understood that the overall MSW disposal procedure in this area is unsatisfactory. Therefore, this study was conducted with the objective of identifying the types of wastes generated, identifying the drawback in the existing solid waste management (SWM) plan, and thereby to propose a suitable method to adapt the Net Zero concept, analyzing the Energy Recovery Potential, and propose a suitable Zero Waste Management (ZWM) model for the AMC. A mixed method approaches included field visits, use of structured interviews and collection of data from the available document in the AMC and literature review were used. The study reveals that daily accumulation of biodegradable waste of approximately 22 tons which is equivalent 83% of the total waste. Other types of waste are plastic waste, metals waste, rubber, and Glass. It is estimated that biodegradable waste accumulated daily could produce 2.21 tons of compost and 11080 m^3 of Biogas potential.

The Proposed MSW model introduces distinct-vise approaches and strategies for the AMC, and also suggest strategies to large-scale waste produces to use 5R approaches to convert them into valuable resources and get sustainable benefits before handing over to the AMC. If the proposed MSW model is implemented, the AMC can have sustainable financial benefits. By levying small fees from business enterprises and by selling compost fertilizer, biogas, and recyclable products etc., are adequate to overcome operational costs. The fee structure may be based on the scale of the business size, rate amount of waste accumulation. Seeking government investment and exploring alternative funding sources is essential. By highlighting long-term benefits such as improved public health and reduced pollution, the council can secure necessary funding. A comprehensive waste management strategy and partnerships could be established with the proposed sustainable and economically viable MSW disposal model providing considerable extent of benefits to AMC.

Key words: Municipal Solid Waste, Net Zero Waste, Sustainable Waste management.

INTRODUCTION

A combined strategy must be taken throughout the complete waste stream to discover the best waste management strategy using all available resources [1]. Waste administration can indeed refer to the methods for preventing and limiting waste production [2]. It should be sought for inadequacies in the utilization of resources,

power, and physical resources. To meet the requirements of all the world's population, extraordinary efficacy in the use of any resource will be essential to ensure a sustainable future. A zero-waste plan will accelerate innovation and progress much beyond progressive techniques which don't have a clear end goal in mind [3]. Major and minor business organizations have implemented zero waste approaches and a considerable economical saving with optimized environmental effect have resulted. With good waste management strategies money is saved, development is made faster, socioeconomic well-being is increased, sustainability is supported, environmental protection is augmented, social well-being is enlarged, and material flows are improved [3].

The absence of proper landfill sites poses significant environmental and health risks due to the high organic content of the waste, leading to polluting leachate and water contamination. The Asia SWM Project found 199 waterborne diseases and 22 deaths due to dengue in 2001, indicating potential impacts on water quality in urban supply zones [4]. High acid levels were found in the groundwater near a former waste dump in Sri Lanka, exceeding chemical oxygen demand limits. Sri Lankans produce roughly 0.62 kg of solid waste per person on an average day [5]. The waste collection rate in the major cities has been found to be relatively higher. The National Water Supply and Drainage Board (NWSDB) identified pollution in Colombo's groundwater aquifers due to improper waste disposal, making it unacceptable for drinking. The environmental damage's opportunity cost highlights the impact of unscientific waste dumping in and around Colombo [6]. Burning of open solid waste is a major source of greenhouse gases, including methane and carbon dioxide, causing air pollution and climate change. This results in high levels of odor, dust, and toxic fumes. Additionally, haphazard dumping negatively impacts wetland habitats, causing ecological and socio-economic consequences, flooding, and exposure to medical and industrial waste, especially in the Attidia and Muthurajawela areas, with heightened environmental damage due to high rainfall and humidity [5].

AMC is a prominent town situated in the coastal belt of Ampara district in the Eastern Province of Sri Lanka, AMC consist of a population of 38,000 in an area of 6.507 km^2 [7]. It faces an acute waste dumping problem due to wrong collection and treatment techniques. The waste management issue is made worse and has an impact on the community by a high population density and insufficient land capital. The collected waste of AMC is transferred to the garbage dump yard, which is located at Aalimnagar nearly 8 km away from Akkaraipattu town. The five-acre dump site consists of a manual waste separation unit, which experiences limited utilization owing to a range of prevalent issues. The residents of the dumping and surrounding area face serious health hazards, disturbed by unbreathable foul smell and escalated spreads of diseases such as dengue. Healthy risks are worsened due to infection of waste eating animals such as rodents and flies. Ecological factors such as air and water pollution have also been attributed to improper SWM. It was revealed that both the government and private sector organizations often produce a large amount of solid garbage, such as litter, paper products, electronics wastes, food scraps, plastics, and general debris. The volume of waste sent to the landfill could be reduced by improving employees to awareness on net zero waste management guidelines. Implementation of net Zero Waste Management (ZWM) at AMC will reduce, reuse, recover waste streams and convert them to valuable resources. This process will reduce the adverse environmental effects, conserves resources, minimizes the waste problems, promotes social equity, builds community cohesion, and supports a local circular economy and creates jobs. Only half of the waste produced in Sri Lanka is collected (Environmental Foundation of Sri Lanka, 2017). Few researchers [8][9] have been conducted to confirm the key problems and potential strategical gaps in implementing ZWM plan. Though it is well known that all the elements of SWM such as collection, transport, treatment, and disposal by many of the employees of the AMC, it was a well-accepted fact that the existing system is not up to expectations. Therefore, increasing quantity of debris and the absence of proper waste management system in the AMC area is considered as the major problem that requires immediate attention of authorities concerned.

The environmental pollution avoidance hierarchy is traditionally based on the 3R model based on Reduce, Reuse, and Recycle. This 3R model has been lengthened to a 5R model, as introduced by Etsy and Winston (2009). The further subdivisions of “re-design” and “re-imagine” serve to complete the 5R pyramid of five-level analysis framework. Moreover, the 5R can be extended into a 6R or even 7R model because of the findings and data grouped. SWM can also refer to the methods for eliminating and limiting production of waste [2]. Solid waste solutions that focus on reduction and recycling might save a lot of properties and power. Implementing waste management into sustainable construction factually and effectively will improve overall energy usage [10]. Themes such as the 7Rs (Reduction, Reusable, Recycling, Researching, Refusal, Redevelop, and

Reconsideration), the triple bottom line, strategy for the surroundings, product lifespan assessment, and the zero-waste concept provide a theoretical foundation. ZWM procedures are currently adapted in Sri Lanka. According to the Case Study on the waste management practices [11] of a green production facility in the apparel industry of Sri Lanka practically implemented waste mitigation methods were identified. These practices illustrate the facility's diverse and eco-friendly waste reduction efforts. According to the Study [12] on the development of a Net Zero Waste Building Guideline for Office Buildings in Colombo the 5R strategy pertaining to waste mitigation methods were identified, starts with refusal, underlining the avoidance of disposable items and decrease of waste at its beginning. The strategy then turns to reduction by supporting for goods with minimal packaging and durability, urging bulk purchases to minimize waste generation. Reuse emerges as a crucial step, promoting the adoption of reusable alternatives in delivery and packaging, alongside refurbishing appliances for extended use. Repurposing takes shape through composting organic waste like food scraps and garden leftovers. Finally, the guideline emphasizes collaboration with waste service providers to ensure an efficient recycling process, particularly for hazardous materials. This streamlined strategy underscores a commitment to sustainability and responsible waste handling within Colombo's office infrastructure.

In Sri Lanka, there are numerous Waste Management models studied and available. Saja et. al. [09] discussed on MSW management practices and challenges in the southeastern coastal cities of Sri Lanka. This study targets on the waste management in southeastern coastal cities of Sri Lanka, these areas manage with a daily waste volume of 10 to 50 metric tons. Despite having essential waste management infrastructure, inefficiencies persist due to improper waste separation, resource shortages, lack of waste reduction regulations, irregular collection schedules, and limited technical expertise. The study provides practical solutions solves the identified challenges and emphasizing the need for immediate action to enhance waste management and encourage sustainable cities. Mahesh Jayaweera [13] elaborated on integrated SWM for local authorities in Sri Lanka which provides practical and appropriate customize models according to the studied context. According to this study, the proposed concept aligns with the government's policies and aims to address SWM challenges through sustainable practices and resource efficiency.

This research was conducted with the objectives of identifying the types of wastes generated, identifying the gaps and issues in the existing SWM plan, selecting the most suitable method to achieve the Net Zero concept, analyzing the energy recovery potential, and proposing a suitable Zero Waste Management model for the AMC. Also, 3R, 5R and 7R systems were analyzed to obtain the optimum energy recovery potential, and thereby to propose a suitable ZWM model for the AMC.

METHODOLOGY

Initially, the drawbacks of AMC’s waste management plans were identified. Subsequently, waste types were categorized, providing insights into waste composition. Leveraging this data, a suitable waste reduction method was chosen, alongside an assessment of energy recovery potential. Integrating these findings, a tailored zero waste model was proposed, addressing identified gaps, and aligning with the specific needs of the council. Figure 1 clearly explains the steps followed towards achieving the objectives of this study.

This study was mainly based on qualitative methodology. The information and quantity related aspects of the collected waste were obtained as secondary data from the AMC. The appropriate magazines, journals, and direct interviews with responsible and experienced officials were used to gather the essential data and information. Concerning availability and types of information, interviews were held with the AMC staff including the commissioner, mayor, engineer, technical officers, workers and randomly selected residents in the AMC specially surroundings of the dump yard areas.

The data related to the following were collected: recourses required and used, types of wastes available and sorting procedure, issues at various functional level, types of waste management practices in use, potentials for energy conversion in form of biogas and compost, possibilities for using waste management models such as Net Zero Waste, the opinions on the challengers in implementing SWM system. In addition to the above, offsite interviews and field visits were made to collect additional information from the dump yard at Attapalam and the from the compost plant at Pallakadu.

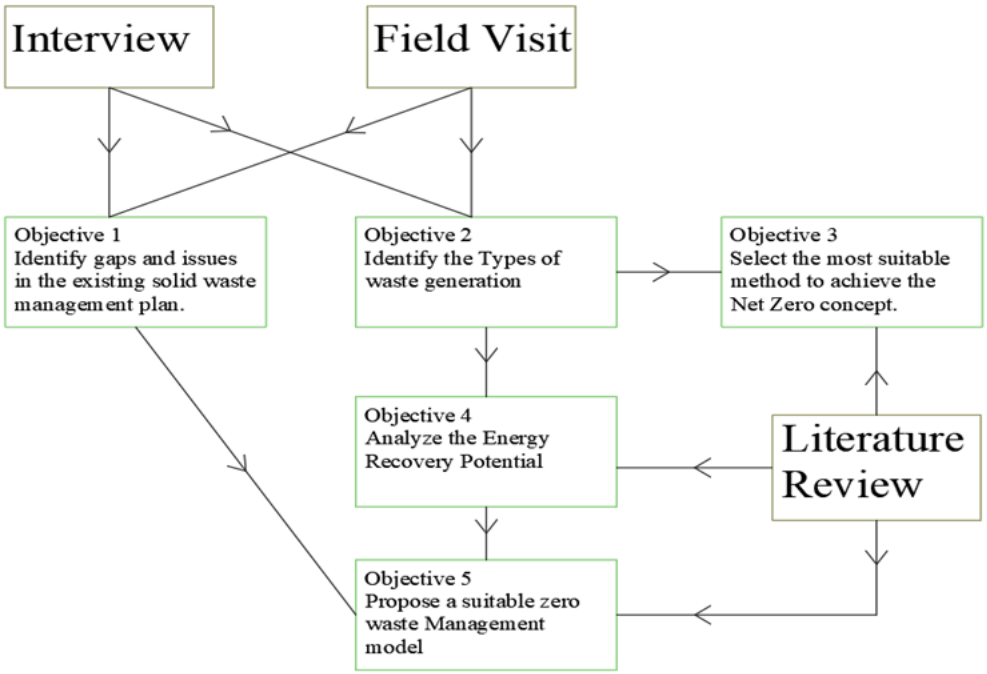

Fig. 1 Methodology

RESULTS AND DISCUSSION

The alignment of findings across multiple studies is significant. This study's results share substantial parallels with several other studies: Development of a Net Zero Waste Building Guideline for Office Buildings in Colombo[12], A case study of a leading apparel company in Sri Lanka with regards to issues[11], MSW Management Practices and Challenges in the Southeastern Coastal Cities of Sri Lanka[9], Integrated SWM for local authorities in Sri Lanka: a viable model for better management[8] and , Organic Waste System Assessment: Kaduwela Municipal Council [14]. While highlighting disparities where they emerge, these studies collectively emphasize consistent themes and findings.

Issues at the sources of waste generation points: Generated solid waste are not sorted at the points of collection before storing. Waste is temporarily stored in a mixed form by these sources in portable containers, bags or openly heaped until the collection by the team from AMC. Color-coded bins or distinct bags were not used in any of the study's areas to collect biodegradable and non-biodegradable waste separately. This clearly indicates that no strict system of sorting at these points of generation has been properly introduced and monitored by the collection authorities. The challenges and difficulties faced by AMC because of this mixed form of wastes segregation is further leads to additional inconveniences in energy conservation and wastes management process and considered as the biggest challenge in implementing zero-waste management approach.

Issues at the Collection: The municipality uses different vehicles for collection, but a shortage of vehicles and skilled personnel creates scheduling issues. Therefore, there's no fixed waste collection schedule, and the public is often unaware of collection dates. Collection frequency based on vehicle availability. Waste is mainly collected twice in week from residential areas using composters and trucks, with additional sweeps on internal roads. However, due to a lack of public education and support, mixed waste is often sent directly to trucks without prior separation. The absence of officers to educate the public further limits support for proper waste collection procedures.

Issues at Transport: Collected waste is transported in an unhygienic and unsafe manner except compositors. The lack of availability of proper vehicles is also the cause for this condition. The workforce involved in collecting the waste is not knowledgeable enough on the safety and hygienic transport.

Issues at the Final Disposal: The current preferred way of getting rid of solid waste in AMC is open dumping away from residential area which hazardous, not sustainable, and not acceptable by the civilians living in the vicinity of the dump yard. Infestation by wild animals and flies are added problems for the public around the dump yard.

Types of wastes generation is given in Table 1.

Table 1: Quantity of Waste collected

Type of Waste	Average Daily Waste Collection (Ton)	Percentage
Biodegradable Waste	22.16	83.84%
Plastic waste	1.87	7.07%
Metals Waste	1.07	4.04%
Rubber and Glass waste	1.34	5.05%
Total	26.43	

Table 1 clearly points out that large portion of the waste (84%) is biodegradable while metals and rubber and grass wastes are reported at 4% and 5% respectively.

It was understood that the 5R method, emphasizing refuse, reduce, reuse, repurpose, and recycle is the best option to proceed with rather than 5R and 7R methods. The 5R approach, built on the 3R Method, simplifies waste control and encourages community responsibility, making it accessible even with limited resources. Implementing 7R method create more challenges for the AMC, it requires a feasibility assessment considering cultural, financial, and policy factors. Conclusively, the 5R method is suggested as the most suitable for AMC, promoting active community engagement and Net zero waste practices. In future 7R Method can be updated to system with the progress of implementation.

Analyzing the energy potential: In this it was analyzed in this study under compost production and biogas production potential. Composting is a natural process which decomposes organic waste materials into stable, nutrient rich decomposed organic materials. Organic waste input is 10 tons/day plant can produce 25 ton to 30 tons of compost monthly [15]. Biogas production involves the anaerobic digestion of organic waste and produces biogas that contains methane (CH_4) and carbon dioxide (CO_2). The total biogas yield from municipal garbage per kg dry matter was observed to be 0.5 m^3 and the average methane content of the biogas was observed to be 70 %vol [15].

Potential compost production in AMC: The daily collection of biodegradable waste is 22.16 tons/day in AMC and calculated conversion rate is 10% according to the study [14]. Therefore, based on the data, approximately 2.21 tons of compost can be produced daily in Akkaraipattu municipal council. (Potential Compost Production = 22.16 tons/day X 0.1 = 2.21 tons/day)

Potential Biogas Production: The biogas production rate is 500 m^3/ton of waste [15], Therefore, based on the data, approximately 11,080 $m^3$of biogas could be produced daily in AMC (Potential Biogas Production = 22.16 tons/day X 500 m^3/ton = 11,080 m^3/day)

It is notable that the above estimates provide an idea of the energy recovery potential based on the gathered data. To achieve competent results, a thorough analysis considering area conditions, waste characteristics, and the specific composting and biogas production technologies are also proposed to be used by AMC whenever necessary.

Proposed Waste management Model for Akkaraipattu municipal council

Considering the mentioned facts, Figure 2 shows the proposed waste management model. This model for AMC aligned with the government's policies and directs to address SWM challenges through sustainable practices and resource efficiency. Findings from scholarly articles [9],[3],[11],[12],[14] were considered while developing this proposed model and it is suggested to go through a stage wise testing and a trial run before fully implementing the proposed model.

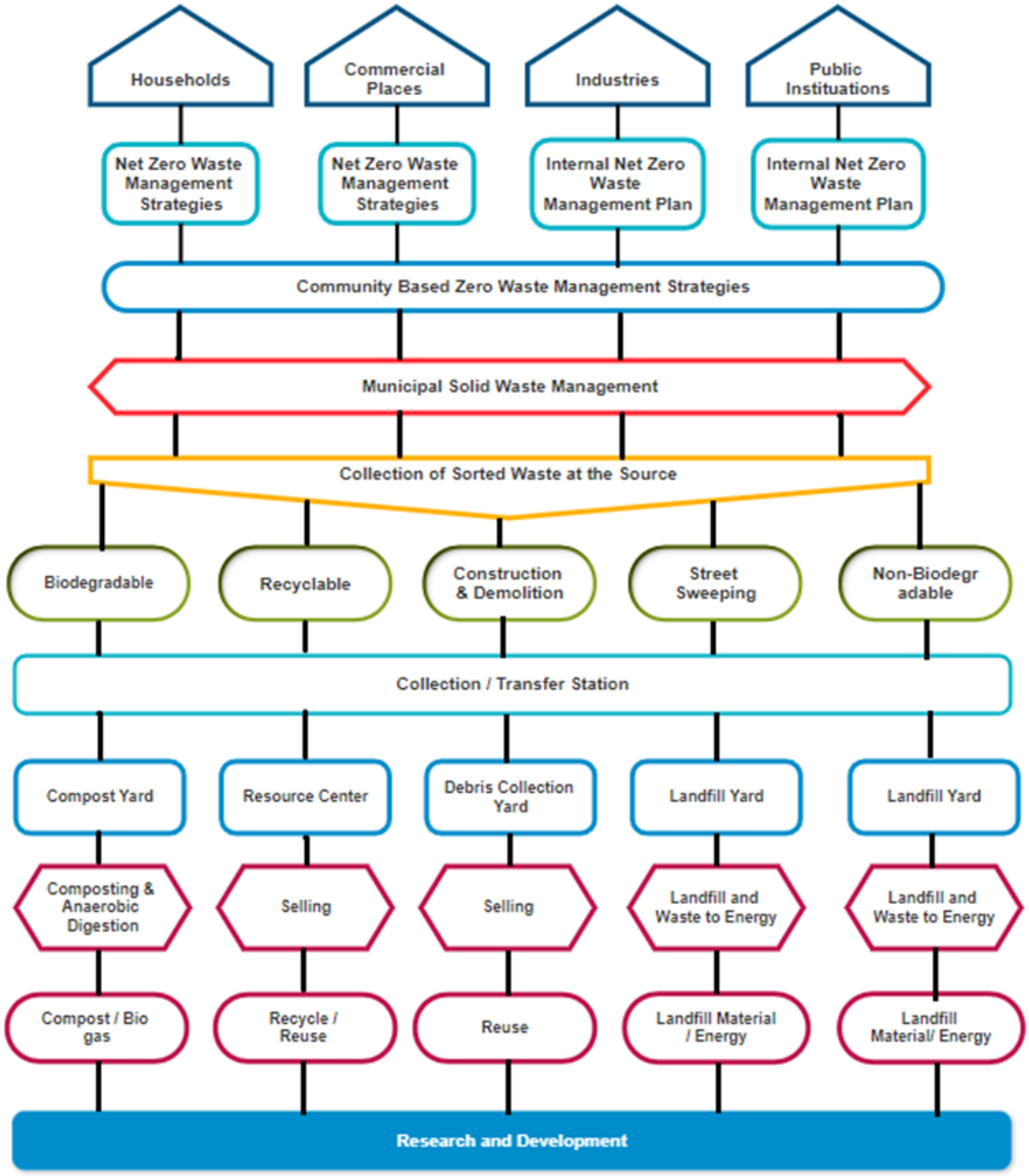

Fig. 2 Proposed Waste model for Akkaraipattu Municipal Council

If the ZWM practice is to be considered as a suitable model to overcome the issues in AMC, the proposed model should be practiced by waste producers and the AMC. The whole approaches could be divided in to two segments as,

1. Strategies and Approaches Recommended for Waste Producers
2. Strategies and Approaches Recommended for AMC

1.Recommended Strategies and Approaches for Waste Producers

Implementing the 5R strategy before waste collection in AMC faces certain challenges. Following are some specific challenges and solutions and issues in implementing the 5R strategies before waste collection.

i. Lack of Awareness: Residents in AMC are not familiar with the 5R strategy. Educating the community about the benefits and methods of the 5R approach is important. Conducting Awareness Programs is excellent key for this issue.

ii. Constraint in the Infrastructure facilities: The organizations under AMC are limited with recycling facilities, composting sites, or collection approaches. Working together with local organizations and businesses to establish and improve recycling and composting facilities within Akkaraipattu will be the solution for this issue.

iii. Behavior Change: Bringing about behavioral changes among Akkaraipattu residents is a great challenge. Motivating individuals to reduce waste, reuse items, and separate recyclables requires targeted awareness Programs and incentives.

iv. Accessibility: Accessibility to recycling and composting facilities is an issue in Akkaraipattu. Ensuring that these facilities at convenient locations will be easy to use can encourage more people.

v. Lack of Support and Resources: Akkarapattu residents have shortcomings in the necessary information, guidance, and resources to implement the 5R strategy successfully. Providing educational programs, clear guidelines, and support from the Municipal Council is vital to curtail this issue.

However, the following strategies could be followed by domestic level and commercial level establishment as its own or community based before collection by AMC.

Strategy-1 : Refuse

Measures are developed and implemented to prevent the generation and accumulation of the wastes as follows:

- Avoidance of waste at the source
- Avoid disposable items.

Strategy-2 : Reduce

Accumulations of wastes could be minimized by following means,

- Review purchasing strategy for goods with minimal packaging.
- Select products made from recycled materials.
- Select products that are life-long and durable.
- Buy in bulk and use refillable containers.

Strategy-3: Reuse

Ways of reusing the selected items from the wastes which includes,

- Examine suppliers for the possibility of using delivery trays, return certain packaging and/or change to a more ecologically friendly alternative.
- Refrigerators, ink cartridges and computer printers, for example, can be refurbished for re-use.
- Switch to reusable and high-quality batteries.

Strategy-4: Repurpose

Converting the energy in the degradable wastes by reproducing. For examples,

- Composting of food waste, garden waste and other organic waste.
- Bio-gas production

Strategy-5: Recycle

Converting the form of the non-degradable waste materials into usable form. Example.

Working with Waste Service Providers to ensure the recycling of waste material, particularly on Hazardous Waste.

In addition to the above the following practical approaches of 5R method could be applied for specified types of waste.

Papers and Cardboards

- Promoting and advising to Use digital forms, Emails and keep digital Records.
- Provide recyclers at regular intervals for recycling.
- Printing double-sided and only making copies and prints, when necessary, will also drastically reduce the output.
- Reuse the Cardboard and Paper for Packing
- Reuse the Scrap paper for Notes and memos.
- Shred paper and reuse it as packing material.

Furniture Waste

- Reuse the furniture after Refinish or reupholstering.
- Sell Any Furniture that Is in Good Enough Condition

- Provide recyclers at regular intervals for recycling.
- Donate if anyone has the requirement.
- Purchas on a rental base

Printing Products

- Repair or Refill and use
- Provide recyclers at regular intervals for recycling.
- Make an agreement with the supplier for recycling when purchasing.

Plastic Products

- Whenever possible, choose to use durable items instead, like personal aluminum or glass water bottles, rigid and washable food containers, and reusable bags.
- Provide recyclers at regular intervals for recycling.
- Totally Avoid the use of Unrecycled plastic

Food Waste

- Provide animal feeding.
- Generate Compost with an Organic composter and provide it to the Staff for their home Gardening in institutions.
- Generate Compost with an Organic composter and use it for Landscaping in the office.

2. Recommended Strategy and Approaches for Akkaraipattu Municipal Council

When Collection and transport of sorted MSW the following are important to be addressed.

Waste sorting and source separation: The first stage is to organize waste sorting and source separation at the household level. This involves training the community about the importance of separating waste into designated different categories, like biodegradables, recyclables, and non-biodegradables. Local authorities are required to raise awareness through various methods, including circulating educational leaflets and conducting door to door visits with the help of NGOs. Capacity building programs will be required to train individuals involved in waste management, ensuring they have the necessary knowledge and skills to carry out waste sorting effectively. Additionally, advertising work will be required to promote waste reduction, reuse, and recycling practices.

Scheduled Collection and Transport: To make certain efficient waste collection, AMC will implement scheduled collection of sorted waste. Through different collection methods, like door-to-door, bell, and community-based collection, will be advised based on the characteristics of the area and the preferences of the residents. Enough workforce and appropriate collection vehicles required to be assigned to make the collection and transportation process. The fleet of vehicles is required to include different types and capacities according to the road size and collection condition. A good collection method with added GPS Technology will further improve.

In addition to waste collection, street sweeping and drain cleaning activities are also required to be carried out regularly to keep the roads fresh. The waste collected during these activities will be separated and required to be sent to the AMC collection center or internal transfer station.

At the final disposal stage the following important to be addressed.

Biodegradable Waste: Biodegradable waste, like food scraps and garden waste, is required to be handled through Biogas production and composting. This biogas can be utilized as a renewable energy source, and the digestate can be used as fertilizer. The compost can be directly used as a Fertilizer.

Non-Biodegradable Waste: Non-biodegradable waste, including materials from street sweeping, as well as non-recyclable and compost residue, required to be managed through landfilling or energy generation activities.

Landfills must be properly designed to minimize environmental and health issues. The responsible government authority is required to oversee the operations of these landfills, ensuring compliance with proper waste disposal protocols. Waste-to-energy plants.

Recyclable Waste: Recyclable waste like paper, glass, plastic, and metal, will be collected separately and sent to waste material resource centers. These resource centers will serve as collection points. Here individuals possibly bring their recyclables directly and get payment based on capacity like weight or volume of the materials. Private collectors could also be encouraged to participate in the collection process. The government is required to supervise the operations of the resource centers, ensuring fair and competitive prices are given to the

public who supply the waste. The collected recyclable materials will be sold in bulk to third parties for further recycling works.

Construction and Demolition Waste: Construction and demolition waste, which includes materials like concrete, wood, and metals, is required to be collected separately and taken to designated debris collection yards within AMC areas. The Government authorities are required to supervise the collection and transportation of this waste. The Ministry of Urban Development also will manage the operation of the debris collection yards, make sure proper management and disposal of the construction waste. Reusable portions of the construction and demolition waste will be sold to individuals who needed or organizations in need as a filling material.

CONCLUSION

AMC handles more than 26 tons of waste daily, facing issues like increased debris, landfill constraints, poor collection, interrupted transport, inadequate treatment, and improper disposal. Yet it's clear the disposal process in AMC needs significant improvement. Challenges include limited budget and low resource allocation. Biodegradable waste provides energy recovery potential, and the 5R waste management approach makes simplicity. Financial sustainability hinges on fees from commercial entities and government or donor funding. The proposed Waste Management model supports a separate approach for waste producers, encouraging 5R strategies to convert waste into valuable resources, and provide sustainable benefits to waste producers. Finally reducing the burden on the Municipality. AMC can sustainably benefit through small fees and selling compost, biogas, and recyclable products. The fee structure may align with business size and waste generation. Highlighting long-term benefits secures necessary funding for a comprehensive waste management strategy, ensuring a cleaner, healthier future for the community and establishing a sustainable MSW disposal model for AMC.

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