



5R's of zero waste management to save our green planet: A narrative review

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Abstract

Earth, the green planet is the only planet in our solar system known to host life. In the absence of food and water, life cannot survive. Without productive soil, the world would fail to support even half of its present organisms, or a tenth of its human population. At present, basic natural resources needed for human life are either growing scarce or are frequently polluted. In many parts of the world, soil is degraded, water is scarce, and food supplies are declining. In modern times, the waste generated by humans has become a big challenge for our environment. Several developed as well as developing countries are generating enormous amount of waste and struggling to deal with it in a sustainable way. Waste that is non-biodegradable or non-recyclable is not only filling landfills but also affecting our water bodies, grasslands, fields, climate, public health, wildlife, and so forth. Since we have limited space on earth to dispose all the waste, it is imperative to take steps to manage the waste by using the resources efficiently. Zero Waste management is a global movement designed to reduce waste in our society. The concept of 5R's is to decrease the number of things we use and simultaneously also decrease the number of things we throw away. The intent of this article is to understand the existing global status of Municipal Solid Waste (MSW) generation as well as to explore various ways to manage ever growing volume of waste, which poses formidable challenges to both high and low-income countries of the world.

Keywords: 3R's, 5R's, zero waste management, sustainability, landfills

Introduction

There has been a massive increase in the solid waste generation around the world in recent decades, and there are no signs of it slowing down. This is due to several factors, such as population growth, urbanization, and economic growth, as well as consumer shopping habits. The pace of urbanization across the world especially the developing countries world is witnessing an unprecedented increase with rural to urban migration one of contributing factors putting tremendous strain on cities ^[1]. Currently, about 55% of the humanity world resides in the cities which are projected to rise to 68% by year 2050 as per estimates ^[2]. The world generates 2.01 billion tons of Municipal Solid Waste (MSW) annually, with at least 33 percent not managed in an environmentally safe manner. By 2050, worldwide municipal solid waste generation is expected to grow to 3.4 billion tons. The United States is the biggest generator of waste per capita worldwide, with each citizen producing an average of 808 kilograms per year ^[1]. The East Asia and Pacific region are generating most of the world's waste, at 23 percent, and the Middle East and North Africa region is producing the least in absolute terms, at 6 percent. However, the fastest growing regions are Sub-Saharan Africa, South Asia, and the Middle East and North Africa, where, by 2050, total waste generation is expected to more than triple, double, and double respectively. In these regions, more than half of waste is currently openly dumped, and the trajectories of waste growth will have vast implications for the environment, health, and prosperity, thus requiring urgent action. ^[3] Richer countries produce more waste than poorer countries, but typically have better

waste management programs. It is estimated that less than 20 percent of waste is recycled each year, with huge quantities still sent to landfill sites. With such immense volumes of waste arising, the need for authorities to provide adequate waste treatment and disposal services has become ever more important. We currently live in a linear economy where we extract resources from the earth and then dump them in a giant hole in the ground. The goal of zero waste is to move to a circular economy where we write trash out of existence. The circular economy mimics nature in that there is no trash in nature. Zero Waste lifestyle is a mission to save the world from waste and recyclable materials. Most of us know about the 3R's to reduce waste- Reduce, Reuse, Recycle. However, there are 5R's to promote sustainability and fight our global waste crisis. Refuse, Reduce, Reuse, Recycle and Repair are commonly known as "5R's" of waste management. The 5R's play an important role in solving the problems which can arise out of wrong waste management habits.

Definition and classification of waste

Waste is an unavoidable by-product of most human activity. The term "waste" refers to any product or substance which is no longer suited for its intended use. In other words, waste is the discarded material, generated after its primary use. Waste is of various types and differently classified, based on specific characteristics such as physical states, physical properties, reusable potentials, biodegradable potentials, source of production and the degree of environmental impact ^[4, 19, 20, 21] Various classifications of waste exist in different countries. However, the most used

classifications are discussed below:

1. **Physical state:** Solid waste, Liquid waste and Gaseous waste.
2. **Nature:** Biodegradable and Non-biodegradable.
3. **Source:** Household/Domestic waste, Industrial waste, Agricultural waste, Commercial waste, Demolition and construction waste, Mining waste.
4. **Environmental impact:** Hazardous waste and Non-hazardous waste.

Waste Generation

Every human, community, organization, or human activity generates some type of waste. During pre-historic period, wastes were merely a source of nuisance that needed to be disposed of. Proper management was not a major issue as the population was small and a vast amount of land was available to the population at that time. In those days, the environment easily absorbed the volume of waste produced without any form of degradation.^[5] A substantial increase in the volume of waste generation occurred during the sixteenth century when people began to migrate from rural areas to cities due to the industrial revolution. This mass migration of people to cities led to population explosion that in turn led to an increase in the volume of wastes generated in cities.^[6] The large population of people in cities and communities caused indiscriminate littering and open dumps. These dumps in turn formed breeding grounds for rats and other vermin, posing significant risks to public health. The unhealthy waste management practices resulted in several outbreaks of epidemics with high death tolls. Consequently, in the nineteenth century public officials began to dispose waste in a controlled manner in order to safeguard public health^[5].

In recent times, the rate and quantity of waste generation is rising tremendously. As the volume of wastes increases, so does the variety of the waste^[7]. There are different types of waste that are generated every day, including municipal solid waste, medical waste, radioactive waste, hazardous waste, agricultural and animal waste, industrial non-hazardous waste, extraction or mining waste, oil and gas production waste, construction or demolition debris, fossil fuel combustion waste, and sewage waste. The amount of waste generated is influenced by economic activity, consumption, and population growth. Among industrialized nations, the United States produces the largest amount of municipal solid waste per person on a daily basis.

Waste Management

Disposing of waste has huge environmental impacts and can cause serious problems. The most important reason for proper waste management is to protect the environment and for the health and safety of the population.^[8] It is quite important to understand that waste segregation and management plays a vital role to reduce the detrimental effects of waste on the natural biological systems and thereby support the survival of the earth.

Waste management refers to the handling of waste materials from the time it is made to its disposal. Proper waste management includes various steps such as collection, segregation, transportation, processing, recycling, treatment, and disposing the waste in the best possible way in order to limit or eliminate the harmful effect of wastes^[5, 19, 20, 21]. In the past, waste often was deposited on land just outside developed areas. Current approaches to waste management

evolved primarily due to health concerns and the need to control odors. Waste management is as important as other public amenities or infrastructures without which the life of contemporary man would be extremely difficult. This is because studies have shown a direct link between air, water and land pollution and diseases such as lung cancer, heart disease, cholera and hepatitis.^[8] In addition, climate change and eutrophication are a direct result of water and air pollution. Little wonder why there is a huge disparity in the life expectancy of people in developed and developing countries. Once generated, wastes must be managed through reuse, recycling, storage, treatment, and/or disposal. Most municipal solid wastes and hazardous wastes are managed in land disposal units. For hazardous wastes, land disposal includes landfills, surface impoundments, land treatment, land farming, and underground injection. Land disposal created problems such as ground water contamination, methane gas formation and migration, and disease vector hazards. Modern landfill facilities are engineered with containment systems and monitoring programs^[19, 20 21].

What is zero waste?

Zero-waste aims to reduce the environmental impact of our waste disposable culture and to address climate change issues at the same time. The 'Zero waste' philosophy is based on the idea of managing materials in ways that preserve value, reduce environmental impact, and conserve natural resources. It seeks to ensure that products can be repaired, reused, or recycled back into nature or the marketplace^[9]. Implementing zero waste requires switching from waste management via incinerators and landfills to a value-added resource recovery system.

The Solid Waste Association of North America sums up zero waste as all efforts to reduce solid waste to almost nothing through reduction of excess consumption and maximizing solid waste recovery through composting and recycling. Some definitions of zero waste emphasize recycling and composting as ways to reduce waste. However, the zero-waste concept goes beyond recycling and composting at a product's end-of-life. It spans the entire process from design to raw material sourcing to production and finally disposal. The definition of zero waste according to the Zero Waste International Alliance (ZWIA) is as follows:

"Zero waste: 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."^[10]

Why is zero waste important?

According to the Environmental Protection Agency (EPA), only around 30% of the US waste stream is recycled and around 140 million tons of waste is sent to landfill each year. When it comes to single-use plastics only around 9% are recycled.^[11] Landfills cannot continue to hold the waste, they are not only harmful to the environment, but they also release CO₂, methane, hydrogen sulfide, and other harmful gasses. Additionally, leachate from landfills enters our groundwater and pollutes farmland and drinking water. At current waste generation levels, the recycling industry cannot hope to keep up with demand, and while recycling is highly important to the zero-waste movement, it must not be

so heavily relied on. Additionally, the extra resources and emissions associated with the recycling industry can and should be designed out, using better resource management and by encouraging producer responsibility. Finally, if we hope to address the destructive impact of climate change then zero waste and a more circular economy are truly our most sensible and sustainable options.

Cradle-To- Grave & Cradle-To-Cradle Models

An important distinction between zero waste and conventional waste management and recycling is the prevention of wasteful practices at the start of the chain. This is otherwise known as cradle-to-cradle thinking, which stands in direct opposition to cradle-to-grave thinking. Here's what the terms mean:

- **Cradle-to-Grave (C2G):** A linear model that begins with resource extraction, moves through manufacturing, and sees products end up in landfill. Considered an "open-loop" system that is inherently wasteful.
- **Cradle-to-Cradle (C2C):** A circular model that minimizes waste and keeps resources in use for as long as possible. Considered a "closed-loop" that promotes sustainability and strives for zero waste through reduction, reuse, and recycling.^[12]

An example of cradle-to-cradle thinking is found within the sustainable natural cycles of organic farming and composting, and this efficient process serves as the perfect archetype for the broader concept. Food is grown using natural methods without harmful chemical pesticides or fertilizers and is distributed and consumed (ideally using carbon-neutral distribution channels and reusable/compostable packaging). Once consumed, any food waste is composted, closing the loop as the compost contributes to the growing of more food. However, while this simple and elegant example of the cradle-to-cradle concept works well with organics, when it comes to more complex products there is a clear need to reevaluate our approach. Here, the *zero waste hierarchy* comes to light, essentially expanding the 3R's (reduce, reuse, recycle) to encourage policy-making, activity, and investment in systems that promote the cradle-to-cradle concept. The zero waste hierarchy describes a progression of policies and strategies to support the Zero Waste system, from highest and best to lowest use of materials.^[13] Understanding these green concepts and putting them into practice is a great way to help eliminate waste and create a brighter future for generations to come.

The 5 R's Of Zero Waste Living

The new recycling hierarchy expands the 3R's (Reduce, Reuse, Recycle) to 5R's. The 5R's stand for refuse, reduce, reuse, repurpose, and recycle. The 5R's function as guidelines for a less wasteful, more sustainable life. According to the 5 R's, four actions should be taken, if possible, prior to 'recycling': refuse, reduce, reuse, repurpose, and *then* recycle.^[14] Incorporating this methodology into household or business' waste reduction and recycling efforts will minimize landfill waste and help take the recycling program to the next level.

How To Implement The 5r's: Refuse, Reduce, Reuse, Repurpose, & Recycle

The Five R's refer to the guiding principles for reducing the

waste we output, and they follow a specific order. Here's the 5R's hierarchy and more information on each of the R's^[16, 17, 18]

Refuse: is the first step of the 5R process. It is the leading principle that urges us to refuse anything we don't really need. Refusing to use single-use plastics or wasteful, non-recyclable products is most effective way to minimize waste. Following are a few good examples of refusing:

- Save up to thousands of bottles and cans per year and use refillable bottles instead of buying single use beverage containers
- Use cloth bags at stores and just say NO to paper and plastic

Reduce: is the second step of the 5R process. Reduce refers to the reduction of harmful, wasteful, and non-recyclable materials. By reducing waste, we avoid the unnecessary use of resources such as materials, energy and water. It means there is less waste to manage. Reducing helps to save money as well as benefits the environment. Following are a few ways of reducing

- Buy in bulk to reduce packaging
- Take a reusable shopping bag with you so you don't have to use a paper or plastic bag from the shop
- Say 'no' to a plastic shopping bag when you only have a couple of items
- Choose products that use less packaging
- Buy reusable items rather than disposable ones
- Stick a "no junk mail" sign on your letter box
- Take your lunch to school in a reusable container
- Copy documents on both sides of the paper instead of single-sided copying

Reuse: is the third step of the 5R process. Reusing waste material helps to save money, energy, and resources that would have been used to make the new product. Whenever possible, reuse any material or product you can before giving it away or recycling it. Following are a few ways of reusing:

- Give unwanted toys and books to hospitals or schools
- Put unwanted clothes in used clothing bins
- Use plastic containers for freezing or storing food items
- Save wrapping paper and boxes to use again
- Use old jars for storage
- Take old magazines to your local doctor's or dentist's surgery
- Shop at second hand stores or use online trading websites to buy items that are unwanted by others
- Take household items to your council's resource recovery centre
- Make memo pads out of waste paper
- Re-use envelopes and purchase reuse labels.
- Share gently used clothing and toys your children have outgrown with friends and family
- Consider reusing binders, manila folders, and mailing envelopes

Repurpose: is the fourth step of the 5R process. The idea of repurposing involves taking items that were meant for one purpose but can be used for other ones. This is also known as upcycling in the green or environmental circle. It often requires thinking outside the box. It is important to note that repurpose come before recycling, and this means that

whenever possible, we should see if items can be repurposed. Following are a few ways of repurposing:

- Use old glass jars to store dried food items
- Donate clothing, toys, household items, etc. to thrift stores
- Decorate old glass jars and reuse it as a flower pot
- Reuse the eggshells as planters
- Recycle old cloth into an attractive bag

Recycle: The final step in the 5R process is recycle. Recycling is a form of waste management that involves converting waste and other used materials into reusable products. Recycling has a plethora of advantages to humans and environments. ^[15] Recycling helps to reduce energy usage, reduce the consumption of fresh raw materials, reduce air pollution and water pollution (from landfilling) by reducing the need for “conventional” waste disposal and also reduces greenhouse gas emissions. The main products that can be recycled are paper, cardboard, glass, aluminium, tin and plastic containers. Composting and worm farms are methods of recycling organic waste. Recycling of organic matter leads to the generation of valuable compost, which serves as plant fertilizer.

After one has made quality efforts to go through all the previous steps from the five R's, recycling is a great final option. Following are a few good examples of recycling:

- Buy in bulk to eliminate excess packaging that needs to be recycled
- Recycle your bottles and cans at a local buyback center
- Get off all the junk mail lists you are on

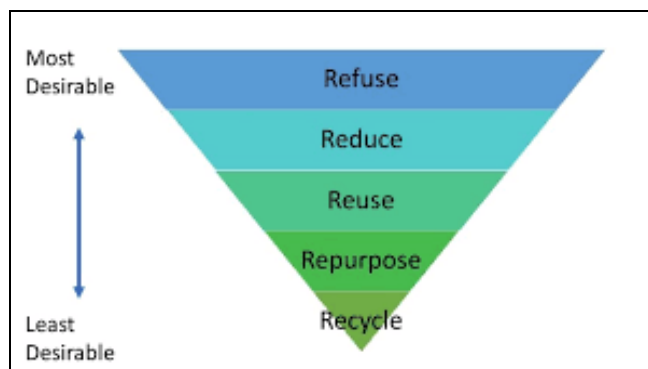


Fig 1: 5R's of Zero Waste Hierarchy

By following the 5R's and their order, we can start taking steps towards reducing our waste and our impact on the planet! We don't have to abide by them perfectly, but they're worth keeping in mind as we go about our day making choices that effect the health of the earth. The order of the R's matters too! They are intentionally structured, starting with the most impactful, to help us make informed decisions to achieve a more sustainable lifestyle, one step at a time.

Conclusion

Solid waste management affects every single person in the world, whether individuals are managing their own waste or governments are providing waste management services to their citizens. Waste management is imperative for the benefit of individuals and nature. Usually, the waste is produced from industrial, residential, and business activities that can be managed in a variety of ways. Solid waste

management comprises of practices and activities required to handle waste from its origin to the final disposal. As we know, solid waste management is a critical aspect of ecological hygiene; it must be included in environmental protection programs. Organizations should conduct awareness programs to spread the word regarding the importance of waste management and their end impact towards the climate. The zero waste hierarchy refers to the 5R's which classifies waste management strategies according to their desirability in terms of waste minimization. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of end waste. As citizens of a society we have a responsibility to manage our waste sustainably. We can do this following the 5R's of waste management: refuse, reduce, reuse, repurpose, and recycle. Now you know what the 5 R's are, you can make better choices. Remember that they go in order. Refusing and reducing means you're bringing less into your home. Reusing means you're keeping new things from being made and old things from being wasted. Practice the first three R's and you'll automatically have less stuff to recycle and rot. Last but not the least, awareness is the very first step to manage the solid waste in order to ensure ecological best practices.

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