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Zero Waste: An Approach To Sustainable Waste Management- A Review

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Abstract

Rapid urbanization, booming economy, increasing population, and the rising quality of life in the world has greatly accelerated global solid waste generation. Solid waste is amongst the major environmental issues because of its management involving a constant decline of available finite resources, leading the world to an unstable future. In order to avoid further decline of global resources, strategic waste management system and sustainable consumption would be needed. One approach suggested to address these concerns is the "Zero Waste" concepts. The Zero Waste Approach was formulated with the goal of promoting the efficient use of resources; consumption and production at the highest possible level of waste recycling. The concept of zero waste (ZW) constantly encourages both consumers and producers to implement sustainable strategies to reduce their expenses and contribute to a better environment. With the reusability and recycling of the generated waste in another manufacturing process, sustainable production theories, use of optimization tools, and development of precision manufacturing systems, etc., zero waste management can be supported. It is still difficult to transform currently over-consuming practices into zero waste. Taking into account the growing and serious concern about solid waste issues and the urgent need for a comprehensive approach to their management, this study concluded a literature review on 'Zero Waste'.

Keywords: *Zero Waste; Reduce; Recycle; Waste Management; Reuse*.

1. Introduction

Waste is an indicator of lack of efficiency of modern society and a representation of misallocated resources. With the generation of large solid waste, a huge amount of natural resources is wasted on a regular basis. The generation of any waste uses water and energy, puts pressure on the land resources, contaminates the environment and ultimately generates extra economic costs for waste management. The large amount of waste has also put enormous pressure on the authority to handle waste more sustainably. SWM is essential and significant when the structure of society shifts from low density and widespread agricultural population to urban, high density population [1]. The waste we generate these days comes from multiple sources which are damaging environment and are very expensive to be managed efficiently. The wide variety of waste stream leaves decision-

makers with no choice but to select environmentally polluting and inefficient approaches for waste management [2].

The scarcity of Planet's resources and the exponentially increasing amount of waste generated necessitate a reduction in waste, which ultimately makes reuse and recovery of waste products an urgent requirement of economic interest. In contrast, innovative waste management is on the way of introducing the principle of ' zero waste ' instead of waste disposal [3].It is an idea that enables the resource life cycle to be optimized in order to reuse all goods. Zero waste focuses primarily on the systematic design and management of products and processes to eliminate waste and to preserve and recover all resources from the waste stream. Waste is a social issue that we have created, so it is our responsibility to make it zero by using modern technology. Zero Waste Management (ZWM) addresses the goal to reduce resource use or decrease consumption by society and maximize the usages of R's of waste management such as repair, reuse, regeneration, redesign, replication, resale and reduction. Zero waste implies diversion of municipal solid waste from landfill by waste recycling, which can only be done if the integrated waste management approach and some innovative strategies are added to the existing SWM framework [4].

2. Strategies To Achieve Zero Waste

To order to develop and carry out waste management operations, a strategic zero waste system (ZWF) is necessary. The main aim of zero waste management is (i) Sustainable production by designing the cradle to cradle approach and managing the product; (ii) responsible and collaborative consumption of natural resources; and (iii) Zero waste management through resource conservation and more importantly is to implement these all principal effectively and environmental friendly [8]. The 3R principles of waste management (re-use, recycling, and reduction) are amongst the top 3 in the hierarchy of solid waste management and they are regarded as the founding principles of the system of sustainable waste management. The "3R" principles of waste management have been applied to 5 steps of the waste hierarchy in the European Union Waste Framework Directive 2008: waste disposal, reuse, prevention, recovery and recycling [8].

2.1 Engage the whole community

It is not only the duty of waste experts to engage themselves in waste management issues but every citizen needs to take a leadership role in organizing meetings and engage all sectors of the community**.** All organizations (business, non-governmental organizations, governmental, grassroots movements,) that provide waste takeback, reduction, recycling, composting, and reuse services should be taken into consideration so as to achieve ZW. All these groups and individuals should be encouraged to embrace Zero Waste at college, home, university, play, and work as their communities create long-term programs and policies for the community as a whole. Current service providers should be asked to take ZW as their goal and take advantage of opportunities to provide local retailers and manufacturers with take-back services, reduce waste, and help businesses and

communities reach Zero Waste. Communication with all areas of the society should be ongoing in all stages of the Zero Waste Project preparation and implementation [8].

2.2. Educate residents, businesses and visitors

Zero Waste is a strategy which aimed at improving organisation, better industrial design, and better education. In order to achieve the cultural change needed to reach Zero Waste, communities need to create strategies to train and educate residents, college students, school children, visitors, and businesses about new rules and programs [8].

2.3. Demand decision makers manage resources not waste

There must be a closure of existing incinerators and no new ones should be built. Landfill processes must be reformed in order to prevent all water and air pollution, including pre-processing of all residues at landfills before their burial so as to stabilize the organic fraction and prevent the production of methane gas and the use of waste separation. Landfills are a major source of GHG's (especially CH4, which heats up the atmosphere 23-72 times faster than CO2) as well as ground contamination. Thermal treatment and incineration technologies such as gasification, biomass burners, plasma arc, cement kilns, pyrolysis, using waste as fuel, and power plants are an indirect and direct source of GHG's to the atmosphere [13].Not incinerators nor landfills are a suitable response to the peak oil problem, which will make any new incinerator impractical in its lifetime, as embedded oil and energy will become too expensive to replace. It is possible to save more energy and reduce the impact of global warming by reusing goods, reducing waste, composting, and recycling than can be generated by burning discards or recovering gases from landfill. Communities should make every effort to bring in new incinerators and replacing existing incinerators and landfills with ZW programs and policies, including resource reuse, composting, and recycling facilities [12].

2.4. Develop New Rules and Incentives to move towards Zero Waste

Subsidies / Incentives can be provided to individuals or communities working on Zero Waste Strategies. With new incentives, new policies, and new rules, communities can change significantly what is "economic" on the local marketplace. Communities should restructure policies and contracts to make the avoided costs of disposal and collection a main driver for moving towards ZW [12].

2.5. Perform Zero Waste Assessments

A waste audit should be conducted to find out the type and amount of waste being generated in their locality. This audit further will help us determine opportunities for recovery and jobs, save costs, and assess the progress of the recovery and reduction programme [12].

2.6. Adopting 3 R's of waste management

Minimizing resource utilization in the distribution, manufacture and use of products consumed by community with maximum recycling, reuse and recovery has been embodied as a 3R concept. Due to the higher levels of pollution and declining natural resources in the environment, the 3Rs principle has commenced to gain more attention in recent days [13]. The waste management perspective has been shifted. It's not seen as an issue but as an opportunity. Reduce, recycle, and reuse is the idea that wherever people begin to understand and apply themselves to regular life, they need to marinate a sustainable life [13].

Reduce, reuse and recycle is a concept that people everywhere are starting to understand and apply to everyday life. Its principles are quite basic, but are a necessity for maintaining a sustainable life. To remain productive reducing one's intake of energy and materials is vital. The toxicity of trash is at an all time high and the only way to stop this is by preventing waste from the v

2.6.1. Reduce

Minimization and reduction requires all measures intended to reduce the production of waste. Limiting the amount you purchase is the most effective of all waste management options. Waste minimization is one of the most significant approaches for achieving sustainable development. In practice, waste can be minimized by carrying out life-cycle analyzes [9]. Such types of analyses have been used in different areas and on any level – in a manufacturing plant, for example, or in a single-family household. There are a number of benefits that can be achieved in attempting to prevent waste. There are two important advantages: environmental and economic benefits [9]. The key is to buy only those goods which we need and in the proper amount. In the first place, if we never produce products, we do not need to extract raw resources, use additional shipping resources, produce shipping materials, manufacture goods from scratch, and then devise ways to dispose of them [14].

2.6.2. Reuse

Reuse is the practice of "reusing" a discarded material or product, but reuse needs to be in its original state either in the same manner for which it was manufactured or in a new manner, but without any chemical or physical changes. Although this strategy has different applications and can result in substantial savings but it has certain limitations, particularly those relating to sanitation and public health [9]. Reuse provides many economic, environmental and cultural benefits as long as the reuse programs are well-considered. Reuse was practiced worldwide in a variety of situations several years ago; however, fads, labor costs, and other factors in many countries led to this practice being abandoned. The implementation of this concept can also lead to job creation, significant decline in the requirement for raw materials, and of course, a reduction in the quantity of products dumped in a landfill or partially destroyed in a thermal conversion facility [9]. In recent years, the usefulness of this issue has become even more evident, given that universities and schools alone generate almost 3.6 million tons of waste annually, representing 2% of the total waste in the country. Within the school setting, almost half of all waste generated is produced from paper. As a

school, we can save even one ton of paper, which would save 3 cubic yards of landfill space, 17 mature trees, and 7,000 gallons of H2O. From the point of view of reuse, paper conservation can often go far beyond simply placing a paper recycling bin [15].

2.6.3. Recycle

If it is not possible to apply reuse and reduction, then recycling will be the next option available. Recycling the discarded materials is the method by which the materials are recovered and processed to turn the goods into new products. The recovered materials can be processed either chemically or physically to salvage valuable components in the recycling option [11]. Thermal treatment and recycling are certainly the most broadly used methods of treatment in industrialized countries, whereas different low-tech recycling methods in developing countries are the most common treatment methods [11].

2.7. Composting

Composting is the method through which diverse aerobic micro-organisms decompose raw organic material in order to obtain material and energy which they needed for reproduction and growth. The stable by-products of this process, the biomass of living and dead microorganisms and the undegradable parts of the raw material form the end product known as compost [16].

Table 1. Optimum conditions for composting

Parameter	Condition
C:N Ratio	25-40:1 target=30:1
Moisture	50-60%
Temperature	130-150 degree F
Oxygen	5-10%
Particle Size	½-2 in
Initial bulk density	<1,100 lbs /yd ^{3}
pH	6.5-8

The organisms which are responsible for composting need to function and survive under certain environmental and nutritional conditions. They require appropriate quantities of micro and macro nutrients, water, and oxygen. These organisms have optimal growth rates only in certain pH and temperatures ranges [14]. This process is performed by a diverse population of primarily aerobic micro-organisms that break down organic material in order to grow and reproduce. Micro-organisms activity is facilitated by the management of the compost pile's carbon-to-nitrogen ratio, moisture content, oxygen supply, pH, and temperature. Composting that is managed properly enhances the rate of natural decomposition and produces enough heat to kill pathogens, weed seeds and larvae [12].

Table 2. Typical C: N Ratio of common backyard compost ingredients.

Ingredient	C:N Ratio*
Wood Saw dust	500:1
Waste paper	400:1
Straw	80:1
Dry leaves	60:1
Cornstalks	60:1
Shrub trimmings	50:1
Fruit wastes	35:1
Rotted manures	20:1
Grass clippings	17:1
Kitchen scraps	15:1
Vegetable culls	12:1
Chicken manure	8:1

*The C: N ratio of all the materials can vary considerably depending on age and source.
(Source: msstate.edu)

3. Benefits From The Implementation Of ‘‘Zero Waste”

When applying zero waste techniques, the advantages can be divided into various categories. In reference to the environmental benefits, material which is recovered from waste stream would compensate for the extraction of the equivalent material amount and would ultimately avoid GHG emission, energy and water consumption during the extraction process [5]. As a consequence, there will be no waste left for littering or landfills [5]. The zero waste programs have created many employment opportunities. It could reuse a huge amount of waste products and produce new materials from them. An outlet for the sale of products has been established [6]. In terms of community benefits, there is an incentive for public participation to help implement ZW, complemented by changes in people's mindset around waste disposal attitudes and consumption patterns. In addition, the introduction of ZW-related activities greatly minimizes the public health risks and promotes employment opportunities through recycling and the development and integration of separation and waste collection practices [7]. In terms of Industry and its shareholders, diverse benefits includes increased productivity and efficiency more with less; improved design of products in order to extend life cycle; Increasing the competitive potential of companies by customers satisfaction and improved reliability; Incentive for the establishment of a sustainable chain of suppliers; and Practices of industrial symbiosis where companies supply other companies with their waste and vice versa [7].

4. Conclusion

With rapid globalization and economic growth, a huge amount of solid waste has been produced and has attracted attention globally due to its potential impacts on the environment and waste of resources from the activities such as transboundary movement of industrial waste, illegal dumping,

the food loss, the informal recycling of e-waste, and GHG emission. Presently, we are facing more critical issues in reference to the handling of solid waste than the earlier days and how to deal with solid waste problems draws the major challenge worldwide. The "Zero Waste" approach is an efficient way to resolve the issues related to solid waste. Zero waste is intended to encourage the redesign of resource life cycles in order to reuse all the products. Based upon the literature review, this study concludes that there are varied options available to adopt ZW but its implementation is still in development. However, in terms of its practicality and implementation practices, we need to redevelop the integrated zero waste strategy

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