Green Manufacturing for Waste Reduction in the Food Industry

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Abstract

Going green is an inevitable manufacturing practice in the midst of growing concerns over the need to reduce environmental waste. Compared with the pre-industrialization era, the carbon footprint has increased from 228 ppm to 413.3 ppm, landfills have increased and so has the leaching of toxins into nearby water bodies. The food industry is one of the largest contributors to the current state of the environment and hence, the reality of the need for waste reduction within the industry cannot be overemphasized. This paper assesses the dairy, soft drink and bakery industries, and brings the following to the attention to the manufacturer: waste production, energy losses, pollution and its impact to the environment during each stage of the product lifecycle. Particular attention is paid to the current production processes, and these are critically analyzed, considering the raw materials, the processing, and the final products. Finally, the paper proposes solutions on the manufacturing process and on how the wastes can be avoided, reduced, reused, recycled, recovered, treated and disposed responsibly.

Keywords
Green Manufacturing, Food Industry, Waste, Sustainability

1. Introduction

Green manufacturing is a system that integrates product design and process design aspects that affect the production, planning and control in order to identify, quantify, assess and manage the flow of environmental waste, with a goal of reducing waste, maximizing resource utilization and subsequently minimizing the negative impact to the environment (Dilip Maruthi and Rashmi, 2015). It is concerned with both the process and product related impacts on the environment, and its aim is to reduce the generation of hazardous substances in both the design and manufacturing phase (Paul et al., 2014). It reduces production waste while at the same time, creating less pollution to the environment. Waste refers to anything that takes up manufacturing time and cost without adding value to the product. This can be non-value adding processes or residues from the semi-processed product. Value is what the customer is willing to pay for (Helmold, 2020). Sustainable manufacturing practices such as energy substitution, hybrid energy technologies, resource-efficient production, waste minimization, cleaner production and recycling result in a significant reduction of the manufacturing costs and improves product quality (Rusinko, 2007). The food industry plays an integral part in the wellbeing of the people. It cannot be overemphasized that without the dairy, bakery and soft drink industry life would not be the same. It is also important to note these industries have to abide by strict regulations in order to remain operational. Production cost has to be minimized in order to sell the products at a competitive price. Hence there is a need for maximum utilization of resources and minimization of waste, that is, to do more with less. As a hybrid approach, green manufacturing takes into account the environmental and economic approach (Leong *et al.,* 2019). This brings viability through environmentally friendly manufacturing processes, and it is very critical at this time when the food industry is facing pressure from supply-demand and the stringent climate change regulations. The world is ever-changing and customer needs keep on changing.

Competition for the market is becoming stiffer as companies are striving to sustain themselves and this calls for resource-efficient production and sustainable products. This paper therefore is about green manufacturing for waste reduction in the food industry.

2. Production waste

The production processes of the dairy, soft drink and bakery industries are discussed in this section following the general production flow in Figure 1.

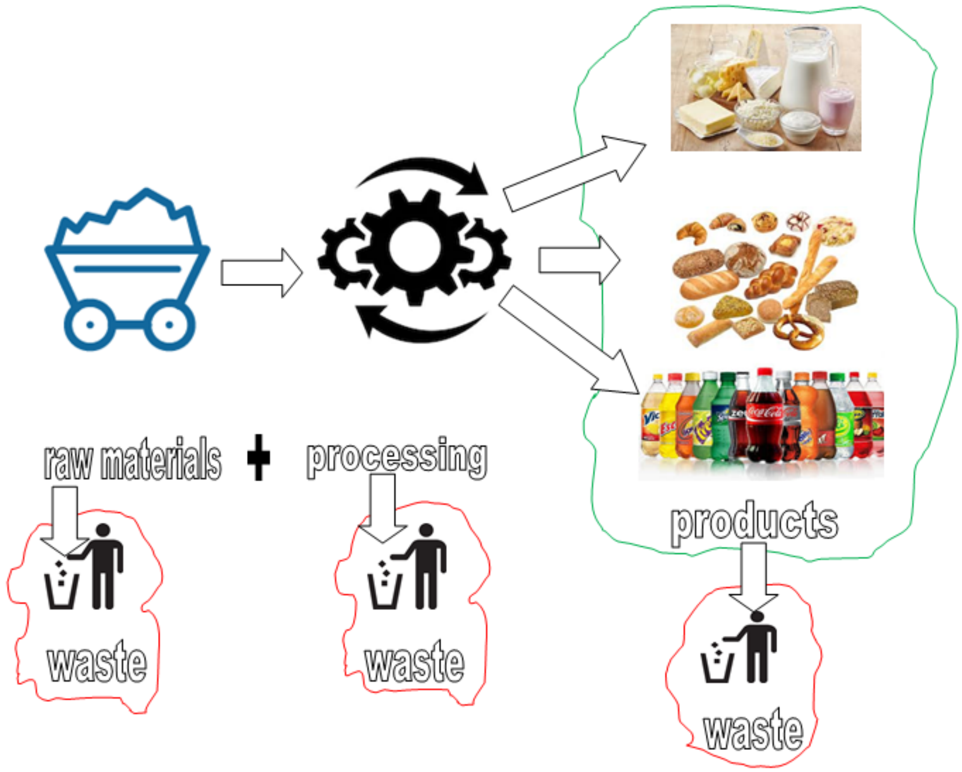

Figure 1: General production flow in the dairy, soft drink and bakery industries

The food industry waste accounts for 50% of the total waste produced throughout the manufacturing sector (Lin *et al.,* 2013). Its processes consume extremely high energy (Groposila, *et al*., 2019). It also has an excessive water consumption and discharge of effluents when compared with other industries (Karthikeyan et al., 2015). In general production flow shows that there is waste production from the point of receiving raw materials, where material which do not meet the quality standard is discarded, to the final disposal of the product, where landfills have increased. Waste from this industry can be classified into three (3) categories according to the origin:

1. Waste from the processing the product.
2. Waste from packaging the product.
3. Waste from consumption of the product (food).

These are discussed industry by industry in the sections below.

2.1 Dairy industry

Milk production is expected to have a 22% growth rate within the 2018 – 2027 projection period (OECD/FAO, 2018). However, the growth in production brings with it the predicament of waste production as it grows too. This waste includes whey, dairy sludge and fat sludge (Kozłowski *et al.,* 2019). The environmental indicators in the dairy industry are product yield, wastewater discharge, water-to-milk ratio, water consumption, water reuse, energy consumption, energy-to-milk ratio, solid waste performance and usage of chemicals (Djekic *et al.,* 2014). Looking at product yield, the dairy industry has high productivity with over 95% of raw milk converted into products such as ice cream, fresh milk and chocolate (Faccia, 2020). Some of the exceptions include:

- Cheese production, where, as an example, 10 liters of fresh milk are required to produce 1 kg of cheese and produces 90% waste in whey (Suryaningrat *et al.,* 2020).
- Sour milk production, where 50 liters of fresh milk can produce as little as 15 liters of sour milk while 70% is whey.

As for wastewater, this is the main production waste and industrial damage occurs if these are released to water bodies. The dairy industry produces the largest quantity of wastewater when compared with other industries (Britz *et al.,* 2006). Every 1 litre of processed fresh milk generates about 6 – 10 litres of wastewater (Ahmad et al., 2019). Dairy like any other food processing industries consumes a lot of water. The water-to-milk ratio is very low. Research done by the Statista Research Department, (2020) reveals that a total of 628 litres of water are needed to produce 1 litre of fresh milk. This based on water use efficiency per litre of milk, which includes the irrigation water for the feed, cow drinking water, water used to wash the dairy processing area, and water content in that 1 litre of milk. The majority of the dairy products are manufactured on the same line with frequent changeovers. This is to accommodate different products. Studies by Berlin et al., (2007) showed that these frequent changes lead to increased milk waste, the need for more cleaning agents and high-water consumption. The overall water consumption can be lowered through water reuse (Baskaran *et al.,* 2003). A study was made by Vourch *et al.,* (2008) on how reverse osmosis can be used to recover wastewater for reuse. 11 French dairy plants were used as a case study. Results showed a 90-95% water recovery. This is the water which would then be used on other processes which are not involved with drinking or in direct contact with the food. These are Cleaning-In-Place (CIP), outside washing of equipment, and boiler make up water.

The energy-to-milk ratio is another important factor to consider. The dairy industry consumes a lot of electricity, the bulk of which is fossil fuel produced (Roy et al., 2009), and contributes 4% of the anthropogenic carbon emissions (Shine *et al.,* 2020). In addition to the emissions soaring up, landfills are increasing because of the wastes which are plastics mostly from the packaging. Food waste constitutes of the end products of various food processing industries that have not been recycled or used for other purposes (Lin *et al.,* 2013). A lot of effluent with high organic components is discharged. The effluents include suspended solids and organic matter, by-products from the processing of raw milk such as whey concentrates, oils, residue of cleaning products, nitrogen, phosphorous, sodium chloride residue, milk fermentation (Ahmad *et al.,* 2019). Since there is high organic content in the dairy raw materials, this means that the waste produced is also organic, and this poses huge a threat to the environment (Jaltade *et al.,* 2020; Kushwaha *et al.,* 2011). If organic waste is not disposed responsibly, but dumped in a landfill, it undergoes anaerobic respiration and this generates methane, which is 25 times more potent a greenhouse than CO_2 (Todd *et al.,* 2011). These wastes would have utilized resources which were channeled towards the production without adding value to the initial product. However, there are wastes which are turned into useful products. Taking whey as an example, it has several uses such as substitute for water in baking, and as an ingredient in producing yogurt, kefir and liquid fertilizer. Another example is methane, a valuable gas which is used to produce electricity for heating and lighting purposes at the dairy processing plant.

2.2 Soft drinks industry

Beverage production companies have dated as far as in the 1890s, and since then, companies have been diversifying their products and targeting a wide range of market. The general flow diagram of carbonated soft drinks and associated wastes are shown on Figure 2 below:

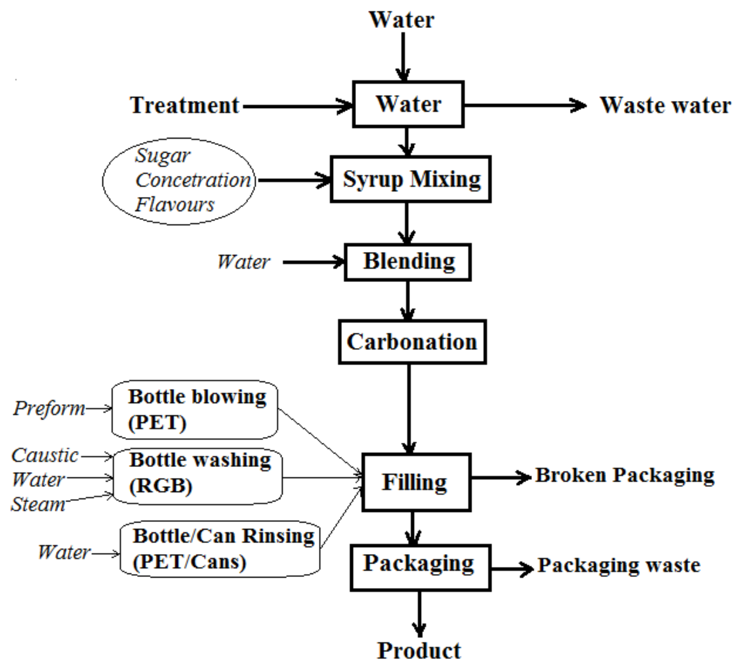

Figure 2: General flow diagram of carbonated soft drinks (Copeland and Carter, 2017)

Starting with the broken packaging and packaging waste, it constitutes up to two-thirds of trash can volume. Plastic is the major packaging material used. Aluminium and glass containers are also used. These usually end up in landfills (Kumar et al., 2016). This has resulted in many discussions around environmental issues. This also led to the Coca-Cola company launching the World Without Waste in 2018, whose focus is on the following areas (The Coca-Cola Company, 2020):

- Design – all packaging to be 100% recyclable by 2025, and using at least 50% recycled material in the packaging by 2030.
- Collect – by 2030 every bottle or can to be collected and recycled.
- Partner – involvement of people in support of a healthy, debris-free environment.

This saves money in terms disposal costs, conserves the environment by reducing landfills, and improves company-customer relations though community engagement.

Just like the dairy industry, the processing of soft drinks makes use of a lot of water especially in the sterilization and processing (Copeland and Carter, 2017). The sources of wastewater are diagrammatically represented on Figure 3 below:

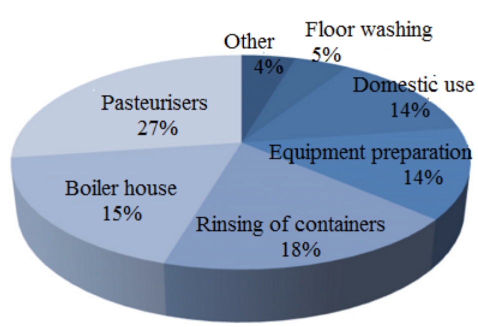

Figure 3: Soft drink industry sources of wastewater (WRAP, 2007)

As an example, 500 ml of Coca-Cola pet requires 35 litres of water to produce. This is at a ratio of 70 litres of water for every 1 litre of Coca-Cola produced. The breakdown of the water consumption is as follows (University of California, 2020):

- 15 litres is green water. This is the water uptake by sugar cane equivalent to the quantity of sugar in the 500 ml coke.
- 8 litres is blue water. It is the main ingredient of the carbonated water.
- 12 litres of wastewater.

2.3 Bakery industry

As for the bakery industry, the life cycle assessment (LCA) of bread and related products such as doughnuts, pies and muffins start in the field where wheat is produced. This goes on to the flour manufacturing plant and other related plants which process the raw materials, to the bakery, then the customer, and finally to the disposal of the waste. Using the production of flat bread as an example, the raw materials or ingredients used are; flour, water, salt, sugar, milk, butter, emulsifiers, yeast and bread improvers (Bantacut & Zulaikha, 2019). The production process of 2 906 loaves of flat bread is shown on Figure 4 below.

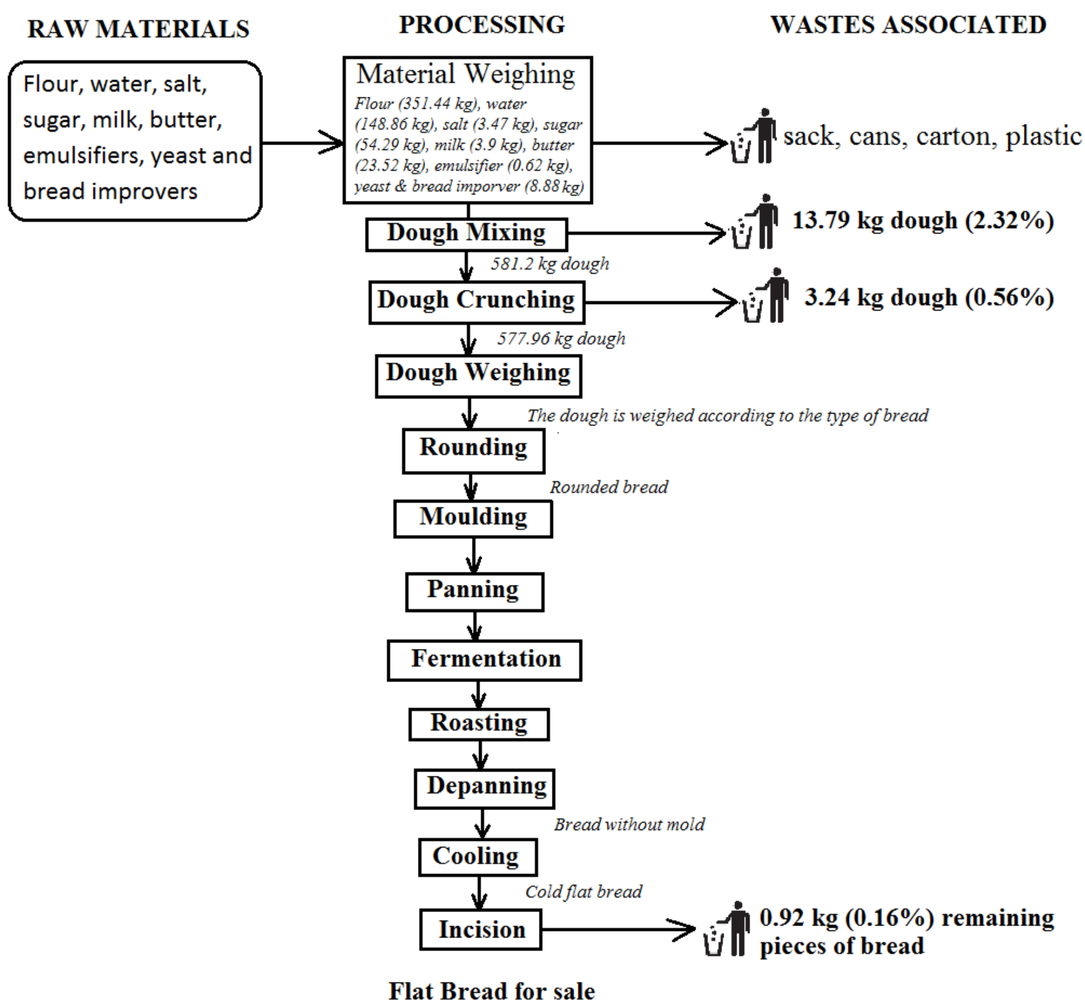

Figure 4: General flow diagram for a flat bread (Bantacut & Zulaikha, 2019)

Each type of bread has a different weight of dough. According to Bantacut & Zulaikha (2019), a 200 gram of dough was used for the procesing of flat bread. Based on the flow diagram on Figure 4 of the process of making flat bread per day it was found that there was a loss of ingredients in several processes Table 1.

Table 1: Dough loss during flat bread making process of 2 906 loaves of bread (Bantacut & Zulaikha, 2019)

Process	**Dough loss (kg)**
Mixing	13.79
Crunching	3.24
Moulding	0.69
Total	**17.72**

These wastes discussed in this section have led to a lot of negative effects on the environment, notably, the increase in the carbon footprint, global warning, pollution of water bodies, landfills inter alia. These are discussed in the following section.

3. Impact of production waste on the environment

Manufacturing activities have the greatest contribution to the adverse environmental impact. Comparative studies of the negative impact before and after the industrial revolution have shown that the level of CO_2 increased simultaneously with the increase in human activities. The pre-industrial revolution CO_2 concentration was 280 parts per million (ppm) (NOAA, 2020). The measurements done by the Scripps Institution of Oceanography as at 26 November 2020, showed that the level was 413.30 ppm. This is way above the safe level of 350 ppm. Over the years there has been an exponential growth in the level and this is illustrated on Figure 5 below:

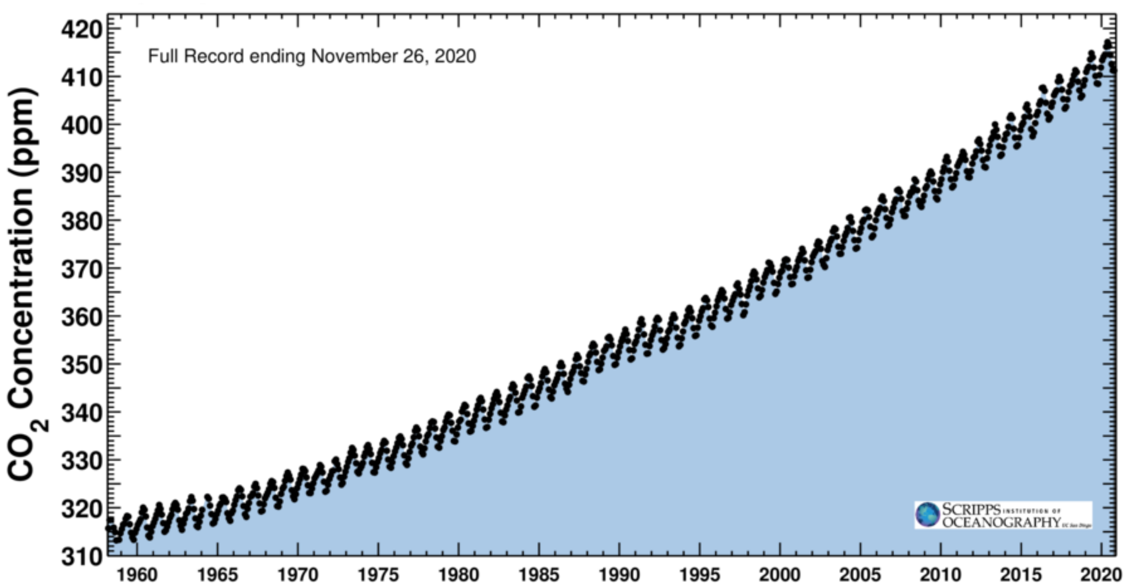

Figure 5: Level of CO_2 in the atmosphere as at November 2020 (Scripps Institution of Oceanography, 2020)

The high energy usage in the production processes and poor recycling methods have contributed immensely to the current state of the environment. Pollution is the introduction into the environment of a substance which has harmful or poisonous effects (Thompson & Darwish, 2019). Pollutants damage the quality of air, land and water. These are discussed in sections below.

3.1 Air pollution (Climate change)

This results mainly from the burning of fossil fuels. The emission of CO_2, CO and SO_2 into the atmosphere starts at the manufacturing plant where the raw materials are extracted, through the production process, and to the end use of the products (Hu, *et al.,* 2019). Taking the production of ultra-high temperature (UHT) milk as an example, it goes through the manufacturing process shown on Figure 6 below.

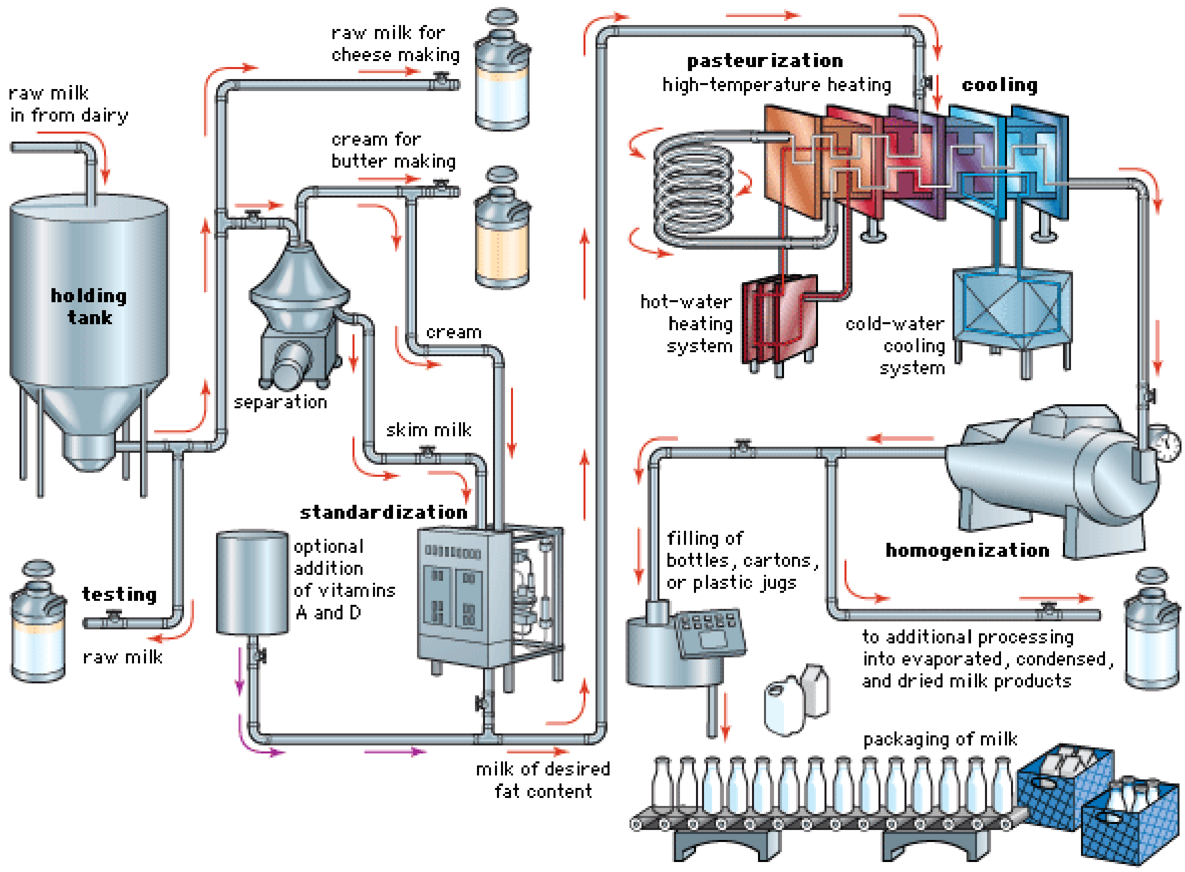

Figure 6: UHT milk process flow chart (Britannica, 2020)

The process is electricity intensive. According to Jour (2006), for a milk flow rate of 2500 kg/hr, the measured temperatures were 138°C, 143°C, 149°C, and 154°C. The energy requirements for the UHT processes, that is, chilling, pre-heating, pasteurization, ranged between 573 kJ/kg and 667 kJ/kg milk.

The other challenge is the use of plastics as packaging material. Save for the recyclable aluminium cans and glass bottles in the beverage industry, the rest of the packaging is made chiefly out of plastic, which is non-biodegradable. This has seen a lot of landfills, especially in the developing countries. CO_2 and methane are released into the air when plastic wastes which were on land decompose (Alabi *et al*., 2019). When these plastics are burnt, whether in open air, landfills or incinerators; poisonous/toxic chemicals are released into the atmosphere. Air pollutants can cause irritation to eyes, skin, throat, or nose headaches, dizziness, nausea and respiratory tract diseases such as bronchitis and asthma (Hu, *et al.,* 2019). It also releases dioxins and furans, which settle at the bottom of the water bodies such as rivers and lakes, and cling onto mud and sediment. These toxins last for 7 to 11 years before breaking down. Hence, they eventually find their way into the food chain and have the capacity to cause cancer, neurological damage and the disruption of the reproductive thyroid and respiratory systems (Verma *et al.,* 2016). Carbon monoxide, which upon inhalation of large amounts can cause deaths, is also released into the atmosphere. Other adverse effects of air pollution are the heat waves across the globe, shifts in climate weather and acid rain (Grennfelt et al., 2020). As a result, the World Health Organization (WHO) stated that air pollution is the worst risk on human health (Roser and Ritchie, 2017).

3.2 Water pollution (Adverse effects on human and aquatic life)

The food industry uses large amounts of water during the production process. Over two thirds of the world's fresh water goes towards the food industry (Kirby *et al.,* 2003). Some of the waste is not hazardous, but it comes in contact with harmful chemicals, which then render them environmentally harmful. When wastewater comes into contact with chemicals it then needs to undergo end of pipe treatment before safe disposal. In the event that this has not been done, the released poisonous substance may find its way to the water bodies such as rivers, lakes and oceans, which puts human and the aquatic lives at risk. Humans are exposed to water pollution toxins in these ways (Kirby *et al.,* 2003):

- Ingestion of food irrigated with raw wastewater.
- Ingestion of food whose ingredients came into contact with wastewater during processing.
- Ingestion of food whose water content was contaminated with wastewater.

This can be traced to inadequate end of pipe treatment. Furthermore, diseases that human can be exposed from drinking unsafe water range from cholera, typhoid, or Giardia (Denchak, 2018).

Between 60 to 80% of the debris on beaches and oceans is plastic (Derraik, 2002), and this harms marine life (Vitale, *et al.,* 2018). Animals are exposed to plastic waste majorly through ingestion and entanglement. Plastic waste is mistaken for food by most ocean animals (Alabi *et al.,* 2019). Table 2 below shows the effects of plastic wastes on some of the sea animals.

Table 2: Effects of plastic wastes on animals and their mechanism(s) or action (Worm, et al., 2017)

Species	**Specie variant**	**Plastic type**	**Effect / Impact**
Sea bird	Greater shearwater	Plastic bottle cap	Starvation due to gastrointestinal obstruction.
	Magellanic penguin	Fragments, line and straws	Stomach perforation.
Sea Turtles	Green sea turtles	Plastic bags and other debris	Impediment of hatching movement towards the sea, exposure to predators.
	Leatherback turtle	Plastic bags and debris	Blocked and injuries cloaca, impedes laying of eggs.
Fish	Larva Perch	Micro-plastic particles	Inhibited hatching, decreased growth rate an altered behavior.
Aquatic mammals	Sperm whale and sea lion	Plastic papers	Stomach rupture and starvation and entanglement caused mortality.

Plastics also have a devastating effect on terrestrial, carnivals and other land animals. They cause intestine blockages and starvation (in most cases death) especially after these animals ingests the plastics.

3.3 Land pollution (Solid waste landfill)

Global plastic production has continued to increase rapidly because of its versatility, lightweightness, low cost, durability, and flexibility (Verma *et al.,* 2016). Plastics are used in food packaging from the dairy, bakery to the soft drinks industries. They can be molded into bottles, trays, cups and other related products. They make 10% of household waste (Verma *et al.,* 2016), and their end use causes environmental problems (Godswill, *et al.,* 2020, Stefanini *et al.,* 2020). Not all the plastics are recycled; part of it ends up in landfills, polluting soil, or in the incinerator, polluting the atmosphere again this is clearly shown in Figure 7 below:

Figure 7: Solid waste landfill (Setiyanto *et al.,* 2012)

4 Proposed ways to achieve green manufacturing

For sustainable production/ manufacturing a number of methods and techniques to mitigate the pollution are discussed addressing the waste from their source to the end when consumers dispose the product.

4.1 Energy related

These include the use of hybrid technologies, biomass for heating and lighting purposes.

4.1.1 Hybrid technologies

These technologies can be a combination of solar energy and electricity from fossil fuels or a combination of wind energy and electricity from fossil fuels. In place of fossil fuel, hybrid technologies can be used as substitutes to reduce the emissions. These can be for example a combination of solar energy and electricity, a combination of wind and electricity and in the dairy case use of biogas can be a very good substitute (Lian *et al.,* 2019). In biogas, for example at a dairy the cow dung can be used together with the waste products from expired products such as whey.

Solar energy can be utilized and counter fit the demand of energy in the food industries. This is due to the various possible applications of solar energy which comprises of water heating, building heating/cooling, cooking, power generation and refrigeration (Sumathy, 2011). Passive and active solar energy systems are used. The passive systems depend on solar radiation striking directly on the area to be heated. An example is in greenhouses where they capture and retain the sun rays through the glass windows. The active systems on the other hand, rely on external energy sources such as hot water pumps to capture, store and convert solar energy into a more usable form, such as electricity or hot water.

4.1.2 Waste-to-energy

Biogas can be used for industrial purposes such as heating and can also be converted into electricity (Uhunamure, 2019). Cow dung, whey, dairy products and other biodegradable by products can be used as inputs of a biogas digester. Any biodegradable organic material can be used as substrate for processing inside the bio-digester. However, for economic and technical reasons, some materials are more preferable as input than others (Shallo, 2020). If the inputs are easily available biodegradable wastes are used as substrate, then the benefits could be twofold:

- Economic value of biogas and its slurry; and
- Environmental cost avoided in dealing with the biodegradable waste in some other ways such as disposal in a landfill or in a lagoon.

Biogas is about 20 percent lighter than air and has an ignition temperature in the range of 650° to 750° C (Shallo, 2020). It is an odourless after burning and colourless gas that burns with clear blue flame similar to that of LPG gas.

4.2 Process related

Cleaner production and waste minimization techniques are discussed.

4.2.1 Cleaner production technologies

This process attempts to integrate environmental strategies on the aspects of process, products, services to improve efficiency, and reduce risks to humans and the environment (UNEP, 1990). If properly applied, it can help on environmental management by reducing the amount of emissions and waste disposed of in the air, land and water (Tan *et al.,* 2016).

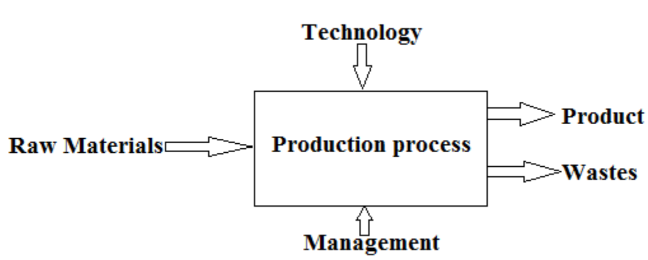

Figure 8: Cleaner production waste generation and causes approach (UNEP, 1990)

Application of cleaner production in the bakery industry is used as an example. The waste generating processes and related causes are identified. For instance, bread production processes form several solid and liquid wastes, which are bread dough attached to the tools, bread that does not pass selection, remaining slices of bread and unsold bread. Good manufacturing practices can be adopted, for instance, daylight energy savings. Reuse of waste products can be done, for example, the processing of slices and rejected bread to crumb flour. After which the environmental benefit of cleaner production alternatives can be studied following Table 3.

Table 3: Tabulation of the feasibility of Cleaner Production in the bakery industry

Aspect	Problems	Alternative use	Environmental benefit
Wastes	Bread pieces remaining, rejected breads discarded	Crumb flour	Reduces the amount of waste
Product	Unsold breads	Animal feed flour	Reduction in the amount of bread waste
			Increase the sale value of waste

4.2.2 Waste minimization techniques

Figure 9 shows the waste management hierarchy. This underlines that prevention is the best option followed by minimization, reuse, recycling and energy recovery. Disposal (landfilling, incineration with low energy recovery) is the worst option and its negative effects to the environment were discussed in the previous sections.

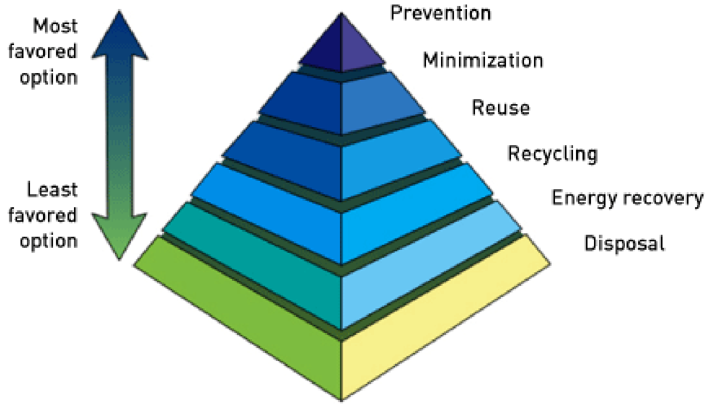

Figure 9: Waste management hierarchy (Kamalski, 2010)

4.2.2.1 Minimization

This is the preferred environmental option, and should always take precedence over re-use or recycling. Also known as waste prevention or pollution prevention, it involves decreasing the amount of materials or energy used during the manufacturing or distribution of products and packages. It includes:

- *Good housekeeping:* Involves changes in management and personnel practices, for example, employee training to raise awareness of waste reduction, and incentives to achieve it. It also includes improvements to operation and maintenance, for example, elimination of leaks and spills to reduce losses; optimized equipment performance to reduce downtime. Also covered is the segregation of different wastes to optimize opportunities for re-use and recycling. Furthermore, it includes amendments to materials handling and inventory practices, for example, better handling and storage to reduce loss through damage.
- *Product reformulation:* It involves changing the way in which the product is designed and manufactured, to produce something that creates less waste, or is less toxic, more suitable for recycling or more amenable to treatment. Alternatively, product reformulation may involve the replacement of the entire product with one which creates less waste, or is less toxic, more suitable for recycling or more amenable to treatment.
- *Changes to the raw materials used:* This can reduce the toxicity of the residual waste, or could make the product more amenable to recycling, or easier to treat prior to disposal.

- *Changes in the technology:* This is the most expensive good housekeeping alternative. It involves the replacement of outdated equipment with one that functions more efficiently, requires smaller amounts of material input, or produces less waste.

4.2.2.2 Reuse

Reusability refers to the use of materials more than once in their original form instead of throwing away after each use (Njomo, 2019, Obebe and Adam, 2020). According to Stefanini, *et al.,* 2020, reuse of glass bottles proved to be a promising solution to reduce the environmental impact of 0.75 ml glass bottles. It allows the recovery of the entire bottle, if undamaged. In reuse there are two impacting phases, sterilization and drying. This is unlike recycling which involves the melting of the glass and the formation of the bottle, thereby consuming large quantities of heat and electricity (Landi, *et al.,* 2019). According to Amienyo *et al.,* 2013 by reusing the glass bottle only once, the environmental impact can be reduced by 40%. The best solution is to reuse glass bottles at least 20 times in order to obtain favorable results (Amienyo, *et al.,* 2013). The reuse of glass bottles would allow a substantial decrease in the environmental impact. For carbonated PET bottles, if the recycling is increased to 60%, the Global Warming Potential (GWP) would drastically be reduced.

4.2.2.3 Recycle

Recycling of plastic involves collection of plastic waste and reprocessing it into new products, in order to reduce the amount of plastic in the waste stream. Plastics do not break down easily; the same plastic can be used for another purpose entirely. Recycling transforms the plastic to a new one, still it's the same plastic. Recycling does not mean the plastics are reduced, what it simply means is there is a reduction in the environment pollution (Obebe and Adam, 2020). Figure 10 below shows that since 2006, the amount of plastic waste sent to recycling has doubled however in 2018 about 25% of plastic post-consumer waste was still sent to landfill (Plastics Europe, 2019).

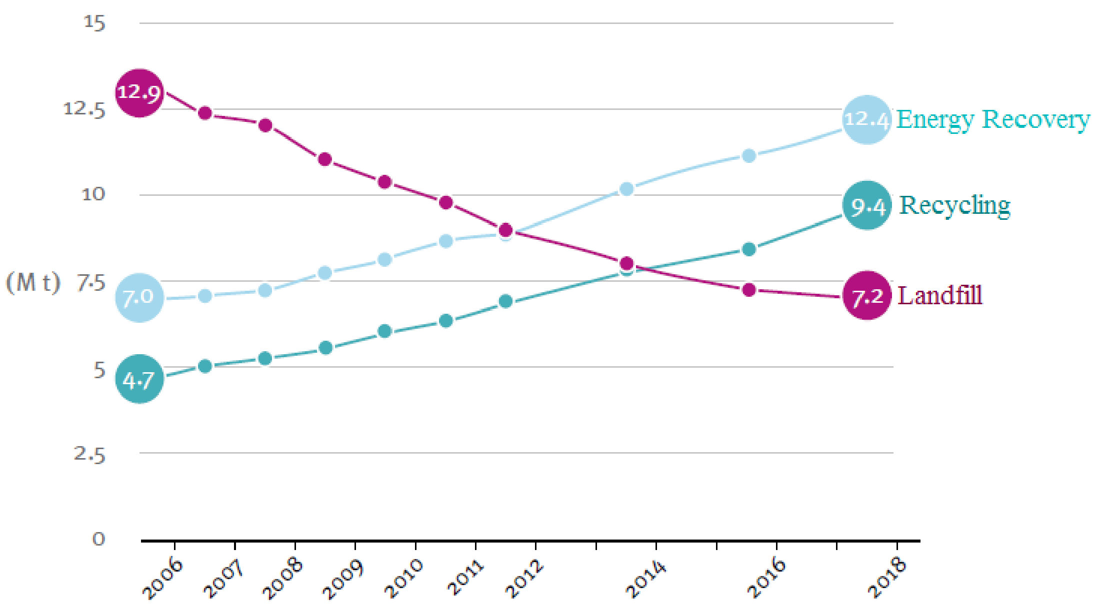

Figure 10: Evolution of plastic post-consumer waste treatment from 2006 – 2018 (PlasticsEurope, 2019)

4.2.2.4 Recovery

Food recovery is a way of utilizing food waste by recapturing the valuable components and/or developing new products with a market value (Galanakis, 2012; Galanakis 2013; Galanakis and Schieber, 2014; Rhamanian *et al*., 2014). Reducing food waste through recovery of its valuable components is an important way of increasing the sustainability of the food production systems. Industries can no longer ignore the need to act in a sustainable way.

4.2.2.5 Reduce

In order to reduce plastic pollution, there is need to reduce our usage of plastic. This translates to changing our daily attitudes and avoiding the use of plastic when there is a better alternative to it and only using plastic when it is seriously needed. Plastic packaging needs to be avoided instead reusable bags or jars should be used (Obebe and Adam, 2020).

4.3 Product related

Table 4 below shows the food industry waste mitigation methods.

Table 4: Food industry waste mitigation methods (Gavrila, 2007)

	Type of waste	**Waste mitigation method**
1	Solid Waste	Recovery in agriculture or animal husbandry, incineration, anaerobic or aerobic fermentation, composting.
2	Liquid Waste	Ground application, various methods of physic-chemical treatment, fermentation.
3	Waste with more than 50% humidity	Anaerobic fermentation with the production of biofuels.

Rahman *et al.,* 2014 showed that small scale bread industries in Mymensingh Bangladesh wastes greatly contributed to the environmental quality. This shows the need to pay attention to existence of small industries since most of them are located or close to residential areas and their environmental impact disturbs the surrounding residents. For such industries, cleaner production can be practiced and implemented.

5 Summary and outlook

The paper has discussed the various wastes which are produced in the dairy, soft drink and bakery industries and has proposed solutions which will go a long way in mitigating the negative impacts to the environment. Table 5 below shows the soft drink industry summary of the types of waste, source and proposed solution.

Table 5: Soft drink industry summary of the types of waste, source and proposed solution

Products	**Waste**		**Harmful Environmental Impact**			**Proposed Solution**
	Type	**Source**	**Land**	**Water**	**Atmospheric**	
All non-alcoholic beverages	Wastewater	Processing and clean up	Minimal	Discharge to open water sources	Minimal	Onsite pre-treatment for reuse Routine monitoring and control of water wastage
	Bottles and plastic sachets	Packaging damages and used containers	Landfill	Plastic waste in beaches and rivers	Release of methane when incinerated	Use of biodegradable packaging Recycling

Table 6 below shows the bakery industry summary of the types of waste, source and proposed solution.

Table 6: Bakery industry summary of the types of waste, source and proposed solution

Products	**Waste**		**Harmful Environmental Impact**			**Proposed Solution**
	Type	**Source**	**Land**	**Water**	**Atmosphere**	
Bread, doughnuts, pies, muffins, cookies, biscuits	Plastics	Packaging material	Landfill Breeding place for harmful bacteria	Minimal	Release of methane when incinerated	Use of biodegradable packaging Recycling
	Burnt products and returns	Product failure		Pollution of open water sources		Process improvement

Table 7 below shows the dairy industry summary of the types and source of waste and the proposed solutions

Table 7: Dairy industry summary of the types of waste, source and proposed solution

Products	**Waste**		**Harmful Environmental Impact**			**Proposed Solution**
	Type	**Source**	**Land**	**Water**	**Atmospheric**	
Fresh milk, cheese, butter, yoghurt, ice cream, powdered milk	Wastewater (Major waste)	Water mixed with detergents, sanitizers, milk wastes from milk receiving, spillages	Minimal	Release of toxic substances into water bodies. Promotes growth of algae and bacteria causing the depletion of dissolved oxygen level Oils and grease form a film on the water surface hindering oxygen transfer to aquatic life Breeding ground for insects like mosquitoes Low settleability of sludge Contamination of underground water through the conversion of nitrogen from raw milk waste to nitrates	Minimal	Eliminate pollutant from the source Onsite pre-treatment for reuse Irrigation purposes since it is a great source of nutrients and does not contain heavy minerals Routine monitoring and control of water wastage
		Processing, Cleaning-In-Place (CIP), clean up for product change, washing practices of bottles and floors, butter washing, sanitary water piped into sewage works				
	Whey concentrates, oils, residue of cleaning products, sodium chloride residue, milk fermentation	By-products from the processing of raw milk				Ingredient in producing yogurt, kefir and liquid fertilizer
		Cheese clumping				
	Buttermilk	Processing cream for butter				Ingredient in making buttermilk biscuits, and certain types of melted cheese.
	Microbial contamination of milk	Herd related – hygiene, health status, mastitis prevalence				Proper drainage to prevent pools of stagnant water from forming
		Production environment, and milking parlor and milk conserving practices in dairy farm				
	NH_3 and CFCs	Leakage of chillers	NH_3 – soil acidification	NH_3 – Release of toxic substances into water bodies leading to toxic buildup in internal tissues and blood, and potentially death.	NH_3 – nitrogen pollution CFCs – Ozone layer depletion	Routine Maintenance of the chillers
	CO_2, NO_x, CO, SO_2	Heating processes	Minimal	Acid rain	Ozone layer depletion	Energy substitution
	Plastic sachets	Packaging damages and used containers	Landfill	Plastics harm marine life when ingested	Release of methane when incinerated	Use of biodegradable packaging Recycling

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