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EFFICIENT WASTE MANAGEMENT IN THE FOOD INDUSTRY: A REVIEW

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Abstract

One of the main issues facing the food industry is waste management, particularly in light of the stringent rules and regulations established by the federal, state, and local governments to preserve and protect the environment. Because of its latently pathogenic nature, unstable autoxidization rate, and potential to become a biohazard due to its high level of perishability and enzymatic activity, managing food waste is difficult. Waste products from the food industry must be disposed of, contributing to environmental pollution. Combining abilities and knowledge in the physical sciences, engineering, economics, ecology, human behaviour, entrepreneurship, and good governance are necessary for sustainable waste management. Thus, this paper examines some best waste management practices to reduce waste in the food industry and environmental pollution.

Keywords: Waste Management, Food Waste, Food Industries, Environmental Pollution.

Introduction

Unwanted materials that are thrown away from a variety of sources are referred to as waste. Anything deemed useless but created by the same process that creates helpful things is considered waste (Tobias *et al.*, 2014). It might be a waste product from homes, businesses, industries, agriculture, municipalities, mines, or other endeavours, pursuits, or sources. Something is typically considered waste and discarded when it is unwanted or no longer useful. Since so many authors have written about waste, there are various perspectives on what it is. Waste is defined by Gilpin (1976) as a material with a solid or semi-solid character that the possessor no longer thinks is valuable enough to keep. According to Jennifer and James (2010), waste is any material that has been used but has been rejected as useless or unwanted.

However, the meaning of "waste" can vary depending on whom you ask, because what one person considers waste may not be waste to another. To put it another way, not all waste is completely useless. What is typically regarded as waste may no longer hold, according to Odocha (1994), since such materials can be recycled to create other products. The situation in some nations where waste recycling has solidified as a component of waste management strategies supports the author's position. For instance, waste scavengers are frequently seen in Nigeria rummaging through waste piles for various items, including plastics, batteries, used auto parts, other metal junk, and the like, which are then sold to the parent smelting company. These items are eventually transformed into crucial raw materials for fabricating various plastic, metal, or other equivalent goods for use in homes and/or industrial applications or uses. Environmental science and technology intervention in food production should improve these archaic waste management methods (USDA, 2010). One such environmentally friendly measure is efficient waste management, especially regarding agricultural and food processing wastes (Tobias *et al.*, 2014).

The kind of activities people engage in and the amount of waste they produce in those areas have an impact on the quality of the surrounding environment and the health of the local population. Tropical environments, where a variety of environmental media are loaded with various pollutants, the majority of which are frequently provided by waste, show the dynamics of the relationship between the environment and health. Municipal waste is without a doubt Nigeria's most glaring and serious environmental issue given the mountainous piles of waste (particularly refuse) that are typical sights in the majority of her urban cities, littering the roads and defacing the landscape with various public health implications (Ezejiofor *et al.*, 2013).

Households, agricultural farms, and industries, including those engaged in the industrial processing of agro-food, all produce waste (Tobias *et al.*, 2014). During their daily operations, agricultural activities generate a variety of wastes, including biological waste, solid waste, hazardous waste, and wastewater (South Pacific Applied Geosciences Commission [SPAGC], 2013). To safeguard the community's residents as well as the environment, these wastes must be properly identified and managed. Waste is a direct result of human technological and social progress. Anthropogenic activities, particularly industrial development and innovation, are directly linked to waste materials. As a result, the compositions of various wastes have changed over time and place. Different nations, industries, and organisations have adopted different waste management strategies at different times, and each of these has implemented a different level of technology, depending on what is available and accessible at the time in terms of available technology, and this too is defined by the availability of financial and other resources, as well as the level of education and knowledge of operators (Tobias *et al.*, 2014). Any improper management of waste, including but not limited to improper application of available technology, would undoubtedly have a variety of adverse effects on the environment as a whole. When this happens, the resulting pollution negatively impacts the terrestrial, aquatic, and arboreal aspects of the environments and the species that live there (Tobias *et al.*, 2014).

Thus, this paper explores waste management practises as a way of reducing environmental pollution and waste in the food industry.

Brief History of Waste Management

Premodern times saw minimal human waste production due to low population density and resource exploitation. Ash and biodegradable waste were the main types of waste produced, and wooden or metal tools were typically reused or handed down from generation to generation. This led to a rapid decline in sanitation standards and the general quality of urban life. Corbyn Morris proposed in 1751 to create a municipal authority with authority to remove waste, which was the first to call for the creation of a municipal authority with authority to remove waste. Edwin Chadwick's 1842 report, the Sanitary Condition of the Labouring Population, argued for the importance of adequate waste removal and management facilities to improve the health and well-being of the city's population, leading to legislation on the subject in the mid-19th century.

The Nuisance Removal and Disease Prevention Act of 1846 and the Public Health Act of 1875 made it mandatory for households to deposit their weekly waste in "moveable receptacles" for disposal. The Metropolitan Board of Works was the first city-wide authority to centralise sanitation regulation. Incineration plants were developed due to the increase in waste, but were met with opposition due to the large amounts of ash they produced. New York City became the first U.S. city with public-sector garbage management in 1895. Early garbage removal trucks were open-bodied dump trucks pulled by horses. Motorized in the early 20th century, close-body trucks with a dumping lever mechanism were introduced in the 1920s. The Garwood Load Packer was the first truck to incorporate a hydraulic compactor in 1938.

Type of Waste Generated by Food Service Operations

Food waste

Pre-Consumer food waste is discarded by staff within the control of the food service operator, including overproduction, trim waste, expiration, spoilage, overcooked items, contaminated items and dropped items. It also includes items on cafeteria stations such as salad bars, steam wells, self-serve deli stations, misordered product and expired grab & goes items. Leftover catering items are pre-consumer waste if they remain on the catering line and have not been received by an individual customer. Pre-consumer waste offers opportunities for waste reduction and cost savings (LeanPath, 2014). Post-Consumer food waste is discarded by customers, guests, students, patients, and visitors after the food has been sold or served. This waste is sometimes referred to as "plate waste" or "table scraps", and the decision to discard it (or leave the food on the plate) is made by the consumer rather than the food service operator. Post-consumer food waste can be reduced through smaller portions and awareness programs (LeanPath, 2014).

Packaging waste

Inbound supply chain waste refers to palettes, cans, cartons, plastic wrap and other materials used to package supplies and food (LeanPath, 2014). Packaging waste is waste associated with packaging and serving food to guests. Commonly wasted items are clam shells, hot and cold cups and disposable trays.

Operating supplies

Front-of-the-house operating supply waste can include napkins, disposable cutlery, portion-controlled condiments and table linens. Back-of-the-house operating supply waste can include towels and rags, expired seasoning and paper.

Types and Reuse Potentials of Food Processing Wastes

Lignocellulosic wastes

Lignocellulosic wastes are fibrous remnants of forage grass and cereal and vegetable wastes, primarily made of cellulose, hemicelluloses, and lignin. They are the most prevalent agricultural wastes and contain close to 50% cellulose, with hemicellulose and lignin making up the remaining content nearly equally. However, their low protein, vitamin, oil, and other nutrient content and limited digestibility and palatability to ruminants limit their use in animal feeding. However, after protein enrichment, they can be used for animal nutrition by using a variety of microorganisms like fungi and bacteria. Solid Substrate Fermentation (SSF) has been prioritised in most efforts in this direction (Tobias *et al.,* 2014). Wastes have been used as primary raw materials and as a carbon source for the fermentation-based production of feed-related products, as well as protein enriching them for use in ruminant nutrition. Pre-treatment processes such as steam explosion, acid, alkali, peroxide treatment, gamma irradiation, combinations of two or more, and enzymatic treatment using cellulases, hemicellulases, and ligninases have been used to select the microbial type that will grow on lignocellulosic wastes (Tobias *et al.,* 2014).

Protein enrichment of agro-food waste can be accompanied by the economic extraction of valuable biochemicals. The production of protein-enriched lignocellulosic waste has been associated with the reduction in the content of lignocellulose. This process improves palatability, acceptability and digestibility of treated wastes for ruminants due to the enzymatic disintegration of the plant cell wall. The low technology and reduced reactor volume employed in the SSF process can be easily adapted for use in less affluent farm communities (Misra et al., 2007).

Animal residues

Animal waste has been used to produce methane, sugars, alcohols, char, oil, and gaseous fuels. The biochemical process produces methane, while the thermochemical process produces char, oil, and gaseous fuels. Animal blood from slaughterhouses has been reported to have nutritional value and is primarily used as a source of protein. The drawback of the thermochemical process is how much moisture must be eliminated (Tobias *et al.,* 2014). Blood char is an industrial decolorant made from animal blood. Blood albumin is an affordable alternative to egg albumin powder and is used to create lighter-coloured protein finishes for leather. It is water soluble and can create highly tacky solutions with strong adhesive properties. Heat or formaldehyde treatment can make the substrate joints that are adhered with blood albumin-based adhesives water-resistant (Tobias *et al.,* 2014).

Industrial food processing waste

Industrial Waste products from the food processing industries have not been recycled or put to other uses. This includes peels, stones, fibres, skins and hides, blood, fats, horns, hoofs, hair, feathers, shells, bones, liver, and intestines. In the course of preparing and eating food, catering services, businesses, canteens, and households all produce food waste. Some of these waste materials are useful, while others are not. The nature of the product and production method used affect the composition of waste leaving food processing facilities. Waste may vary from site to site and season to season, and its volume and concentration may not be constant. This can make it difficult to manage a consistent working process. The following traits are typically present in wastes from the food processing sector (Tobias *et al.,* 2014):

a) Large amounts of organic materials such as proteins, carbohydrates and lipids.
b) Varying amounts of suspended solids depending on the source.
c) High biochemical oxygen demand (BOD) or chemical oxygen demand (COD).

Food wastes are harmful to the environment and human health, but they have a higher potential for use due to their rich organic matter and fat. However, if there are suitable technical means for reusing them and the value of the following products outweighs the cost of reprocessing, these wastes could be valuable by-products (Tobias *et al.,* 2014). Tables 1 and 2 below summarise the wastes produced by various food processing industries and the potential applications for wastes produced by various agricultural products during food processing.

Table 1: Various wastes generated by food processing industries

Type of Food Processing Industry	Waste Materials
Animal products	Skins, hides, blood, fats, horns, hairs, bones, liver, intestines
Poultry processing	Skin, blood, fats, hairs, feathers, bones, liver, intestines, wings, trimmed organs
Marine products processing	Shells, roes, trimmed parts, pincers.
Cereals and pulse processing	Husk, hull, chaff, stalks.
Fruits and vegetable processing	Skin, peels, stones, fibre, pith.
Nuts	Shells, coir, pith.
Spices and condiments	Hulls, stalks.

Source: Rao, (2010).

Table 2: Products from Wastes generated from the Harvesting and Processing of Some Agricultural Produce

Agricultural produce	Residue/Wastes generated	Potential use of residue
Corn, wheat, rice	Straw, stalks, husks and cob	Animal feedstuff, fuel, silica, Furfural, compost, chemical feedstock
Cattle	Animal waste e.g blood, bone, dung	Animal glue, animal feed supplement, methane production, activated carbon, manure
Sugarcane	Bagasse	Fuel, furfural, animal feed, particle boards, biopolymers
Fruits and vegetables	Seeds, peels and husks	Animal and fish feed, fuel compost and fermentation
Oils and oil seeds	Shells, husks, fibres, sludge, Press cake	Animal feed, fertilizer, fuel, activated carbon, furfural
Coconut	fibres, shell	Resins, pigments, fillers, mats, activated carbon, tanning materials.

Source: Akaranta, (1996); Tobias *et al.,* (2014).

The domestic food wastes

Domestic food waste is composed of various materials, such as starch, cellulose, protein, water, oil, fruit, vegetables, rice, fish, meat, bones, and eggs. It contains high salt, lipids, and moisture levels, and is a breeding ground for rats, houseflies, mosquitoes, other vectors, and vermin. Untreated food waste can contain pathogenic microorganisms such as Salmonella sp., *Staphylococcus aureus, hepatitis viruses*, and other pathogenic microorganisms. The food industry produces large amounts of solid and liquid waste due to food production, preparation, and consumption. Food wastes leak during storage, collection, and transportation, polluting the environment. If dumped carelessly, they take up much space on the ground and produce toxins and stench gas that pollute the water and the air. If dumped directly into the sewers, it will result in a blockage, seriously degrading the city's appearance and environmental sanitation (Lan *et al.,* 2012).

These wastes consequently represent a loss of valuable biomass and nutrients, present mounting disposal issues, and may even pose serious pollution risks. However, in addition to their potential for pollution and hazards, food processing wastes frequently have the potential to be transformed into valuable byproducts of higher value, or even into raw materials for other industries, or used as food or feed after biological treatment (Tobias *et al.,* 2014).

Central Principles of Waste Management

The waste management hierarchy

Waste management is the "generation, prevention, characterization, monitoring, treatment, handling, reuse and residual disposition of solid wastes". The waste hierarchy refers to the "3 Rs" reduce, reuse and recycle, which classify waste management strategies according to their desirability in terms of waste minimization. The hierarchy is represented as a pyramid, with policy taking action first to prevent waste generation, then reducing waste generation, recycling, material recovery and waste-to-energy, and disposal in landfills or through incineration without energy recovery. The hierarchy represents the progression of a product or material through the sequential stages of the pyramid of waste management, representing each product's latter parts of the life cycle (United Nations Environmental Programme [UNEP], 2013).

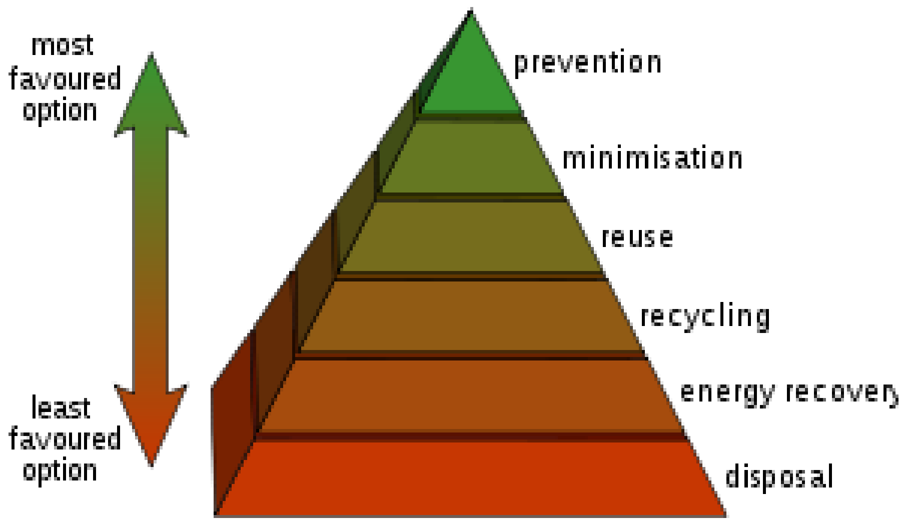

Figure 1: The Waste Management Hierarchy
Source: UNEP, (2013).

Waste prevention

Waste legislation aims to prevent waste generation through three types of practical actions: strict avoidance, reduction at source, and product reuse. It also includes the avoidance of hazards and risks, as safety is of major concern. Waste minimization is the top of the hierarchy of waste management options, which includes strict avoidance, reduction at source, and product reuse (Riemer & Kristoffersen, 1999);

a) Waste prevention i.e. reduction of waste by application of more efficient production technologies.
b) Internal recycling of production waste.
c) Source-oriented improvement of waste quality, e.g. substitution of hazardous substances.
d) Re-use of products or parts of products, for the same or other purpose.

Waste reduction

Source reduction is the most effective way to manage waste. By designing systems and policies to prevent, minimize or avoid waste in the first place, we can save food and labour dollars while making the most significant positive impact on the environment. By preventing waste, we are not spending money on raw materials, labour costs associated with handling or processing these materials, and hauling and landfill fees associated with recycling, composting or disposing of the waste (LeanPath, 2014).

Waste reuse

Waste Reuse is the next best option after source reduction. With reuse, you find a secondary way to obtain value from an item that would otherwise be wasted. In food service, the most common reuse opportunities involve.

a) Redeploying overproduced food elsewhere on the menu (provided you comply strictly with food safety guidelines) and

b) Donating to a food recovery program that will provide it to those in need. In certain jurisdictions, food can also be donated to feed animals provided it is handled and treated correctly (LeanPath, 2014).

Waste recycle/compost

Recycling/Composting is a good final option prior to disposal, as it diverts waste from the landfill or elsewhere in the solid waste stream and ensures ongoing value when the item is converted into something useful. Resource recovery is the systematic diversion of waste intended for disposal for a specific next use, and is cost-effective. It decreases the amount of waste for disposal, saves space in landfills, and conserves natural resources (Wickpedia, 2021).

a) Life-cycle of a Product: The life-cycle begins with design, then proceeds through manufacture, distribution, use and then follows through the waste hierarchy's stages of reuse, recovery, recycling and disposal. Each of the above stages of the life-cycle offers opportunities for policy intervention, to rethink the need for the product, to redesign to minimize waste potential, to extend its use. The key behind the life-cycle of a product is to optimize the use of the world's limited resources by avoiding the unnecessary generation of waste (UNEP, 2013).

b) Resource Efficiency: The current global economic growth and development cannot be sustained with the current production and consumption patterns. Globally, we are extracting more resources to produce goods than the planet can replenish. Resource efficiency is the reduction of the environmental impact from the production and consumption of these goods, from final raw material extraction to last use and disposal. This process of resource efficiency can address sustainability (UNEP, 2013).

c) Polluter Pays Principle: The Polluter Pays Principle is a principle where the polluting party pays for the impact caused to the environment. With respect to waste management, this generally refers to the requirement for a waste generator to pay for appropriate disposal of the unrecoverable material (UNEP, 2013).

Food Processing Wastes: The Concept of Waste Minimization and Recycling

Waste recycling is a process of turning what has been considered waste into valuable products. It involves collecting discarded materials such as husks, peels, poultry droppings, cow dung, biomass, etc., processing them, and turning them into new products. The essence of recycling is to minimize the quantities of waste exposed to our environment and the consequent health hazards. According to Safeguard International Training Institute (2001), waste minimization is at the top of every version of a waste management hierarchy worldwide. Waste recycling aims to put what has been discarded as waste into another helpful product. According to Gillian (1992), there are six benefits of recycling wastes;

1. It reduces the amount of waste requiring disposal.
2. It saves natural resources including non-renewable resources such as petroleum.
3. It reduces the amount of energy needed to manufacture new products.
4. It reduces pollution and destruction caused while obtaining new raw materials.
5. It provides employment opportunities.
6. It helps the national economy because fewer raw materials have to be imported.

Food wastes as substrates for the production of different types of enzymes

The use of agro-food residues to produce enzymes via Solid State fermentation (SSF) has gained renewed interest from researchers as it solves the solid waste disposal problem and produces less wastewater. Agro-industrial residues are the best substrates for SSF processes, as they undergo complex microbial degradation and transformation by various microbiological processes. These substrates have been used to cultivate microorganisms to produce enzymes (Tobias *et al.*, 2014). Substrates used include sugar cane bagasse, wheat bran, rice bran, maize bran, gram bran, wheat straw, rice straw, rice husk, soy hull, sago hampas, grapevine trimmings dust, sawdust, corncobs, coconut coir pith, banana waste, tea waste, cassava waste, palm oil mill waste, aspen pulp, sugar beet pulp, sweet sorghum pulp, apple pomace, peanut meal, rapeseed cake, coconut oil cake, mustard oil cake, cassava flour, wheat flour, corn flour, steamed rice, steam pre-treated willow, starch, etc (Mekala *et al.,* 2008; Sukumaran *et al.,* 2009). Wheat bran, however, holds the key and has most commonly been used in various processes. Table 3 below summarises some solid waste and the potential enzyme that can be produced.

Table 3: Spectrum of Waste substrates employed for production of various Enzymes in solid state fermentation systems

Substrate	Enzyme
Wheat bran	β -xylosidase, β-glucosidase, xylanase, cellulase, acid protease, α-amylase
Bagasse	Laccase, Mn-peroxidase, phenol oxidase, cellulase, β- glucosidase
Apple pomace	Xylanase
Wheat straw	Xylanase, CMCase, laccase, Mn-peroxidase, aryl-alcoho oxidase
Coffee processing plant waste	Xylanase, cellulase, α- arabinofuranosidase, β-xylosidase
Rice husk	Cellulase
Rice bran	Protease
Soy hull	Cellulase
Cassava waste	Xylanase, cellulose
Soybean meal	Alkaline protease
Cellulose, starch, cellulosic wastes	Cellulase, amylase, β- glucosidase
Sugar beet pulp	Polysaccharide degrading enzymes
Ligno-cellulosic materials	Various enzymes
Tea production wastes	CMCase, xylanase, laccase

Source: Tobias *et al.,* (2014).

Food wastes as substrates for the production of microbial biomass (Single Cell Proteins)

Single-cell proteins are the dried cells of microorganisms that can be grown in large-scale culture systems for use as protein for human or animal consumption. They have been used to synthesise high-protein products like cheese and fermented soybean products, and are being used to fight malnutrition and poor protein diet in third world countries. One of the most important examples is Single Cell Protein (SCP) (Tobias *et al.*, 2014).

Food processing wastes as substrates for production of animal feeds

Various food processing industries produce wastes that can be used in animal feed production. These include the palm oil/vegetable oil industry, cereal/grain processing plants, and factories that process legumes. Palm kernel cake (PKC) is usually discarded as waste, but has found use in animal feed formulation, especially for poultry. PKC is formulated with other supplements and given to birds as feed, and studies have shown that birds fed with such feeds have improved carcass weight (Tobias *et al.,* 2014). Soya bean cake obtained from extraction of soya bean milk is used in poultry feed. Cereals/grains milling factories generate waste in the form of husks and chaff, which are then processed into animal feed. Groundnut cake is obtained from the groundnut processing industry during groundnut oil production, which is then taken up by animal feed formulators for poultry feed production. Groundnut cake is rich in proteins and other nutrients the birds require for proper growth (Tobias *et al.,* 2014).

Animal products processing industries generate large amounts of bones after deboning meats, which are taken up, crushed and added to animal feeds to increase the calcium content. Pig farms use food waste from homes, restaurants, hotels and other places involved in large-scale food production, such as fruits and vegetables, solid and semi-solid food wastes. This provides a perfect avenue for disposing of domestic wastes of this nature (Tobias *et al.,* 2014).

Food wastes as substrates for making organic fertilizers

Aerobic microorganisms degrade food waste, reducing its stench and toxic and hazardous substances. Organic fertilizers, bio-organic fertilizers and soil conditioners contain a variety of plant growth-accelerating agents. Fertilizer can be used for flowers, trees, vegetables and other plants, and can improve soil structure, increase soil fertility and promote crop growth. This will reduce the burden of urban waste and promote the mass production of organic fertilizer and reduce the use of chemical fertilizers, thereby reducing pollution of soil and water (Tobias *et al.,* 2014).

Advantages of Efficient Waste Management

Waste is not something that should be discarded or disposed of with no regard for future use. It can be a valuable resource if addressed correctly, through policy and practice. With rational and consistent waste management practices there is an opportunity to reap a range of benefits. Those benefits include;

1. **Economic**: Improving economic efficiency through the means of resource use, treatment and disposal and creating markets for recycles can lead to efficient practices in the production and consumption of products and materials resulting in valuable materials being recovered for reuse and the potential for new jobs and new business opportunities (UNEP, 2013).
2. **Social:** By reducing adverse impacts on health by proper waste management practices, the resulting consequences are more appealing settlements. Better social advantages can lead to new sources of employment and potentially lifting communities out of poverty especially in some of the developing poorer countries and cities (UNEP, 2013).
3. **Environmental:** Reducing or eliminating adverse impacts on the environmental through reducing, reusing and recycling, and minimizing resource extraction can provide improved air and water quality and help in the reduction of greenhouse emissions.
4. **Inter-generational Equity:** Following effective waste management practices can provide subsequent generations a more robust economy, a fairer and more inclusive society and a cleaner environment (UNEP, 2013).
5. **Save Money:** Waste reduction allows you to save money on commodities, labour, energy and disposal costs. When you consider that 4-10% of the food you purchase will become pre-consumer waste before ever reaching a guest, it becomes clear thatwaste reduction should be one of the first and easiest ways to control costs (and hedge food cost inflation) (LeanPath, 2014).
6. **Help the Environment:** Waste leads to significant carbon emissions. In the case of food waste, farm inputs, transportation and storage each require petroleum inputs. And landfill disposal often leads to production of

methane gas, a greenhouse gas which is over 20 times more potent than carbon dioxide. By reducing foodservice waste, you can make a real environmental difference. (LeanPath, 2014).

7. **Community Engagement:** Engage staff, guests and community members by showing that waste reduction is achievable and makes a positive difference for all of us (LeanPath, 2014).

Disadvantages of Improper Waste Management

In Nigeria, large quantities of wastes are produced annually and are underutilized. This could be due to inadequate knowledge of waste disposal, management and recycling strategies. To address this, two actions are needed: changing personal and public views towards waste utilization and providing incentives to stimulate greater use of utilization technologies. This has led to dumping waste products in rivers, streams, holes, seas, etc. (Onyediran, 1997). Poor and unplanned waste disposal in rural communities can cause environmental pollution by introducing bacteria or nitrate, which are harmful to humans and animals. Odours from animal dwellings can also cause problems with neighbours and create a negative public perception. Poor disposal management and reutilization of waste can also lead to environmental pollution (Tobias *et al.,* 2014).

Conclusion

Waste production is a significant byproduct of almost every human activity, including food production and processing. Management is essential to avoid their accumulation's unpleasant effects. Unfortunately, most waste management strategies have tended to view waste as an unnecessary entity that needs to be properly disposed of. However, a close examination of most natural systems reveals that these wastes can be recycled to create other useful products. Preventing waste material from being created, also referred to as waste reduction, is a crucial component of effective waste management. Examples of ways to avoid using products include reusing used products, fixing broken items, designing products to be refillable or reusable, encouraging consumers to avoid using disposable products, removing any food or liquid remnants from cans and packaging, and designing products that use less material to accomplish the same task.

Recommendations

1. The Ministry of Environment is responsible for enlightening the public and creating awareness on the treatment and reutilization of waste, which minimises cost and ensures the health status of citizens.
2. Several concepts about waste management vary in their usage between countries or regions. The best option for waste management is to follow the golden rule of the 3 Rs Philosophy viz: reduce, reuse and recycle, whereby the waste generated is minimised and converted into an asset for reuse.
3. Since agricultural wastes are available abundantly at no or low costs, it has the potential to provide low-cost industrial raw materials and adsorbent for cleaning our environment.
4. Waste recycling should therefore aim to extract the maximum practical benefits from it and generate the minimum amount of waste.
5. Therefore, societies should be sensitised to the strategies of making waste useful for sustainable agricultural and environmental protection with the economic benefits of these recycling methods.

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