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Advancing Viable Waste Solutions: Transforming Waste into Opportunity

Dr. Junaid Khan

Assistant Professor, Maulana Azad National Urdu University, Hyderabad

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ABSTRACT

Poor waste management is posing a serious risk to environment and human health and overwhelms the resources and capacity of municipal bodies and communities alike. Increasing population, urbanisation, industrialisation and economic growth are some of the factors responsible for the increasing volumes of solid waste. The amount and complicated nature of municipal solid waste are both growing at an alarming rate, which is an enormous concern and challenge for the whole world and especially for developing countries... This waste ultimately finds its way to landfills, open dumping sites and water bodies causing soil, water and air pollution, this situation is made worse by the inadequate collection, transportation, treatment, and disposal of MSW. The solution for this lies in solid waste management through which solid waste can be changed and used as a valuable resource. The waste-to-resource strategy proposes a radical change in solid waste management.W2R represents a substantial and mostly unexploited potential to bring about a paradigmatic change in the field of solid waste management. The approach has the potential to turn waste from a problem or a burden to an economically viable resource and create a new product from the waste. The approach can lead towards attainment of sustainable development goals (SDG's).This approach promotes programmes and strategies for adopting 3R"S i.e. Reduce, Reuse, Recycle practices. Establish decentralised facilities

called integrated resource recovery centres (IRRC) that convert municipal waste into resources using simple and cost effective technologies. Waste can be used as a resource to transform an economy from linear to circular by closing the loop between two ends and allowing collection of waste material for material sourcing. The linear economy can balance the rapidly declining natural resources and steadily increasing waste to ensure that we have enough resources to maintain our social sustainability and save our planet.

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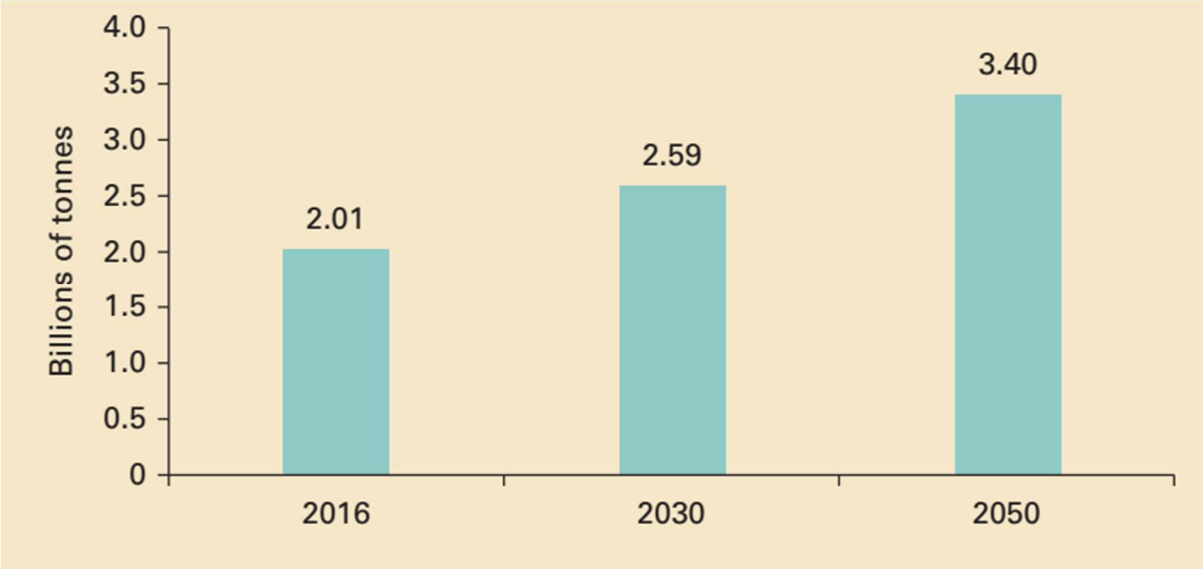
Introduction

Waste management and collection are crucial community services required for safeguarding the environment and public health. Proper Waste Management is vital for effective urban management policy and flourishing economy. The world population estimated at 8 billion and with present (2023) growth rate of 0.84% is estimated to reach 10 billion by 2057[1].The growing population has a direct relation with increased levels of waste generation .Globally, 2.01 billion metric tonnes of municipal solid waste is generated each year, of which 33% is not handled in a sustainable manner, 70% end up in landfills, 19% are recycled, and 11% is reused to turn waste into energy. Up to 14 million tonnes of plastic garbage enter aquatic environments each year, and around 931 million tonnes of food are lost or wasted[2].The waste generation is anticipated to more than double in size during the same time, from 2.59 billion tonnes in 2030 to 3.40 billion tonnes in 2050[3].

The cost of managing solid waste eats up a considerable portion of municipal budgets—up to 20–50% in certain smaller communities, according to UN HABITAT (2010).Sustainable waste management seeks to reduce waste generation, natural resource consumption, and reuse as many materials derived from the environment as is viable. Resource recovery could improve the income base to fund SWM expenditure and reduce the load on local authorities by turning solid waste to material or energy[23]. It is our duty to guarantee sustainability in order to save the planet for present and future generations. An effective sustainable system for managing waste must have feedback chains, a process-driven methodology, flexibility, and waste diversion. Sustainable waste management mainly involves the transition from the traditional make-use-dispose model of production to a more circular economy, using

approaches like integrated solid waste management, 3R'S(reduce, reuse, recycle) of waste management and zero waste strategy.

Figure 1 : Projected Global Waste Generation



Source: *World Bank 2018*

Solid Waste Management System

Management of solid waste has long been an important part of every human society. Solid waste management (SWM) aims to efficiently collect, transport, process, and disposal of waste at every stage, starting from the point of waste generation to its final disposal. SWM ensures protection of environment and human health.Maintaining clean and healthier communities requires proper SWM to reduce the pollution and its detrimental effects on the environment. SWM tries to mitigate air and water pollution, soil contamination and greenhouse gas emissions. Sustainability must be observed in this area so that every bit of trash can be managed effectively rather than simply being dumped in landfills. Proper waste management is a critical component of community health and environment. While being one of the most ineffectively administered services, solid waste management is one of the most fundamental and crucial services managed by local governments. The strategies used are unscientific, obsolete, and inefficient.[4]. The cost of managing solid waste eats up a considerable portion of municipal budgets—up to 20–50% in certain smaller communities, according to UN HABITAT (2010).

Sustainable Waste Management

Over a period of time rapid urbanisation and population growth in developing countries have caused a spike in unemployment and poverty rates, infrastructure and social services issues, environmental issues, and other negative socio economic and environmental effects..As a result, the necessity of achieving the Sustainable Development targets was acknowledged globally.

Sustainable waste management is a process employing some specific practices and strategies tominimize negative environmental impacts of waste disposal. The capacity of a dynamic framework to continue into the foreseeable future by incorporating economic, environmental, and social principles into waste management procedures is the essence of sustainability.[5].Global efforts are now in force to reorient SWM systems towards attaining sustainability. The United Nations General Assembly in 2015 ratified sustainable development goals as a worldwide call to action to end extreme poverty, protect the environment, and provide peace and prosperity for humanity on the planet by the year 2030.SDG'S encompass numerous sectors of urban governance, solid waste management is one of the important sector. Environmentally sound waste management impacts many crucial facets of development[6].The management of solid waste, often known as SWM, is a problem that cuts across multiple sectors and may be directly connected to 12 of the 17 Sustainable Development Goals set by the United Nations which emphasises the importance and political priority and urgency of solid waste management.[7].These global goals can be achieved if waste management is recognised as a powerful driver of sustainable development. Solid waste management has the potential for achievement and improvement of many indicators of SDG'S directly and indirectly. SDG'S, Paris Agreement on climate change, and New Urban Agenda (NUA) are among the many international commitments and agreements towards achieving sustainable waste management. Global efforts are now in force to reorient SWM systems toward sustainability.

Expanding the Scope of the 3Rs in Solid Waste Management

One of the ways to keep to keep as much waste out of landfill is putting 3RS (Reduce, Reuse, Recycle) of waste management plan into action. The3R'S initiative was developed in early 2000's at the G8 Sea Island Summit in June 2004.The three R's principle stands for reducing waste, Reusing and Recycling resources and products.

Reduce means reducing the amount of waste produced, less consumption will lessen the rate of recycling and reuse.

Reusing anything implies to put it to use again for its original function or to repurpose it for another use. Reusing minimizes the quantity of waste produced.

Recycle: The term "recycle" describes the process of converting waste into a resource that may be utilised to manufacture new products or rebuild old ones.

The fundamental principle behind 3R'S is waste minimization. The3RS is also referred to as waste hierarchy as in fig 1 below, that categorise waste management strategies according to their desirability in terms of optimising product utilisation and minimising refuse production. Due to accelerated population growth and urbanisation, the need for reusing and recycling of wastes has become more important over time[8].

Reduction or minimization is aimed at decreasing or reducing the amount of waste generated, after prevention it is considered as the second most crucial strategy for achieving sustainable development. Reduction is followed by reuse. The approach of reuse should theoretically be used after all reducing options have been explored. Reuse is the practise of "reusing" a product or substance that has been abandoned, but that a product or substance be used in its unaltered form, whether that be in the manner for which it was designed to be utilised or in a new manner, but without undergoing any kind of physical or chemical modification if reduction and reuse are not possible. Recycling refers to the process of turning waste into a resource that may be used to create new products or to remake existing ones. The object or substance that has been collected may be processed either physically or chemically utilizing the recycling option in order to reclaim the valuable components or elements.3R'S strategy leads towards sustainability and zero waste conserves valuable resources and protects environment by cutting down air water and soil pollution by reducing quantity of waste going to landfills..At the same time contributing to the economy and generating green jobs. The initial 3R'S model is gradually evolving towards including more R's to further broaden the spectrum of sustainable waste management, such as the 5rs of conservation and 7rs of sustainability[9].

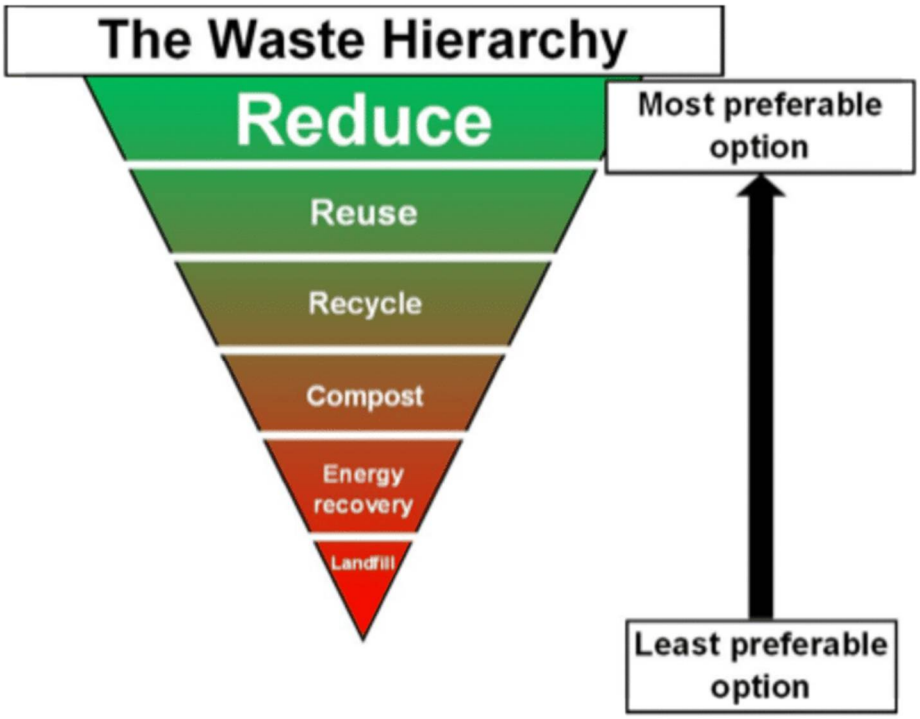
5R's of Conservation of Resources

Repurpose, Reduce, Refuse, Recycle, Reuse

7R'S of Sustainability:

Rethink, Refuse, Reduce, Reduce, Repair, Re-gift, Recycle

Figure 2 : Solid Waste Management Hierarchy[10]



Zero Waste Strategy

The zero waste strategy is a visionary objective and approach to sustainable waste management. ZWIA (zero waste international alliance) defines this concept as

"The conservation of all resources by means of responsible production, consumption, reuse, and recovery of products, packaging, and materials without burning and with no discharges to land, water, or air that threaten the environment or human health" The term "zero waste" refers to an economy that produces and consumes less trash while also keeping waste out of landfills.[11].It is not just an end rather a set of guiding principles which seeks to eliminate waste at any and every level of the process. The zero waste approach encourages the circular strategy to the way resources are used. Zero waste is the key to making circular economy into a reality. The concept also includes the 3R principle of Reduce, Reuse and Recycle, believed to be the foundation of environmental consciousness, as well as the promotion of ecological balance and the conservation of resources through the conscious conduct and choices of consumers[12].This concept ensures the materials are utilised for as long as feasible before being returned

to the environment with minimal or no detrimental effects on the environment. The products are reused, repaired, sold or refurbished within the system, recycling or recovering is opted if reuse and repair is not possible.

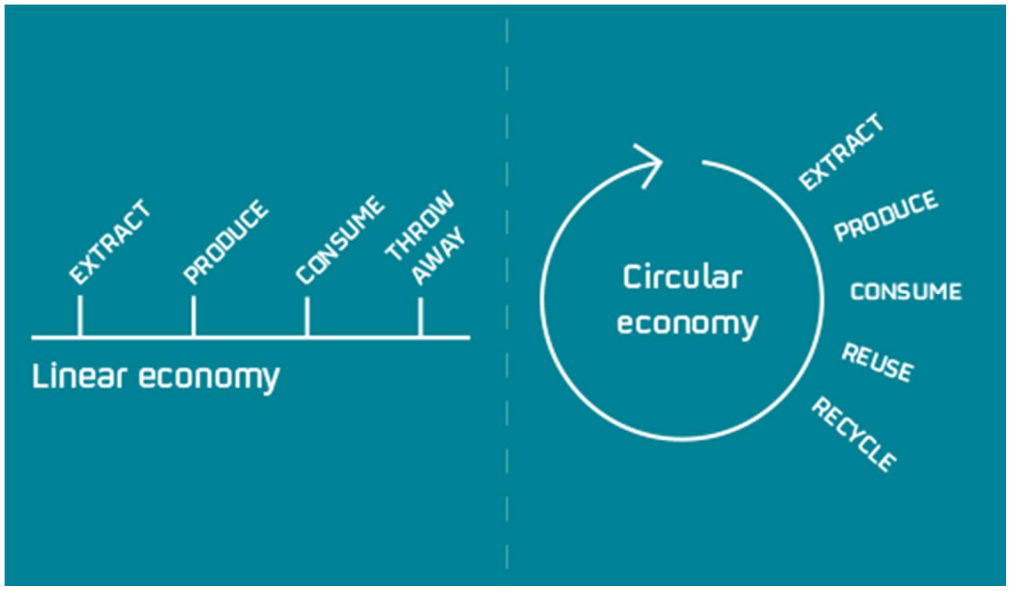
ZR is a shift from "cradle to grave" thinking, which is an open-loop system or a linear model that is inherently wasteful. Zero Waste approach promotes "cradle to cradle" thinking, which is a circular model that reduces pollution and maximises the reuse of resources. It is a "closed-loop" that strives for Zero Waste through Waste Reduction, Reuse, and Recycling thus promoting sustainability. Zero Waste measures can help achieve the goals and targets of the 2030 Agenda for Sustainable Development, such as SDG objective eleven and twelve recommended by the United Nations, which address all forms of waste, like wastage and loss of food, e-waste, and exploitation of natural resources.

Circular Economy

According to the World Economic Forum, a circular economy is “an industrial system that is restorative or regenerative by intention and design”.

Circular economy also called as circularity or simple CE is a shift from the present linear economy which is based on extracting, producing, using, and throwing away model, believed to be inherently unsustainable. The public notion of trash has. As a consequence of the rapid rise in urbanisation and consumption rates as well as the depletion of natural resources, waste is no longer viewed as an unavoidable by-product of industrial economies but as a precious, reusable asset. the increased global interest in and investment in the circular economy serves as evidence of this transition.[13].Circular Economy is a type of economy that replaces the concept of "end of life" with a change in manufacturing, distribution and consumption operations, minimising, recycling, reusing, and recovering materials. In order to achieve a sustainable future. Promoting economic prosperity, social equity, and environmental quality for the benefit of both the present and future generations[14]. The CE approach is traditionally built around the 3R’s approach. In the waste management process, the 3R’s concept and the circular economy strategy are analogous[15]. It seeks to realise an ideal economic system in which pollution is minimised and more resources can be reused and recycled in closed-loop systems. The model of circular economy has the capability of boosting economic and resource optimisation in the whole system by promoting 3R techniques[6].

Figure 3 : Linear vs. Circular Economy



(Source: https://www.repsol.com/en/sustainability/circular-economy/index.cshtml)

A Circular Economy minimizes resource consumption, redesigns products and services to be more resource-efficient, and recycles "waste" to produce new goods. The circular economy has the ability to safeguard the environment, enhance the economy, and advance social justice[16].A Circular Economy does more than only mitigate the negative effects of a linear one. Additionally, a shift to a circular economy creates opportunities for business and economic growth, benefits society and the environment, and strengthens the economy's long-term resilience. Furthermore, it acts as a natural sky bridge for achieving SDG'S core objectives10. The Circular Economy provides us the tools we need to simultaneously solve urgent social issues and the threat that climate change poses to biodiversity by reducing greenhouse gas emissions and pollution. Thereby enhancing resilience, prosperity and employment.[17]. A report by Accenture predicts a $4.5 trillion in value created by the circular economy[18]. In order to move towards economies and communities that are more sustainable and resilient, the United Nations is presently collaborating with partners to provide incentives for circularity.

Extended Producer Responsibility (EPR) Laws

One of the many large scale interventions towards waste management that has the potential to help transition towards circular and low carbon economies is the concept of extended producer responsibility. Waste management expenses account for an average of 19% of municipal budgets in low-income nations which often face budget deficits for waste management[19].Fundamentally, EPR seeks to

implement the "Polluter Pays" principle by transferring the liability and financial cost of negative environmental effects from public entities and taxpayers to producers, who are in a better position to design less inefficient, harmful, and noxious products before they become "waste."". Thus EPR laws can considerably reduce economic burden on municipalities. According to OECDEPR is an organizational mechanism for the prevention and management of waste that contains certain types of products based on Polluter Pays principle.EPR is thus an action plan to shift the liability of End-of-Life product management from the general public to producers and other parties in the supply chain, while promoting changes to product design that reduce adverse effects on community health as well as the environment at all stages of product lifecycle. EPR serves as a tool to optimise product design, extending the useful life of materials and promoting recycling and reuse. It encourages companies to design more sustainable products and manufacturing processes including product reuse, buyback, and recycling programs. Manufacturers are incentivized to make their goods and packaging more environment friendly.. Specific waste streams are typically the focus of EPR, most commonly small consumer electronics, packaging, tyres, vehicles, and batteries[20].Global plastic production is expected to increase four times by the year 2050.C02 emissions and plastic leaks will also rise as a result of this influx.. It promotes waste collection and waste recycling rates and encourages minimizing plastic packaging from the design stage by making manufacturers liable for the effects of their products and packaging at the culmination of their useful lives.EPR as such is considered as a critical policy tool to this plastic pollution[21].

Although EPR laws for packaging are currently the most advanced and accurate for products made of plastic, this obligation might also be applied to other industries.[22].

As a result, EPR may aid authorities in solving a variety of environmental issues, all while boosting economies, protecting social safety nets, and relieving local authorities of waste management responsibilities. Businesses may get an early start on the Circular Economy transition, reducing regulatory and reputational risks and ensuring the rollout of affordable waste management strategies.

Integrated Solid Waste Management

To begin with conventional Solid waste management focused on reduction of public health risks, it then aimed at environmental aspects, lately the dimension of conservation of resources and recovery has become a critical factor for SWM. As such 3R approach is applied as the guiding principle of SWM. Thus, SWM has evolved into ISWM to improve the whole waste management process, from waste segregation and collection through waste transfer stations followed by to waste processing and recycling

to ultimate disposal of waste. Initially, only municipal solid refuse was addressed. It is progressively expanding to include other waste-generating industries also[23]. According to the U.S. Environmental Protection Agency, ISWM entails minimising waste, recycling, recovery, treatment, and disposal to accomplish operational efficiency, improve community well-being, and mitigate environmental risk in order to address the mounting challenges of MSW disposal in urban areas.

ISWM is built around the waste management hierarchy (Fig. 2).ISWM is a holistic approach to manage municipal waste that maximises service efficacy and achieves the objectives of the 3R strategy.[23]ISWM is closely linked to the 3R approach to waste management, which seeks to maximise efficiency and recovery of resources while decreasing the quantity of garbage sent to landfills.. An evaluation of local demands and conditions should result in the choice of most suited amalgam of techniques and technologies based on this waste management hierarchy. Reduction of sources, reuse, composting, waste-to-energy conversion, environmentally sound disposal, and recycling are all preferred methods of waste management that reduce the load on municipal services while also benefiting public health and the environment. ISWM's ultimate goal is to enhance the efficacy of waste removal from all sources, including homes, businesses, public spaces, building sites, demolition sites, farms in urban areas, hospitals, and other medical institutions, parks and gardens. ISWM includes participation from all relevant parties, such as generators of waste, service providers, the informal sector, regulators, the government, as well as the society or individual families.[24].

The ISWM is focused with developing an acceptable fusion of contemporary waste management techniques to handle the trash as effectively as possible. The elements of ISWM include reducing sources, composting, recycling, waste transportation, and land filling.[25].ISWM employs maximum amalgamation of available, suitable techniques of prevention, minimization, recovery and disposal of solid waste. ISWM strives to find a balance between three aspects of waste management: social acceptance, environmental efficacy, and financial viability. In the context of ISWM “waste" has a negative connotation if it has not been exploited to its full potential and not processed to produce valuable energy or goods[26].

ISWM is a global, encompassing, multifaceted, and sustainable solution to the problems of municipal solid waste management (MSWM). ISWM contains the key to achieving sustainable waste management, public health, green employment, and economic growth.

Conclusion

Solid Waste Management is a crosscutting sector of urban management that significantly impacts quality of life, community health and environment. Waste management is among the major global challenge and crisis. However, there is a substantial and mostly untapped possibility for revolutionary change inside this crisis and challenge. In order to ensure a sustainable future, effective solid waste management is essential for the preservation of scarce resources. Conventional strategies and processes have not yielded adequate results to face this challenge. The focus and strategies need a drastic shift from the conventional approaches and strategies to tackle this crisis. Global waste generation is increasing at a rapid rate and this increases the urgency with which we must concentrate on recycling, reusing, and recovery. With the rapid decline of natural resources and rapidly increasing quantity needs a change in our outlook to treat waste as resource or an opportunity. The waste to resource approach holds the key towards sustainable development and turn waste to generate social, economic and environmental gains. Now is the time to close the loop between the waste and the resource. The approaches, strategies needed towards this end should lead towards sustainable waste management. The approaches, strategies gaining momentum and attention lately at the global level are ISWM, Zero Waste approach, Circular Economy, EPR and 3R'S. The application of these strategies and approaches has the prospective to not only transform waste into a resource and an opportunity, but also promote sustainable waste management and sustainable development.

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