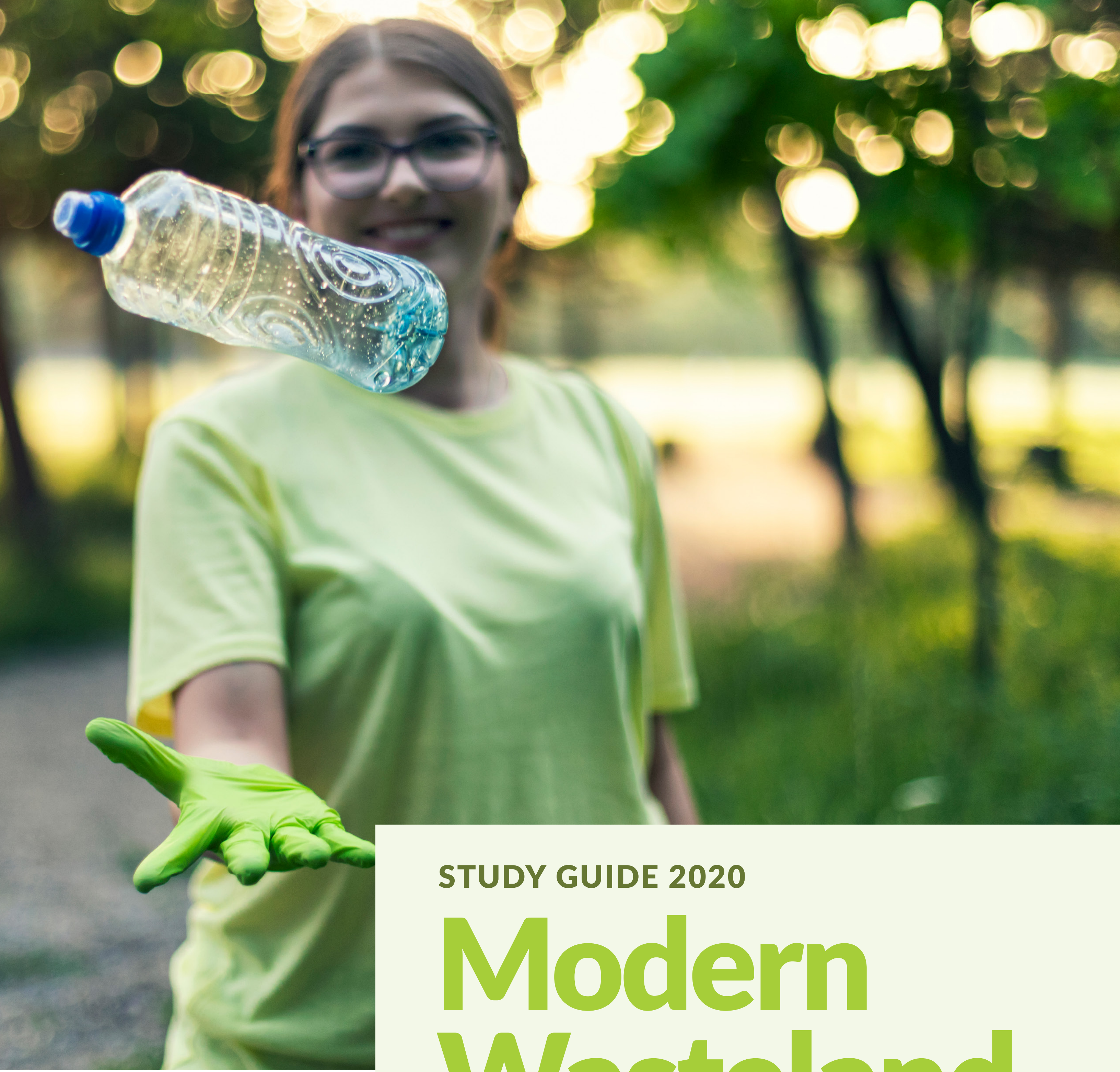

STUDY GUIDE 2020

Modern Wasteland

Exploring Waste Management

FORESTS ONTARIO

ONTARIO ENVIROTHON 2020

Acknowledgements

The following study guide was created by a team of students from the Ecosystem Management Technology Program at Fleming College. The team comprised of Douglas Bennett, Danielle Chiasson, Sadie Fischer, and Matthew Perry. The purpose of the study guide is to provide high school students with study materials that reflect the 2020 Ontario Envirothon Current Issue Topic: Waste Management. Key topics and learning objectives and interspersed throughout this document and are accompanied by various case studies and hands-on activities.

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2020 Learning Objectives

KEY TOPICS

1. Basic principles of waste management
2. Types and sources of waste
3. The effects and impacts of waste and waste management to economy, society, and environment
4. Waste disposal methods
5. Roles and responsibilities of government, consumers, and industry in preventing, diverting, and managing waste
6. Waste management strategies and technologies with a focus on preventive measures
7. Role of awareness, outreach and education on waste management

LEARNING OBJECTIVES

1. Define waste management and demonstrate overall knowledge of the importance of waste management in Canada
2. Understand basic principles of waste management and current methods of disposal employed in Canada
3. Describe and understand the importance of waste diversion
4. Describe and discuss the difference sources and types of waste
5. Comprehend the effects of waste and waste management on the environment including; aquatic, forest, wildlife, and soil
6. Analyze the economic, political, social, and environmental practices and how they relate to waste management strategies
7. Understand the effectiveness of different waste diversion and disposal methods (landfill, recycling, reusing, and upcycling)
8. Understand the scientific principles involved in processing solid, liquid, and gaseous waste (primarily combustion and decomposition)
9. Investigate alternative waste management systems such as circular economy and extended producer responsibility
10. Overall knowledge of strategies and technologies used in the collection, storage, and disposal of waste (recycling, composting, landfills, compactors, and enzyme digesters)

Tools and Recommended Resources

The following tools and recommended resources can better help you and your team prepare for the Envirothon program.

E-WASTE WORLD MAP
http://step-info.org/step-e-waste-world-map.html

FOOD WASTE PLEDGE
https://wrwcanada.com/en/get-involved/resources/food-waste-themed-resources/take-food-waste-pledge

THE GREAT PACIFIC GARBAGE PATCH IS NOT WHAT YOU THINK IT IS | THE SWIM
https://youtu.be/6HBtl4sHTqU

THE SMELLY, OOZY, SOMETIMES EXPLODE-Y SCIENCE OF GARBAGE
https://youtu.be/x4x8HsAhp8U

SINGLE STREAM RECYCLING – TOUR A MATERIAL RECOVERY FACILITY (MRF)
https://youtu.be/M5nmNKVNCBw

NATIONAL FOOD WASTE REDUCTION STRATEGY
http://www.nzwc.ca/focus/food/national-food-waste-strategy/Pages/default.aspx

SAVE THE FOOD – DINNER PARTY PORTION GUEST-IMATOR
https://savethefood.com/guestimator/guests#guest-container

MY LITTLE PLASTIC FOOTPRINT
https://mylittleplasticfootprint.org

RECYCLE YOUR ELECTRONICS
https://www.recyclemyelectronics.ca/on/

WASTE ATLAS
http://www.atlas.d-waste.com/

WASTE MANAGEMENT
https://www.wm.com/us

WORLD WASTE PLATFORM
https://opendata.letsdoitworld.org/#/

1.0 Introduction to Waste Management

An indicator of a healthy ecosystem is its ability to naturally decompose wastes into smaller base components – for example, water, minerals, and nutrients – that are ultimately recycled back into the environment. Such natural systems and processes are an essential component of healthy communities as they retain ecosystem integrity and protect the health and safety of human populations (International Solid Waste Association, 2002). Compared to other organisms, humans generate a variety of wastes that cannot be processed by natural systems, and as such must be managed through collective human action. Effective waste management systems must engage multiple stakeholders on several fronts and include education, hazard reduction and **waste diversion** components. Within Ontario we utilize several waste management systems including **landfill**, compost and recycling programs, incineration, and reduction-diversion strategies.

Waste is a particularly pressing issue in Canada. As a country, we produce more waste per capita than most other countries on earth (Environmental Commissioner of Ontario, 2017). According to a 2016 report from the Environmental Commissioner of Ontario between 2002 and 2016, the total amount of solid waste collected in Canada increased by 3.5 million tonnes (11%) and the amount of waste disposed in landfills or incinerators increased by 0.9 million tonnes (4%). Ontario residents generate more than 33,000 tonnes of waste every day, equating to more than 900 kilograms per person annually (Environmental Commissioner of Ontario, 2017).

There are many challenges associated with managing waste including the possible depletion and contamination of valuable resources. Methods such as landfill and incineration may consume and contaminate air, water and soil if improperly implemented. Additionally, the breakdown of disposed waste materials can also generate powerful greenhouse gas emissions (Environmental Commissioner of Ontario, 2017). Looking forward, Canada and Ontario must continue to explore sustainable solutions to further prevent and reduce the impacts of waste in its creation and management.

1.1 Sources of Waste

Waste is generated from many sources as the result of day-to-day activities. Common sources of waste include:

Table 1: Common sources of waste

SOURCE	DESCRIPTION
Agricultural	Waste created from horticulture, livestock, and nurseries can include items such as manure, plant materials and soil. Can include hazardous materials such as containers with residual pesticides.
Automotive	Referring in this case specifically to wastes created in the manufacturing process and at vehicle end-of-life. Often includes metal, plastic and hazardous liquid material such as oil or coolant.
Biomedical	Waste produced at healthcare facilities, often hazardous, includes surgical tools, pharmaceuticals, blood, needles and human organs. Can also be referred to as Medical/Clinical waste.
Construction and Demolition	Waste generated through the construction or demolition of buildings, roads etc. Includes concrete debris, wood, soil and material packaging.
Electronics	Also known as e-waste this includes cell phones, computers, appliances, and other household materials with a cord. Some electronic waste can contain materials such as lead, mercury and cadmium which can be harmful to human health and the environment.
Industrial	Wastes produced from the manufacturing of goods and processing or refinement of raw materials. Wastes produced vary by industry but could include **slag**, contaminated soils, aggregates, gas, and liquids.
Municipal	Includes everyday waste materials generated in households, schools, offices, markets, or other public spaces.

2.0 Types of Waste

Not only are there multiple sources of waste, but there are multiple types of waste. It is important to understand the characteristics of each type of waste in order to select and apply the most appropriate management and disposal method.

Figure 1: Pie chart depicting different types of waste in Canada (ReclaimGrowSustain, n.d.).

SOLID WASTE

Solid waste, commonly referred to as "garbage" or "trash", consists of discarded materials and items. There are many options available for managing solid waste including recycling, composting, landfills, and incineration. In selecting the most appropriate waste management technique, the items' component materials must be considered in addition to budget and waste management goals. Proper solid waste management in landfills is extremely important as the accumulation of materials has the potential to lead to issues with odour, chemical exposure, environmental contamination, and the spread of disease.

LIQUID WASTE

Liquid waste, also referred to as **wastewater**, is produced in the residential, commercial, and manufacturing sectors. The source of wastewater will impact its composition and therefore treatment requirements. In some cases, liquid waste may contain chemical compounds which are hazardous to human health and the environment and in these cases, wastewater would require more stringent processing and treatment. Oils must be properly disposed of through a separate process.

Inadequately or improperly treated wastewater released into lakes, ponds, steams, rivers, or **aquifers** can have significant health and environmental impacts, including (Government of Ontario, 2014):

- Excessive nutrient run-off (most commonly nitrogen and phosphorus) causing **eutrophication**, a process characterized by excessive plant growth and die-off reducing the available oxygen in an ecosystem which in turn degrades spawning grounds and harms aquatic wildlife;
- Increase in volume of chlorine compounds which are toxic to aquatic life;
- Contamination of drinking water by bacteria and disease-causing pathogens such as *E. coli*; and
- Release of microplastics and fibres into waterways which **bioaccumulate** in wildlife.

GASEOUS WASTE

Gaseous waste has many **anthropogenic** sources including manufacturing, processing, and the consumption of goods, as well as biological processes such as the decomposition of organic material. A significant portion of gaseous waste is also produced through burning fuels, exhaust from motor vehicles and power plants, as well as the production of fertilizers and pesticides used in agriculture (Woods et al., 2010). Common pollutants found in gaseous waste include; carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), methane (CH_4), and particulate matter, defined as small particles of gas, dust, and other matter.

If released, untreated gaseous waste can lower air quality and increase **ambient air** pollution. Technologies to capture and prevent gaseous waste from being released into the environment, such as scrubbers and filters, are commonly used to manage pollution levels. These pollutants are not just harmful to human health, but they can also be potent **greenhouse gases** (GHGs) such as methane, which are significant contributors to climate change. In Canada, it is estimated that landfills are responsible for up to 20% of methane emissions (Natural Resources Canada [1], 2017). While it would be preferable to divert organic materials from landfills, it is possible to both capture and repurpose gaseous waste from landfills to generate electricity, fuel industries, heat buildings, and reduce dependency on non-renewable energy sources.

2.1 Recyclables

Recyclables are materials which can be reprocessed into new products. Materials that can be recycled include aluminum and other metals, some types of plastic, glass, paper, and fibre products.

Recycling reduces, or diverts, waste from landfills and incinerators. It also conserves natural resources by lessening the demand to extract, harvest and process new raw materials. This in turn saves energy and can result in a reduction of greenhouse gas emissions. Recycling can also support the local economy by creating a source of domestic materials, local manufacturing and job creation; it is estimated that for every 1,000 tonnes of waste diverted from landfill an average of seven jobs are created in the recycling industry (Ministry of Environment Conservation & Parks [1], 2019).

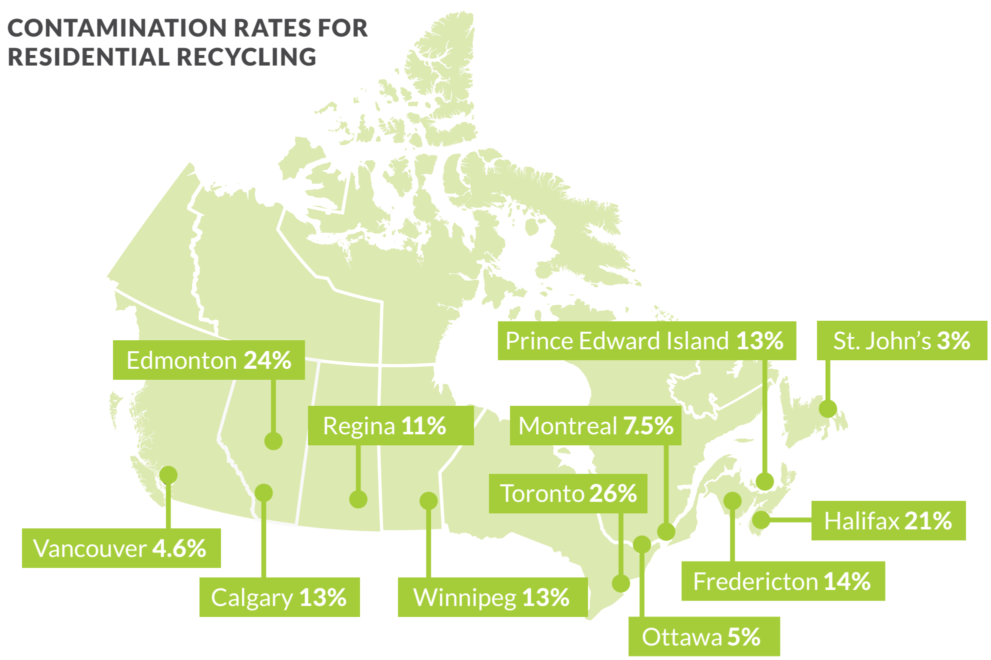
Materials accepted into recycling programs vary from municipality to municipality. Given these regional differences it can be challenging to accurately determine recycling rates at a provincial or national level. However, some estimate put the Canadian recycling rate for residential and commercial sectors combined as low as 30% overall (Community Research Connections, 2018) and at 9% for plastics (Recycling Council of Ontario, 2019).

In waste management contamination refers to improperly sorted waste, for example organic materials mixed into items meant for recycling.

At the residential level, one of the greatest challenges in increasing recycling rates is communicating to residents what materials are accepted in their municipal recycling program. When recyclables are properly sorted at the curb, time and energy are saved at recycling facilities. Conversely when non-recyclable materials enter the recycling stream, they are considered contamination. Depending on the nature and volume of the contamination all the impacted materials may be redirected to landfill.

Another challenge for individuals are misleading labels on products such as items which are identified as recyclable but are not readily accepted in a municipal waste program, examples include disposal coffee cups, coffee pods and plastic cutlery.

Figure 2: Recycling contamination rates for cities across Canada (CBC, 2018).



No city data available for Whitehorse, Yellowknife, and Prince Edward Island.

2.2 Organic Waste (Source Separated Organics – SSO)

Organic waste in Ontario is made up of leaf and yard waste, food waste, paper products, manure, and human waste. In 2015 Ontarians generated 3.7 million tones of food and organic waste, representing a significant source of waste production (Ministry of Environment, Conservation and Parks [2], 2019).

Organic waste requires mindful management as its decomposition generates carbon dioxide and methane (David Suzuki Foundation, n.d.). Additionally, the decomposition of organic waste creates compost, a valuable resource. If not lost to landfill, this nutrient rich organic matter can be added to soils and used as fertilizer. See section 3.4.1 to read more on composting.

Figure 3: 2015 Waste Streams in Ontario (Ministry of Environment, Conservation and Parks [2], 2019).

OTHER MATERIALS 68%

7.9 million tonnes of other materials such as printed paper, packaging, electronics, and household hazardous waste

FOOD AND OTHER ORGANIC WASTES 32%

3.7 million tonnes of food and other organic wastes such as food scraps, soiled paper, and leaf and yard wastes

2.2.1 Household Organics

More than half (55%) of all food and organic waste in Ontario is produced in the residential sector. The remaining 45% is generated by businesses, institutions and industry (Ministry of Environment, Conservation & Parks, [2] 2019).

Household organic waste is a broad classification and there may be differences between municipalities with regards to which items they target and accept. According to Environment Canada commonly accepted items include:

- Grass, leaves, garden debris and weeds
- Tree and brush trimmings
- Bread, muffins, cake, cookies, pies, and dough
- Coffee grounds and tea bags
- Eggs and eggshells
- Fruit and vegetable peelings
- Meat, chicken, and fish including bones
- Nut shells
- Pasta and rice
- Sauces and gravy
- Solid dairy products
- Table scraps and plate scrapings

Household organics are collected through Yard Waste and Green Bin programs. Materials collected are processed using a variety of methods resulting in nutrient-rich compost which can be used to feed and to nourish soils. Common methods for processing organic waste will be covered in greater detail in section 3 of the guide.

2.3 Agricultural waste

Agricultural waste is generated as a result of farming operations. Common agricultural wastes include animal waste such as manure and carcasses, plant waste from the processing or harvest of crops, and plastics from packaging. Though water accounts for 75-95% of total livestock waste by volume, the remaining 25-5% is a combination of organic and inorganic matter which may support parasitic microorganisms and viruses (Obi et al, 2016). Contamination of livestock products heading for market with waste is a mean by which parasites and illness could be spread to the consumer.

Agricultural waste can contribute to air pollution if improperly stored or treated. This is usually a result of manure **putrefaction**, wherein manure can generate greenhouse gases (such as methane) on top of contaminating the surrounding water and potentially affecting the fertility of soil (Obi et al, 2016). For more information on the potential environmental impacts of waste, see Section 4.1.

In addition to these more benign forms of waste, agricultural waste can also include hazardous or toxic materials, such as pesticides in the form of herbicides, fungicides, and insecticides, among others.

2.4 Hazardous Waste

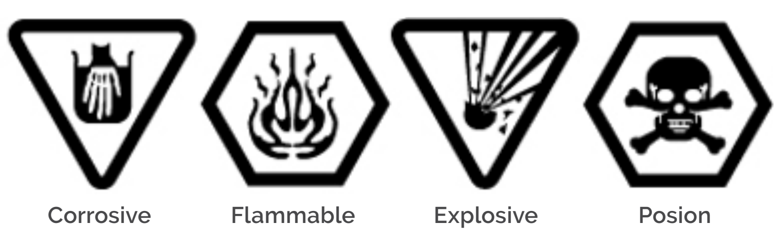
Hazardous wastes, when not properly managed, can threaten human, animal, and environmental health. The Environmental Protection Agency describes hazardous waste as possessing at least one of the following four characteristics:

Flash Point: the lowest temperature at which an organic compound will release enough vapours to ignite in the air when exposed to flame.

1. **Ignitability:** Wastes that can easily catch fire, such as liquid wastes with flash points below 60˚C, non-liquids that may cause fire in specific conditions, and ignitable compressed gases and oxidizers.
2. **Corrosivity:** Liquid waste with pH of less than or equal to 2 or greater than or equal to 12.5. Also applies to wastes that have the ability to corrode steel.
3. **Reactivity:** Waste which can easily explode. May be unstable under normal conditions or may react to water or heat.
4. **Toxicity:** Poisonous wastes that are harmful when absorbed or ingested. Toxic wastes may be able to leach out and pollute groundwater.

Household hazardous waste is found in virtually every home and include items such as; Compact Fluorescent Lights, fluorescent tubes, batteries, cleaners, paints and solvents, car and garage products, personal care products, medications, household cleaning products, pesticides, and lawn care products (City of Toronto, n.d). Given their ubiquity, municipalities across Ontario estimate the average home uses between 10 and 40 kg of hazardous materials per year (City of Guelph, 2019).

Figure 4: Hazardous waste symbols (City of Guelph, 2019).



Household hazardous wastes should never be disposed of with residential curbside waste as these materials may require special treatment or storage and can present a health risk to waste facility employees. Many cities and municipalities provide services and programs for individuals to properly dispose of their household hazardous items either through pick-up or drop-off programs.

2.5 Hands on Activity: Food Waste Discovery Challenge

BACKGROUND

The Food and Agriculture Organization (FAO), an agency of the United Nations focused on combating hunger issues, estimates that up to one third of all food produced globally is lost or wasted (FAO, 2019). The FAO describes food loss as any food lost in the supply chain between production and market; this includes food discarded due to pre-harvest issues (i.e. pests) or items damaged during packaging, storage, or transit. Conversely, food waste includes food discarded which is still safe for human consumption.

The volume of food that goes to waste globally is staggering, approximately 1.3 billion tonnes (FAO, 2019). The figures for Canada alone are significant; each year, an estimated $27 billion in Canadian food finds its way to landfills and composting systems. This equates to approximately 40% of Canadian food (Gooch et al., 2010).

Food waste numbers are the result of the behavior of individuals and industry which are determined by the incentives, policies, and processes that, together, shape the way the agri-food sector is structured and operates. What can you do to help?

CHALLENGE

The Food Waste Discovery Challenge allows you to compare your food waste habits to your peers as you track of the amount of food waste created in your home. Food waste will be separated into two basic categories: Unavoidable Food Waste (e.g. orange peels), and Avoidable Food Waste (e.g. discarded leftovers). The challenge will take place over a single two-week period; the first week following regular shopping and eating habits, and the second after implementing two methods of your choice to reduce food waste.

MATERIALS NEEDED

- Food Scale
- Computer with spreadsheet software (Microsoft Excel/Google Sheets)

METHOD

- In a spreadsheet list the types of food waste you accumulate each day for two weeks. Examples could include meats, fruits/vegetables, liquids, coffee grounds/tea bags and unconsumed leftovers.
- Record the amount of food waste produced over the period of one week by weight.
- Use the information collected during the week to identify where most of your food waste is created, select two actions you can take to reduce the volume of food waste produced (e.g. more shopping trips with fewer purchases, improving storage, making shopping lists, meal planning, etc.).
- Implement your reduction strategies and continue the process for another full week.
- Use the Excel table to summarize your food waste generation rates.
- Create a pie chart or other visual to showcase your pre and post assessment.
- Compare your results with your classmates and friends, consider the following:
    - Were there common types of food waste between participants?
    - What techniques were used to reduce food waste, were some more successful than others?
    - Do you think your personal habits will change following this challenge? Why or why not?

Want to increase the difficulty? Considering only purchasing food with minimal or no packaging!

Waste Reduction Week in Canada starts on the third Monday of October every year. Share your Food Waste Challenge progress and spread the word using the following hashtags — #WasteReductionWeek or #FoodWaste.

2.6 Discussion Questions

1. Identify and describe the types of waste described in this section. Which do you think presents the greatest environmental, economic or social threat?
2. Individually, and on a global scale, Canadians produce a high volume of waste. Why do you think this is?
3. According to the EPA what are the potential characteristics of a hazardous waste?
4. How is hazardous waste managed in your municipality, city or town?
5. Why should organic waste be diverted from landfill?

3.0 Methods of Waste Management

As human populations continue to grow and consume it is critical that waste management systems take into consideration the sustainably issues related to product design, manufacturing, and disposal. Waste management systems should aim to achieve maximum practical benefits from products while generating the minimum amount of end waste. With this goal in mind, some waste reduction and management actions are considered more impactful than others. One such example is illustrated by Figure 5.

Another well known, albeit simpler, waste hierarchy, is the Three R's:

1. Reduce: prevent the generation of waste
2. Reuse: seek alternative uses of waste
3. Recycle: convert waste materials into new products

Popularized in the 1970's, the Three R's have been integral in communicating municipal recycling programs and reduction goals to the general public. The Three R's model has since been expanded to include additional actions with a focus on reducing the consumption of goods (and associated waste creation) at the consumer level.

Figure 5 (left): Image of Waste Hierarchy (Hamilton City Council, n.d).

Figure 6 (right): Representation of the 6 R's (MyPGNow, n.d).

3.1 Landfill

Modern or sanitary landfills are areas used to dispose of waste which are isolated from the external environment both underground (with a liner) and above (with soil or another cover). Landfill sites are separated from the environment to both minimize ground and surface water contamination as well as prevent mosquitoes and other disease carrying pests from breeding on site.

Canada is home to approximately 2400 active landfills, both public and private (Wilkins, 2017). When designing a new landfill, efforts are made to minimize negative effects on the environment with strict guidelines that must be followed in order comply with the Environmental Protection Act (Government of Ontario, 2012). These guidelines include:

- Site design report including a site-specific design and two generic design options.
- Implementation of a **buffer area**, surface water and gas control, on site roads and structures and a final cover design.
- Site must include a liner and leachate collection system and a contingency plan for leachate control.
- Operation and monitoring facilities for groundwater and surface water.
- Site closure and post-closure care requirements; and final assurance requirements for private sector landfills.

3.2 Incineration

Incineration is a method of waste management where organic materials in waste are combusted in a controlled environment. The products of this process are ash, **flue gas**, and heat. The ash produced primarily consists of inorganic components found in the original material which are turned into **particulates** suspended in flue gas. The flue gas is usually cleaned of any gaseous contaminants, treated, and sent through emission tests before being released into the atmosphere (Tammemagi, 1999).

During incineration, minimum burning temperatures must be maintained to ensure that complete combustion occurs. If these temperatures are not maintained, or if a limited amount of oxygen is available, incomplete combustion will occur instead (Waste Incineration and Public Health, 2000). Incinerators would then produce carbon monoxide in addition to the other undesirable by-products.

Incineration is a divisive topic in waste management. Under optimal conditions, there are several potential benefits to incineration. The key points are:

- It can reduce the volume of waste sent to landfills by an average of 90% (Tammemagi, 1999). This can extend the lifetime of existing landfills and remove the necessity to create new landfills, especially in densely populated areas.
- The hazardous wastes found in organics and pharmaceuticals are destroyed in the incinerator, reducing the number of contaminants that could otherwise leach into the ground if the waste was left in landfill.
- The heat generated by this process can be used as energy with less environmental impact than non-renewable energy sources such as oil and coal (see Section 3.5 for more information).

Despite these benefits, there are almost as many arguments against incineration including;

- The waste that goes into incinerators may include improperly sorted materials such as plastics and compostable organics that could have been recycled or composted (Conserve Energy Future, 2019).
- Incineration facilities are often expensive, which could divert funds away from **recycling** programs.
- This process requires a constant flow of combustible materials into the incinerator to maintain operational temperatures. While not immediately problematic, it does mean this system of waste disposal encourages a static rate of consumption.
- The airborne by-products of the combustion process can include particulate matter and toxic gases that contribute to acid rain and respiratory health issues. The residual solid waste requires special handling and must be disposed of in a landfill.

3.3 Selling Waste

Processing or storing waste locally can be a burden on the community and may be undesirable for social or economic purposes. Governments may choose to transport their waste to other cities, provinces, or countries for disposal or further processing. This relieves the affect population of the responsibility of managing their own waste. While not uncommon, this practice can prove to be problematic, as waste is frequently transported to countries with lower environmental regulations to reduce costs. This can result in significant environmental contamination and negative impacts on local populations.

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, simply known as the Basel Convention, is an international treaty that was designed to reduce the movements of hazardous waste between nations, particularly from developed to less developed countries. The Basel Convention has been active since 1992 and is comprised of 186 countries. By ratifying the agreement, countries confirm that they regulate activities in accordance with the Convention's provisions. Canada implements the requirements of the Basel Convention through the Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations (Government of Canada, 2019). The overall goal of the Basel Convention is to protect human health and the environment against adverse effects from the generation, transboundary movements, and management of waste. The Convention seeks to minimize the generation of hazardous waste, including hazardous recyclable materials, to ensure they are disposed of in an environmentally sound manner and as close as possible to the source (Government of Canada, 2019).

Hazardous wastes may be transported for treatment, storage, or disposal purposes. Each province requires documentation to be completed and carried with the shipment when transporting hazardous wastes. This helps to ensure that shipments of waste and recyclable material entering, leaving, or passing through Canada can be controlled and tracked by Environment and Climate Change Canada. The potential for pollution to occur during the transportation process varies depending on the waste. Transportation of household waste often accounts for the largest expense and has significant environmental consequences, including greenhouse gas emissions from trucks, littering, and other safety concerns regarding transporting dangerous goods.

In January 2018, China made international headlines when it announced it would close it borders to many materials, including many plastics, and required a maximum contamination rate of 0.5% (Katz, 2019). Many waste producers had long relied on China to accept and process their recyclables, including low value and poorly sorted shipments. The resulting impacts from the boarder closure are still being felt. In some cases, recycling programs have been scaled back or cancelled and incineration rates have risen – however this new reality offers an opportunity for innovation in waste management and address a rise in throw-away cultures (Katz, 2019).

3.4 Diversion

Waste diversion encompasses a range of strategies focused on reducing the amount of waste requiring disposal. Waste diversion has the obvious benefits of preserving landfill capacity and reducing the environmental footprint of creating, disposing and storing waste. Diversion also helps avoid the costs and environmental degradation associated with the extraction and processing of virgin materials. To ensure the success of the various diversion strategies, it is imperative that both residential and commercial sectors participate in these programs.

Waste diversion is an increasingly important aspect of solid waste management, as the capacity of existing landfills is finite. A recent study conducted by the Ontario Waste Management Association found that landfill capacity in Ontario will be reached by 2032 if waste production rates remain the same (Jones, 2019).

Within Ontario there are both government and industry-based diversion programs.

Table 2 represents just a sample of diversion programs offered in Ontario. Initiatives and organizations which deal with textiles, yard waste, scrap metal, and other reusable items also exist.

Table 2: Examples of diversion programs and initiatives in Ontario

PROGRAM	DESCRIPTION	ACCEPTED MATERIALS
Blue Box	Recycles packaging and printed paper	Plastics, glass, aluminum, steel and paper
Green Bin	Redirects household organic waste from landfill to compost	Accepted items will vary by municipality. Includes food scrapes, meat/bones, eggs, vegetables, fruits, and baked goods
HPSA Drop-Off	Collection and disposal of unused and expired consumer health products at pharmacies and other collection points	Prescription drugs, over-the-counter medications, natural health products, and medical sharps (i.e. needles). Accepted items may vary by province
Ontario Deposit Return Program (ODRP)	Return program for alcohol containers at collection points	Glass bottles, bag-in-box, Tetra Pak containers, plastic bottles (PET), and aluminum and steel containers on which deposits have been charged
Orange Drop	Recycles or properly disposes of hazardous materials	Paint, antifreeze, batteries, and fertilizers
Tire Collection Network	Free tire collection network managed by tire manufacturers	Tires
Waste Electrical and Electronic Equipment	Reuses or recycles electronic equipment	Computers, desktop printers, televisions, cell phones, personal/portable audio systems and stereos

In 2018, nearly 1.5 billion alcohol containers were returned in Ontario, with 395 million of those from the ODRP (Brewers Retail Inc, 2019). That's a total of 221, 668 tonnes of alcohol containers diverted from landfills!

3.4.1 Composting

Composting is a natural biological process that converts organic material into a stable humus-like product (Compost Council of Canada, 2010). During the composting process, microorganisms break down organic material into simpler, smaller units. In addition to improving diversion rates, composting produces is a high-quality fertilizer which can be used locally in parks and green spaces or by residents.

As of 2007, there were an estimated 350 centralized composting facilities operating in Canada. These facilities processed the household organic and yard wastes generated by approximately 17 million Canadians (Van der Werf & Cant, 2007).

Composting facilities may employ one of many methods, but the three most common are the in-vessel method, the aerated static pile method, and the windrow method (Compost Council of Canada, 2010).

Figure 7: A variety of compost methods used in Canada. (Top to bottom) In-Vessel (Saskatchewan Waste Reduction Council, n.d.), Aerated Static Pile (Mettler, 2017) and Windrow (Mooney, 2017).

1. **In-vessel Method:** organic material breaks down inside of structures such as drums, silos, or batch containers. Covered or open channels may also be used. Material is aerated and mechanically turned and controlled. Compost must be cured after it is processed. This method can process large volumes of virtually any organic waste. The capacity and space required is determined by the size of the vessel (EPA, 2016).

2. **Aerated Static Pile Method:** organic materials are formed into large piles which are aerated by drawing air into the pile or forcing air out. Organic material is not turned in this process. This method is appropriate for relatively homogenous organic waste including yard waste and household organics. It is not well suited to process animal by-products or grease (EPA, 2016).

3. **Windrow Method:** organic material is placed in elongated piles, called windrows, which are mechanically turned. This method is suitable for large volumes of organic waste but requires significant land. A diverse variety of organic wastes including yard wastes, grease, liquids, and animal by-products (i.e. fish or poultry wastes) can be composted using this method (EPA, 2016).

Compostable vs. Biodegradable – What's the difference?

Any material that can be broken down by bacteria or fungi through biological process is biodegradable. There is no timeframe for the process to complete and undesirable substances, like metal residue, can be left behind.

On the other hand, compostable materials are those that can be broken down naturally to their base elements in roughly 90 days. Compostable materials cannot result in any visible, distinguishable or toxic residue.

Composting is also a useful technique for managing agricultural waste like manure. When added to soil, composted animal waste can improve soil structure and increase the availability of macronutrient and micronutrients (Statistics Canada, 2004). Solid manure should be composted in an aerobic treatment to kill pathogens and reduce volume and odours. Should this material be processed in an anaerobic environment, or an environment without oxygen, the manure will not decompose completely and will form compounds toxic to plants and low in available nutrients in addition to methane (Newport, 2006).

The final product of aerobic treatment of manure is a stable humus that is easy to handle and can be used as a fertilizer. Liquid or semi-solid manure can be treated either by separating water from manure solids through drying, or by storing manure in anaerobic digesters, converting organic matter into methane and carbon dioxide.

Other treatment methods include basic sewage procedures such as filtering liquid manure through constructed wetlands or artificial marshes where nutrients are naturally removed or captured by vegetation (Statistics Canada, 2004).

3.4.2 Recycling

Recycling is the process by which previously used materials are converted from one form to another. How a material is recycled is greatly dependant on what that material is – paper, aluminum, and plastic are all treated differently.

Recycling reduces the demand for virgin materials, redirects from landfill or incineration, saves energy, and supports the green economy. Recycling is most prevalent in homes and schools. Within Canada, the recycling process can be broken down into seven major steps (RecycleBC, 2019):

1. Recycling begins at the source; materials are collected on a set schedule or taken to local collection facilities.
2. Materials are transported to a Material Recovery Facility (MRF pronounced "merf").
3. Once at the MRF materials are loaded onto a conveyor belt to begin the sorting process.
4. Large non-recyclable items are removed manually. Other materials continue down the conveyer belt and are separated into specific categories using equipment such as rotating drum screens, magnetic separators, optical sorters, and air classifiers.
5. Sorted materials are baled, loaded into trucks, and prepared for shipping or storage.
6. Bales are shipped to material manufacturers to make new raw materials. Plastics are shredded and washed, paper is pulped and pressed, and metals are shredded, smelted, and rolled.
7. Some materials are recycled back into their original products; others are made into new products and sold back to consumers.

There are two broad methods of recycling that an item can undergo – upcycling and downcycling.

Upcycling is used to describe when materials are reused without degrading their quality. Items produced from upcycling are of equal or greater value than the original material(s) used in the process. This conserves resources, prolongs the life of materials, and can make a product more attractive to consumers who have sustainability on their mind (Gumtree, n.d).

Conversely, downcycling is when materials are converted into something of lesser value. While some products can be repeatedly reproduced, some materials slowly break down with time as they go through the recycling process. Despite this, downcycling reduces the need to use raw materials for these lesser yet still valuable products. (Resource Center, n.d).

While there are many advantages to recycling, there are also barriers to implementation. Approximately 11% of plastic waste is recycled in Canada, which means that a large percentage of plastic waste ends up in landfills, incinerators, lakes, oceans, parks, and other natural ecosystems. There is also a wide variety of plastics and only certain types may be recycled depending on the community. While recycling can play a bigger role in reducing the rate of pollution, the process has not been widely embraced in many communities and is still a small part of a long-term success plan (Conserve Energy Future, n.d).

The costs of collecting waste, transporting it to a handling facility, sorting it, cleaning it, repackaging it, and transporting it again is almost always more expensive then landfilling that same waste in a local facility.

RECYCLING PAPER

Paper comes in many forms, from printer paper to corrugated cardboard. A 2014 study shows that paper products make up approximately 26% of municipal solid waste (Giroux, 2014). Paper recycling programs are widely established in urban areas and are usually operated and funded by some level of government. As paper products are easily recyclable or compostable, some provinces such as Nova Scotia, PEI, and Quebec have banned their disposal into landfills (Langlois-Blouin, 2017).

The most important factor in paper recycling is the length and strength of the fibres in the paper materials that are to be recycled. The recycling process shortens the fibers, making the resulting paper weaker and less durable. After being recycled 5-7 times, the fibres are typically too short to be recycled again. Instead, the material is turned into paper paste and used to create items such as newspapers or egg cartons (PPEC, n.d.). For more on how paper is recycled, see the Student Activity at the end of the section.

Most paper products are recyclable, but some communities are too far away from a recycling mill for recycling to be an economically viable solution. In these communities (and in others, especially when the paper materials are soiled in some way), paper can be composted with other household organic waste as an alternative diversion method (Giroux, 2014). Paper can add a decent amount of carbon to composted materials, which can make for a more nutrient-rich compost (PPEC, n.d.).

RECYCLING PLASTICS

Plastic is a malleable material that can consist of a wide range of synthetic or organic **polymers**. It makes up a highly visible portion of the waste stream mostly due to its versatility. From lightweight bottles made from PET to flexible hoses made from PVC to food containers made of polystyrene, plastics can be used for just about anything.

As plastic is a very broad category of materials, recycling them is a complex issue with no single solution. For one, recyclable plastics may be contaminated with non-plastic materials or different types of plastic, which could compromise any new products made from those materials. As such, recycled plastics tend to be used for less structurally demanding items than the original products (Rodriguez, 2019).

Every recycling program has specific rules about what plastics can and cannot be recycled (Rodriguez, 2019). Certain plastic materials are known to cause problems for Blue Box systems in Ontario. Black plastic, plastic films, laminates, and polystyrene are all difficult or costly to recycle, and as such are not often acceptable items in blue boxes (Lindsay, 2019).

Plastic as a material is not biodegradable like paper, or inert like glass. It does break down, but only into smaller plastics. See Section 4.2.1 for the impacts of plastics on the environment. There has been some research on bioplastics, or plastics made from more organic components, but they haven't been successful on a large scale due to the production costs and problems with stability (Rodriguez, 2019).

RECYCLING ALUMINUM

While a variety of metals are recyclable, the most commonly recycled metal in municipal Blue Box collections is aluminum. Aluminum is used in a wide variety of products and is an endlessly recyclable material. Its basic properties are not altered with physical or mechanical processing, allowing it to be recycled repeatedly without any loss of quality. Nearly 75% of all aluminum ever produced is still in circulation today (The Aluminum Association, 2011).

Recycled aluminum requires less energy than using new materials. To process, aluminum goods (cans, aluminum foil, baking trays, and so on) are cleaned, sorted, and pressed into bales of metal. These bales are shredded, allowing for the metal to be melted more evenly when it is fed into the furnace. The resulting **ingots** of aluminum are rolled into thin sheets that can then be used to make drink cans, foil, and other products that are near identical to the products that initially went in. This entire cycle can take place over the space of as little as six weeks (The Aluminum Association, 2011).

As there is no limit to how many times aluminum can be recycled, it is by far the most economically sustainable material to recycle (Jarvis and Robinson, 2019). Its high value can generate a considerable portion of the revenue to be found in recycling and subsidizes the recycling of lower-value materials, making municipal recycling programs possible (The Aluminum Association, 2011).

Not All Plastics Are Made Equal!

Plastics may be some of the most common materials we encounter in our day to day lives, but not all plastics are made equal. Different plastics are used in different ways depending on the properties of the materials.

To differentiate between types of plastic, check the bottom of the product! Plastic products are all stamped with a symbol that indicates what exactly they are made of (American Chemistry Council, n.d.).

PLASTIC TYPE	DESCRIPTION
Polyethylene Terephthalate (PET, PETE, polyester)	An excellent barrier to oxygen, water, and carbon dioxide, this plastic is clear and tough. It is commonly used in water bottles and textiles. This is the most commonly used and recycled plastic.
High Density Polyethylene (HDPE)	A relatively stiff material with resistance to most solvents. Milk jugs, laundry detergent containers, and shopping bags can all be made from HDPE. It is tougher than PET, and almost as common.
Polyvinyl Chlorate (PVC)	This plastic has high impact strength and is resistant to grease, oils, and chemicals. It is best known for its use in pipes, but it can also be used for medical tubing, wire jacketing, and window cleaner spray bottles.
Low Density Polyethylene (LDPE)	This flexible and relatively transparent plastic can be used to make condiment bottles and toys, but is mostly used in plastic films. Shrink wrap, grocery bags, and the coating for paper coffee cups are made from LDPE.
Polypropylene (PP)	With a high melting point, this plastic can withstand high temperatures. It is great for holding hot liquids. Medicine bottles, takeout containers, and straws can all be made from LDPE.
Polystyrene (PS)	This plastic is incredibly versatile. In a rigid form, it can be used to make products like CD cases. Foamed, it is an excellent insulator with low thermal conductivity, lending itself to use as packaging for hot items with a short shelf life or as protective packaging (ie. packing peanuts).
Other	Use of this code means that some miscellaneous plastic has been used in the product. It can be a single uncommon plastic, or a mixture of different materials. These types of plastics are often not recyclable, as their contents are unknown.

DISCUSSION QUESTIONS

1. What types of plastic can you find around your classroom? At home?
2. Research what various recycled plastics can be turned into. What could you turn the plastic in your home/classroom into, if you had the means?

RECYCLING GLASS

As one of the oldest synthetic materials, glass has played a role in human societies for thousands of years. Glass does not decompose, release GHGs on its own, nor does it leech harmful substances into its surrounding environment. It is a readily recyclable material that can be melted and reformed repeatedly with no loss to performance in a process that is less energetically demanding than outright creating new glass (Dyer, 2014).

While recycling glass is an efficient process, simply reusing glass bottles saves time and energy. Glass bottles can be used an average of fifteen times before being recycled into new glass bottles (Brewers Retail Inc, 2019). Many recycling systems include container deposit schemes wherein a consumer pays a small deposit that is tied into the price of the item and is refunded that amount upon the return of the glass product (Dyer, 2014). In Ontario, there is the Ontario Deposit Return Program (ODRP) run by the Beer Store. In 2018, 94% of all glass bottles sold by The Beer Store and LCBO (both reusable and not) were returned through this program, keeping glass out of landfills, and allowing municipal Blue Box programs to focus their efforts on other recyclable materials (Brewers Retail Inc, 2019).

Like paper, glass has been banned from certain landfills in places such as Vancouver and Nova Scotia (Giroux, 2014), and for good reason. Not only can glass be bulky and remain intact for an exceedingly long time in landfills, it is also not combustible and could detract from incineration processes by acting as a heat sink (Dyer, 2014).

3.5 Waste to Energy

Renewable energy is energy derived from natural processes that are replenished at a rate that is equal to or faster than the rate of which they are consumed (Natural Resources Canada [2], 2017). By this definition, utilizing the near constant stream of waste going into landfills, wastewater treatment plants, and elsewhere to generate energy is renewable.

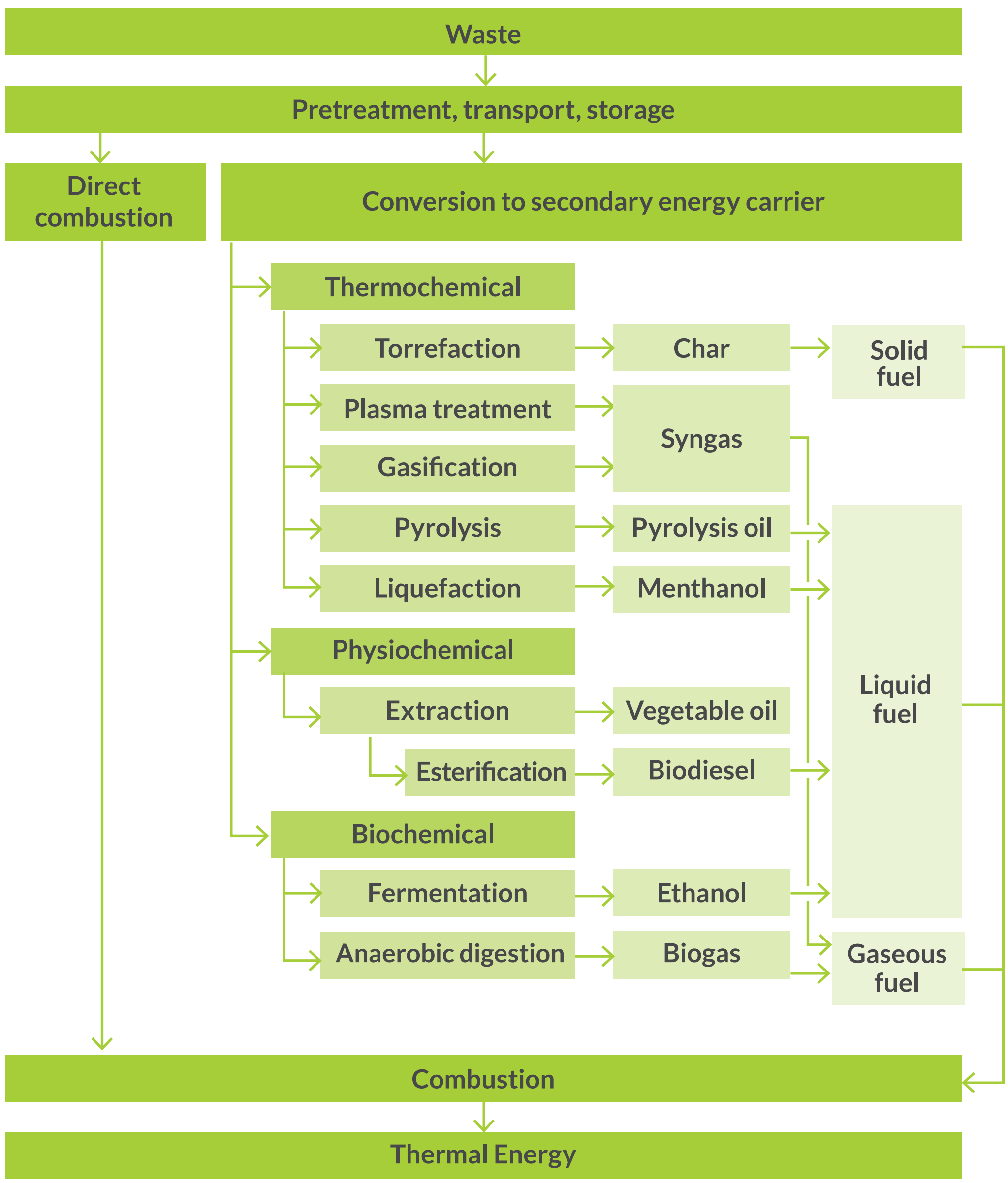
There are many ways to process waste and transform it into energy, either directly or through a fuel of some kind. Municipal wastes are heterogeneous, containing materials that vary in size, shape, and composition. Direct combustion of these materials (otherwise known as incineration) is the simplest way to convert them to energy. It is the most accessible conversion method, as it can handle a wide variety of materials and is less sensitive to fluctuations in size, shape, and composition. (Helsen, 2010). Incineration can utilize plastic waste, which cannot undergo many other transformations to energy (Lee et al, 2019).

Other conversion methods have more specific requirements for what types of materials they can process. To make these systems more efficient, waste needs to undergo pre-treatment that includes but is not limited to size reduction, sorting, drying, or even pelletizing materials. This pre-treatment generally means that these methods to convert waste to fuel are done on a smaller scale than incineration, which in turn allows for more control over the temperature and pressure within the various reactors that may be used from that point onwards (Helsen, 2010).

Once materials have been suitably processed and sorted, they are converted into a fuel of some description. These fuels can be solid, liquid, or gaseous depending on the process used to create them (Helsen, 2010). Converting energy to fuel allows for the transportation and storage of energy in a manageable form that can be used by a broader audience. One such example is biogas (methane), a product of anaerobic digestion. As mentioned in Section 2, the anaerobic digestion of organic material leads to the production of methane. However, methane produced in a controlled environment can be contained and used as a replacement for natural gas in providing heat and energy wherever it is required. The by-products of combusting methane are carbon dioxide and water vapour, which is not only less harmful to the atmosphere than methane, but also generally less harmful than the by-products of combusting fossil fuels. (Lee et al, 2019).

While many of these processes are complex in nature, they provide an avenue to utilise waste in a meaningful way in addition to limiting just how much goes to landfill.

Figure 8: Various waste conversion pathways and the resulting fuels (Helsen, 2010). Each of the processes represented can convert some type of waste into a fuel that can be stored and used at-will, apart from incineration/direct combustion.



3.6 Hands-on Activity: Papermaking

An estimated 90% of all boxboard, newsprint, and paper is collected for recycling in Ontario's residential sector (Giroux, 2014), but how is it processed? Although the technology has changed, paper has been made the same way through all the centuries people have been making paper from pulp. First, the base material is mixed with water to create a slurry wherein fibres are suspended in liquid. Then, the slurry is rolled out into large thin sheets, allowing the water to drain and the fibres to be pasted together. Finally, the new paper is left to dry before it is ready to be cut and used.

Different types of materials can be used to make different types and qualities of paper products. While materials for new paper is often pulp created from some woody biomass, scrap paper can be shredded and used as the base material for a new product – recycled paper.

Try it out for yourself!

MATERIALS

Scrap paper, plant and vegetable scraps (e.g., flowers, grass clippings, leaves, carrots, or beets), non-toxic fabric dye, fasteners (staples, tacks or waterproof glue), two wooden frames (approximately 20 cm x 15 cm), nylon screening, kitchen cloths (porous type), blender, sponge, iron, large plastic basin

METHOD

1. Staple nylon screening tightly to one wooden frame to make a paper "mould". The second frame without the screen is the "deckle", which will help make the edges of the paper more even.
2. Remove any plastic or staples from the scrap paper and tear it into small pieces (about 2 cm). Soak it in hot water for half an hour.
3. Put a handful of the soaked paper into a blender half-full of warm water. Blend at moderate speed until you no longer see pieces of paper. (If you have problems, take out some of the paper.) Add small amounts of plant or vegetable scraps to this mixture (pulp) and blend again. If you want coloured paper, add fabric dye.
4. Pour the mixture into a large plastic basin half full of warm water.
5. Place the deckle on top of your screen. With both hands, dip the mould into the basin and scoop up some of the pulp. (The thickness of your paper will depend on the amount of pulp.) Gently shake the mould back and forth to get an even layer of fibres on the screen. When the water has drained through, place the mould to one side and carefully lift off the deckle, leaving the just-formed sheet on the screen.
6. Lay a clean kitchen cloth on a flat table and lay the screen face down on the cloth. Soak up any extra water from the back of the screen with a sponge. Lift the screen very gently — the paper should remain on the cloth.

7. Cover the paper quickly with another cloth and iron at a medium dry setting. Once dry, pull gently on either side of the cloth to stretch it — this helps loosen the paper from the cloth. Gently peel the paper off.

8. Compare the strength, colour, and texture of homemade paper to that of the different types of paper used in the classroom. Point out similarities and differences.

Note: Be careful not to pour the leftover pulp down the drain. Collect it in a strainer and throw it out or freeze it in a plastic bag for future use.

3.7 Discussion Questions

1. How is solid waste managed in your community? What fraction are landfilled vs recycled, composted, incinerated or exported? Have any of the methods used had negative impacts on residents?

2. What recycling is being done in your community? Is the program successful? How can the program be improved to;
    a. collect a greater amount of recyclables
    b. make it more cost effective?

3. A financial analysis of landfills should include the environmental cost of loss of land and potential groundwater and air pollution. Are there other factors should be used in the creation of a dollar value, and what value would you assign for each?

4. What are the health and environmental risks of dioxins and furans?

5. Research a conversion method used to turn waste into energy. What materials can be converted by that method? How can the resulting fuel be used?

4.0 Environmental, Social, and Economic Impacts of Waste

While the environmental issues associated with the accumulation and processing of waste may be apparent, there are other impacts to be considered. In addition to affecting natural systems, waste can negatively impact human health through water, soil, and air contamination, reduce property values near processing facilities, and can be expensive to implement and maintain, putting stress on municipal and city budgets.

4.1 Environmental Impacts

Over the last century humans have created a significant volume of waste materials, many of which release chemicals as they breakdown. In some cases, these chemicals can be the cause of significant issues for human and animal health and impact ecosystem function.

4.1.1 Soil & Water Contamination

Contamination refers to the introduction of an undesirable substance into the environment which can originate from both natural and anthropogenic sources. Once introduced, the effects of contamination can spread and effect a larger geographic area though ground and surface waters. Contaminants can also be airborne. When contaminates can be linked to a specific source, such as a landfill, it is referred to as Point Source Pollution. Many factors influence the mobility and **bioavailability** of contaminants such as pH, soil texture, and soil organic matter. Given the complexity of **hydrological systems**, contamination can be extremely challenging to predict and remediate. Prevention is the best method.

While landfills provide economic means of solid waste management, improper or poorly engineered landfills are a threat to the environment (Tammemagi, 1999). If not properly sealed from the surrounding environment, landfills can impact ground water through the release of leachate. Leachate is a toxic substance that is created when water generated from precipitation or the breakdown of organic matter passes through a landfill and extracts suspended or dissolved matter from the waste present (Raghab et al., 2013). The way leachate interacts with natural systems is highly dependent on the composition of the leachate, which itself is dictated by the composition of waste where it is formed. Examples of leachate impact could include eutrophication, severely reduced water quality, and the introduction of heavy metals into the food web though bioaccumulation (James, 1977).

Figure 9: Samples of leachate collected as part of a USGS study (Kolpin, n.d.).

In addition to leachate, landfill gas contains a high concentration of carbon dioxide which can significantly contribute to groundwater pollution due to its high solubility (El-Fadel et al., 1997).

Long term exposure to contaminated soils can affect the genetic makeup of the human body, causing **congenital anomalies** and chronic health problems that cannot be easily cured. Some health effects include liver toxicity, kidney failure, and neurological diseases (Carre et al, 2015). The health effects of soil contaminants depend on a variety of factors, such as the nature of the pollutant, mode of attack and vulnerability of the exposed population.

4.1.2 Wildlife & Plastics

All known species of sea turtles, about half of all species of marine mammals, and one-fifth of all species of sea birds are affected by entanglement or ingestion of marine debris (Thompson, 2013).

Plastic products are all around us; in our homes, workplaces, landfills and sometimes rivers, lakes, and oceans. In 2018 alone, 359 million metric tons of plastics were produced globally (Garside, 2019). While many cities and municipalities collect and process plastics, an estimated 8 million tons still find their way into oceans annually, representing nearly 80% of all marine debris (IUNC, 2019).

Plastics are more than just unsightly additions to the ocean – they can cause a host of issues for aquatic life. Wildlife may accidentally consume or become entangled in plastic left floating in the ocean, both of which potentially leading to the death of the animal in question. Plastics can further disrupt ecosystems as they break down into microplastics, a classification of plastics 5 mm or smaller (Canadian Wildlife Federation, n.d.). These microplastics can be generated in many ways, including the decomposition of larger pieces of plastic, microbeads from personal care items, and synthetic fibres.

Millions of marine animals are estimated to be harmed by plastics every year. Nearly 700 species, including species at risk, are known to have been affected (Parker, 2019). Observed impacts have included altered feeding behaviors, impaired reproductive success and in extreme cases starvation (Royte, 2018). The following are just a few examples of how marine plastics are known to impact common aquatic species.

ZOOPLANKTON

Even the smallest creatures are being affected by plastics. Laboratory evidence has shown that many zooplankton taxa mistake microplastics for food and ingest them readily. Microplastics can impair their feeding through obstruction of their feeding appendages and reduce the reproductive success of affected zooplankton. (Botterell et al, 2018).

Plankton are a crucial food source for many aquatic animals, including invertebrate filter feeders, predators, and large mammals. As such, healthy populations of zooplankton are important. Researchers are concerned that these organisms provide an entry point for microplastics into the food web which will cause damage as they bioaccumulate up trophic levels (Cole et al., 2013).

FISH

Plastics are having a negative impact on both marine and freshwater species of fish. In a local example, researchers have found synthetic polymer fibres and plastic pellets in the digestive tracts of fish in Lake Erie. As these microplastics move through the fishes' digestive tracts, contaminants are absorbed, which lead to liver damage (Bhakta & Derksen, 2015).

SEA TURTLES

In Atlantic Canadian waters, Leatherback Sea Turtles usually feed on Lion's Mane and Moon Jellyfish, both of which could be easily confused with marine debris such as plastic bags and deflated balloons. Once ingested, plastic can cause internal blockages causing a turtle to starve, or it can prevent them from properly absorbing the nutrients needed (NOAA, 2014). Other species of sea turtle such as Green, Olive Ridley, and Loggerhead are also at risk to varying degrees depending on their feeding habits (WWF, n.d.).

MARINE MAMMALS

According to the U.S. National Oceanic and Atmospheric Association, nearly 100,000 marine mammals die as the result of trash (NOAA, 2014). Baleen whales like the North Atlantic Right Whale feed by opening their mouths wide on the surface of the water — catching copepods and other invertebrates in their mouths and filtering sea water out in a process known as filter feeding. Unfortunately, as a result of this feed technique plastics can enter into the whales' digestive system.

Plastics can also leach chemical compounds into the water as they break down, further impacting ecosystems and wildlife. These plastic chemicals are among the contaminants that appear to be affecting the St. Lawrence estuary population of Beluga Whales. It has been found that these Belugas have the highest rates of cancer and carry one of the largest amounts of contaminants of any mammals. It is suspected that chemical contaminants are leading to this cancer, as well as the mortality and reproductive issues facing this marine mammal (Martineau et al., 2002).

4.2 Social Impact

Waste and waste management strategies have significant impacts on society. In Ontario, a social impact of waste management revolves around the location of processing and storage facilities. A series of studies published in the 1990's examined the psychosocial effects on populations living within proximity to solid waste disposal facilities, specifically landfills as well as an incinerator in southern Ontario. Researchers studied the ways in which residents experienced the facilities and the impacts on their daily lives. The main concerns expressed from residents near landfills included increased traffic, flocks of scavenging birds, poor water quality, and poor property values. Conversely the major concerns from residents near the incineration unit related to air quality, stack emissions and odours. The study also found that residents lacked trust in local government and authorities in making proper decisions for the community (Eyles et al., 1993).

Society and waste are also linked through everyday rituals, behaviours, local initiatives, and legislation at the municipal, provincial, and federal level. Exposure to waste reduction initiatives such as recycling, composting, and sustainable consumption can be influenced by individuals' experiences, geography, and socio-economic status which in turn impacts the level to which an individual will participate. Education is vital when it comes to better understanding waste management options. Getting involved in school programs and initiatives such as recycling programs, community composting, and neighbourhood cleanups reduce the amount of waste entering our natural ecosystems and strengthens communities.

As mentioned in Section 3.3 waste is frequently processed, treated or stored in locations removed its point of creation at the regional, national, and international levels. Until recently, there was a large international trade in plastics and other recyclable materials, with richer industrialized nations shipping waste to poor countries with looser environmental regulations. The resulting environmental and social impacts have resulted in many countries closing their boarders to the international garbage trade.

4.3 Economic

Waste management represents a significant cost for many municipal governments in Canada (AMO, n.d). Depending on the methods employed and the financial mechanisms introduced, waste management can have varying impacts on the economy. A report published by The Conference Board of Canada claims that diverting significantly more waste could increase employment and economic activity in Ontario, while reducing the province's dependence on U.S. landfills in Michigan and New York state (Knowles & Gill, 2014).

The studies presented in the report suggest that increasing Ontario's waste diversion from its current 23% to 60% would support the equivalent of an additional 12,700 direct and indirect full-time jobs and add $1.5 billion to provincial GDP. It is important to note that the benefits are only attainable once the 60% diversion rate is reached and maintained. The report concluded that for every 1,000 tonnes of waste diverted in Ontario, at least two jobs are supported.

These numbers might seem optimistic, but it is important to consider how regulations and policies achieve waste diversion goals with varying economic implications. These implications vary by region and depend on several factors, such as structure of local economy, sector wage, targeted materials, repurposing of diverted materials, and the degree to which regions import waste services. Policymakers must consider these factors in order to ensure that economic opportunities are maximized and that political consequences are evaluated (Knowles & Gill, 2014).

Litter removal is often a hidden cost within waste management, which can make it difficult to determine the actual cost to local governments. Litter costs are also not included as a budget line item, making it difficult to determine the time spent on cleanups. Local governments spent $2.6 billion on waste management in 2008, up from $2.1 billion two years earlier. Of the total, $1.1 billion went to waste collection and transport, $465 million to run disposal facilities and $368 million for tipping fees (Statistics Canada, 2018).

The cost of transporting waste in Canada is a major issue and is one of the largest costs associated with waste management. The transportation of waste also has many environmental, social, and economic repercussions. Transporting waste increases the number of vehicles on roadways both between the location of production and treatment, creating air and noise pollution, congestion, and other problems relating to road transport. The potential for the release of contaminants during the transportation of waste varies; the more hazardous the waste and the larger the volume that is transported, the more devastating the impact on environmental and human health if an accident occurs. Traffic accidents or train wrecks can result in waste spills and releases of pollutants that may contaminate the air, water, and soil. Waste may also be released while being loaded or unloaded during transportation.

With the increasing amount of waste, there is an increasing demand in space, resulting in many potential landfills being located far from where the actual waste is being generated. This adds significant transportation costs, results in the release of GHG's and, as mentioned in section 4.2, disproportionally affects communities not responsible for the generation of the waste in the first place.

4.4 Hands on Activity: What is Your Plastic Footprint?

80% of ocean pollution is caused by human activity on land. What is your plastic footprint? To get an idea, go room by room and tick off the boxes!

KITCHEN

- ☐ Do you use plastic cutlery, plates, and cups?
- ☐ Do you own plastic storage containers?
- ☐ Do you use plastic bags at the grocery store?
- ☐ Do you use cling wrap?
- ☐ Do you drink bottled water?
- ☐ Do you use plastic cooking utensils?
- ☐ Do you own a single-use coffee maker?
- ☐ If you have a Green Bin program, do you use plastic bags to line it?

BATHROOM

- ☐ Do you toss empty shampoo or body wash bottles in the garbage can?
- ☐ Do you use an exfoliating facial cleanser or body scrub?
- ☐ Do you use disposable razors, toothbrushes, or dental floss picks?
- ☐ Is your vanity cluttered with cosmetics?

LAUNDRY ROOM

- ☐ Do you own polyester, acrylic, lycra, spandex, nylon, or fleece clothing?
- ☐ If yes, do you wash them often?
- ☐ Are your rubber boots really rubber — or are they made of plastic?
- ☐ Does your laundry detergent come in a plastic jug?

BEDROOM

- ☐ Do you use polyester or fleece bed sheets?
- ☐ Do you light candles with a lighter?
- ☐ Do you have a tube of hand cream on your nightstand?
- ☐ Do you use linen spray on your sheets?

OUT AND ABOUT

- ☐ Do you drink from a plastic straw?
- ☐ Do you use plastic utensils?
- ☐ Do you use condiment packets?
- ☐ Do you drink your coffee from disposable cups?
- ☐ Do you drink bottled water?
- ☐ Do you use plastic bags at fast food restaurants?

How did you do? Don't worry if you scored high, there are lots of options to make greener choices all through the house. Keep reading for ideas to reduce your plastic footprint!

KITCHEN

If you're trying to spruce up the kitchen and make it greener here are some things you can change to make a difference.

- When buying new cooking utensils buy wood or metal instead of plastic.
- Go green with groceries! Cut out those plastic bags and buy in bulk when you can to cut down the number of trips you need to make to the store.
- Make the most of the plastics you have. It can be hard to get rid of plastics entirely so instead of throwing out plastic tubs or containers use them for snack containers for your lunch.

BATHROOM

When you're trying to green up your clean up, here are a few things to consider making your bathroom as green as it can be.

- Ditch those microplastics! Microplastics are found in many exfoliating washes and scrubs try swapping these products out for a natural brush and get just as clean while staying green.
- Buy shampoos and conditioners in bulk, this reduces the number of bottles you need to use.
- Go old school, get rid of body washes for a good old bar of soap this reduces plastics used while still getting the job done.

LAUNDRY ROOM

Time to freshen up laundry day; try some of these green alternatives to clean your clothes and the planet:

- Choose natural fabrics for your clothes. Artificial materials from clothing don't break down as easy as natural products, by switching to a more natural wardrobe you can reduce the amount of pollutants coming from your laundry.
- Use natural detergents in your wash; this reduces chemical entering water ways through wastewater.
- Buy in bulk reducing the plastic needed to store the detergent.
- It's time for an upgrade! Upgrading your appliances in the laundry room will both save energy and better filter out wastes from entering waterways.

BEDROOM

There are some easy solutions to reduce the waste that comes from your bedroom:

- Buy natural bedding. This easy switch from artificial fabrics like polyester to silk will keep harmful materials out or the environment and keep you warm at night.

OUT AND ABOUT

Whether you're hanging out with friends or heading to class always remember to bring the green with you when packing for the day:

- Say NO to straws! Minimize your plastic intake by not using plastic straws. If you need one bring your own, there are plenty of options to buy reusable straws.
- Bring your own utensils. Wood or metal utensils are a great alternative to conventional plastic.
- Ditch the plastic water bottles. Get a reusable bottle; this will reduce the amount of plastic you use daily.
- Don't want to waste the food you can't finish? Bring your reusable container to put the leftovers in; this will help say no to single use takeout containers and lower food waste all at once.

It's not hard to reduce the waste you use in your life every day. Take some time and look at the products you use every day and try and find a way to reuse or limit the amount you use them. Some simple changes can make a big difference in the amount of waste we produce around our house.

4.5 Discussion Questions

1. Discuss how waste can contaminate soils and water systems.
2. This section focuses on how waste can impact aquatic wildlife, can waste also impact other wildlife? If you answered yes please expand.
3. Are you personally more concerned about the social or economic impacts of waste? Why?

5.0 Roles and Responsibilities

Proper waste management is a complex synergy of government, producers, and consumers working together. This relationship is only able to function if all parties work towards the same goal of reducing the amount of waste that ends up discarded in landfills or incinerated. Therefore, it is important to know the responsibilities of each sector and what role they play in the waste management cycle.

5.1 Roles of Government in Waste Management

In Canada, the responsibility for managing and reducing waste is shared among federal, provincial, territorial, and municipal governments. In general terms, municipal governments manage the collection, recycling, composting, and disposal of household waste, while provincial and territorial authorities (such as the Government of Ontario) establish waste reduction policies and programs as well as approve and monitor waste management facilities and operations. In this section we will further discuss the different roles and responsibilities associated with each level of government.

The federal government is responsible for the Environmental Protection Act which lays out the requirements that must be followed in the management of waste products within the province (Government of Ontario, 2019), while the federal government is responsible for the development of these rules. The collection and transportation of waste is left to local municipalities (Government of Ontario, 2019). Both large populations and large geographic areas require advanced waste systems to meet the requirements set out by the Environmental Protection Act. The federal government is also responsible for regulating international treaties within Canada on the sale and shipment of waste to other countries.

The provincial government is responsible for regulating and developing rules surrounding wastes and recyclables in relation to the Waste Reduction Act. These waste regulations are laid out using local by-laws and include waste limits, collection fees, and restrictions what can and cannot be thrown away. Differences in local regulations are usually controlled by the local budget allocated to waste management (Recycling Council of Ontario, 2019). As larger municipalities will often have access to more funding, they can implement more advanced waste management systems than smaller municipalities.

FUN FACT!

The largest municipalities in Ontario are, by population, the City of Toronto with over 2.7 million residents (World Population Review, n.d.) and by area and the City of Greater Sudbury which is comprised of 3630 square kilometres (Greater Sudbury, n.d.).

The municipal government is responsible for collecting, transporting, and disposing of waste, as well as managing litter collection in public areas. Different municipalities have different programs and initiatives put in place in order to properly manage waste. It is important to note that municipalities do not have control over the industrial and commercial sector; this is the responsibility of the provincial government. Municipalities are not able to collect industrial and commercial waste/recycling. To curb the issue of underfunding in smaller municipalities, the Federal Government provides local communities funding to invest in larger waste management facilities.

5.2 Roles of Producers and Corporations in Waste Management

Waste issues start at production. Producers are any brand holder with connections to a commercial market or packaging market in Ontario (Ministry of Environment, Conservation & Parks [1], 2019). Some of these producers include importers, wholesalers, and retailers. Producers are required to follow the Environmental Protection Act and, more importantly, the relatively new Resource Recovery and Circular Economy Act that was passed in 2016. Producers must also adhere to the Extended Producer Responsibility initiative, whereby importers and producers bear a significant level of responsibility for the disposal of their products. This includes upstream impacts such as the selection of materials they use and disposal methods of those products.

The Resource Recovery and Circular Economy Act lays out a new provincial strategy in Ontario designed to reduce waste that reaches landfill sites (Government of Ontario, 2016). The act enables the government to hold producers fully responsible for the effects their products have on the environment through financial responsibility for the recovery of the resources used in the production of the product (Canada's ecoFiscal Commission, 2018). To comply with this Act, producers need to find innovative solutions in order to reduce materials used in production, develop products that can be reused, or develop a system to recover waste products before they reach landfills (Government of Ontario, 2016). Products that must be recovered or reduced include any packing product that is used in the transportation of goods. Producers are also responsible for a level of education to the public on the importance of resource recovery with the hope of engaging the community in making more environmentally friendly choices. All projects and plans must adhere to the Integrated Accessibility Standards under the Accessibility for Ontarians with Disabilities Act (AODA), ensuring that anyone can access the services and products. This mandate to reduce or recover resources creates an opportunity for businesses to create profit from recycling, which incentivises responsible waste management at the production level (Government of Ontario, 2016).

Throughout Ontario, there are several private waste management companies. These companies own a majority of the waste disposal sites in Ontario and are responsible for the handling and disposal of waste. Some companies include GFL Environmental, Wasteco, Waste Management Inc. (WM), and Miller Waste Systems. Private waste management companies have a complex network of recycling facilities, waste disposal bins, landfills, and transfer stations to meet a variety of needs, ranging from construction waste to metal to yard waste. After collecting the waste, it is sorted so that the compostable items can be composted, and recyclables can be recycled. The small potion of remaining waste is then taken to the landfill.

There are several reasons why communities see privatization as a logical solution to their waste management needs. Outsourcing one's trash removal can save the government money in terms of personnel and equipment while offering the same level of high-quality services that residents have come to expect. However, there can also be issues in relation to private waste management companies. While privatization can dissolve any unnecessary monopolies, be more effective and flexible than existing services and encourage competition between providers, it can also lead to significant rate increases. It can diminish accountability for officials, compromise services due to the provider's profit motivation and lower morale for municipal workers with an increased fear of layoffs and displacement (The Globe and Mail, 2014).

5.3 Roles of Consumers

Although new regulation puts responsibility back on the producers, consumers still play a vital role in reducing the amount of waste that reaches landfills (Ministry of Environment, Conservation & Parks [1], 2019). The government has put in place regulations to ensure that there are resources available for everyone to incorporate more eco-friendly choices, and consumers must commit to using these available services.

Consumers have two key points at which they can impact waste management; those being when purchasing goods and when disposing of them (Ministry of Environment, Conservation & Parks [1], 2019). Ideally when purchasing products, consumers would make a conscious effort, if possible, to consider the ecological impact of the item; this can include buying products with reduced packaging, longer lifespan, or increased usability. The second point in waste reduction at the consumer level is waste disposal. Impacts can be minimized if consumers select the appropriate disposal channel (i.e. organics into compost, hazardous waste to a collection point). Alternatively, consumers can look for opportunities to donate, repair, or reuse items before disposing of them.

The Extended Producer Responsibility (EPR) requires farmers to be responsible for end-of-life management. In the agricultural sector, this includes waste packaging from pesticides and other non-organic waste. One EPR program is the empty pesticide container recycling program administered by CleanFARMS. As of 2009, the program had collected and recycled over 83 million empty commercial-class pesticide containers from Canadian farmers. Commercial users of pesticides return their empty containers to any one of the 1,000 designated sites across Canada. The program ensures that collection sites, contractors and processors meet strict health, safety and environmental standards. Instead of filling our landfills, the CleanFARMS™ program has prevented more than 68,000 tonnes of greenhouse gas emissions from entering the atmosphere -this is equal to taking more than 13,000 cars off the road or saving the emissions generated from powering 6,000 homes for a year (CleanFARMS Inc., 2011).

5.4 Case Study: Nova Scotia's Zero Waste Initiatives

Nova Scotia was the first Canadian province to reach a 50% waste diversion rate, and it did so without incineration. Waste reduction in Nova Scotia was a hot button topic in the 1990's when Halifax looked to expand an existing landfill. Residents were in an uproar, reporting complaints about odours coming from the area. In response, the municipality looked to open an incinerator with a goal of burning 750 tons of waste a day. Again, area residents said this was not an acceptable solution, which resulted in the launch of a public consultation to determine a viable solution.

In the end, recommendations from the report prepared by Jeffery Morris of Sound Resource Management Group, a consulting company located in Seattle, were selected and implemented, including:

- Source separation and door-to-door collection of recyclables, organics and residuals.
- Facilities for recycling and composting.
- Backup landfill for remaining residual fractions of waste.

A screening facility was constructed in front of the landfill in Halifax which consisted of two sections. The first section sorted residual waste, which entered the facility in large plastic bags, which were dumped onto a tipping floor. The bags were cut, and a large magnet used to remove all iron and steel objects. Workers then separated large and bulk items for the sorters.

The second section dealt with the dirty organic fraction and included materials such as kitty litter and diapers. Once sorted, the dirty organics were shredded and placed into longs troughs with high concrete walls. The materials in the troughs were then aerated by a mechanical turning device for 21 days. The extended period in the trough minimized odours and production of leachate when the materials enter the landfill after.

Other features of the Nova Scotia program include; composting facilities for clean organics, material recovery facilities for mixed recyclables, and enviro-depots for the collection and redemption of beverage containers and drop-off sites for household hazardous waste.

The new waste management system resulted in the creation of one thousand jobs. These jobs were generated in materials recovery facilities, composting, administration and research, tire recycling plant, the waste paint recovery plant destruction and reuse operation and environmental depots (Spellman, 2014).

5.5 Hands-on Activity: Two Week Zero Waste Challenge

Taking the 14 Day Zero-Waste Challenge is something you can do at home or as a class. This is a quick and easy version of the 30-day challenge provided by Going Zero Waste (Kellogg, 2017). Each day there is a goal or an activity each student must complete in order to follow the guidelines of the challenge. Students and or class can make a checklist for the days completed to stay on track with their goals of the 14-day Zero Waste Challenge.

DAY 1	DAY 2	DAY 3	DAY 4
Say no to straws	Use a reusable water bottle	Zero waste snacks	Save water (reduce use of water when washing dishes, brushing teeth, etc.)
DAY 5	**DAY 6**	**DAY 7**	**DAY 8**
School yard clean-up	Walk or bike to school	Bring a reusable bag when shopping	Develop a plan for zero waste grocery shopping
DAY 9	**DAY 10**	**DAY 11**	**DAY 12**
Declutter (donate unwanted items to a deserving local organization)	Waste audit day (as a class sort out the waste from lunches)	Research a Zero Waste Initiative	Research waste management programs in your city or town
DAY 13	**DAY 14**		
Host a waste free potluck lunch!	Watch a video of items being processed at a recycling plant		

This activity will allow individuals to get involved and realize what an impact they can make on a local level. By showing students the effects of zero waste strategies and how they affect everyday life and how we can improve waste volumes in school. In a broader picture it will show how these challenges can be used in a large-scale sense to reduce the amount of waste worldwide.

Already doing some of the suggestions for the Zero-Waste Challenge? Try swapping in your own goals for those days!

5.6 Discussion Questions

1. Describe the concept of Extended Producer Responsibility.
2. How can consumers impact waste management? Do you, your family or your school participate in any of these options?
3. How is waste managed in your community? Is it managed municipally, or by an outside contractor? What restrictions are there on waste disposal in your community?

6.0 Education

Environmental education is becoming increasingly important is our lives and cities. As cities become more congested, populated, and busy, knowledge of the impact we each have on our surroundings is crucial. Equally important, is our understanding of how we can contribute to protecting the environment around us. More specifically, educating the public on the effects of waste and how to properly dispose of waste is critical in ensuring a healthy community for everyone. Education is important for several reasons including:

- Increase in public awareness and knowledge of the consequences of waste;
- Equips individuals with skills to identify and resolve issues relating to waste; and
- Encourages participation in outreach activities such as community litter clean ups.

The Regional Municipality of York has also developed their own waste management program targeted to schools called Trash Blasters. Participating schools are provided with the tools and resources to learn about proper waste management.

There are many initiatives, events, workshops, and programs that the province, municipalities and organizations hold to educate and engage individuals regarding waste management. These programs inspire community members to take active roles in reducing, reusing, and recycling at home, school and in public spaces for a healthy tomorrow.

Alternatively, there are a number of free apps and online resources that you can now download on your cellphone to help you learn how to properly dispose and manage your waste at home. Please refer to the Tools and Resources section at the beginning of this guide for more materials.

7.0 Glossary

A

Ambient Air: atmospheric air which has not been contaminated by pollutants. Primarily composed of nitrogen and oxygen it also includes small amounts of carbon, helium, methane, argon, and hydrogen.

Anthropogenic: relating to or resulting from the influence of human activity. In this case, human being's activity adversely impacting the environment (pollutants, excess emissions).

Aquifer: body of porous rock or sediment saturated with groundwater.

B

Bioaccumulate: the concentration and build-up of a substance in the tissues of organisms.

Bioavailability: the amount of an element or compound that is accessible to an organism for uptake or adsorption across its cellular membrane.

Buffer Area: a green belt or zone located between the waste storage area and landfill boundaries. Buffer area prevents contaminates from exiting landfill site and provides space for monitoring, maintenance and environmental control activities.

C

Congenital Anomalies: Structural or functional anomalies (for example, metabolic disorders) that occur during intrauterine life and can be identified prenatally, at birth, or sometimes may only be detected later in infancy, such as hearing defects.

E

Eutrophication: the process by which a body of water becomes enriched in dissolved nutrients (i.e. phosphates) which stimulate the growth of aquatic plant life usually resulting in the depletion of dissolved oxygen.

F

Flue Gas: Gas that is exiting into the atmosphere via a pipe or channel. It is often referring to the exhaust gas produced at power plants or incinerators.

G

Greenhouse Gases (GHGs): The group of chemical compounds that are responsible for the greenhouse effect. The most important greenhouse gases produced by economic activity are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbons (CFCs).

H

Hydrological Systems: refers to the properties, movement, management and distribution of water, also called hydrological cycle.

I

Ingot(s): a piece of relatively pure material, usually metal, that is cast into a shape suitable for further processing.

L

Landfill: a designed structure built into or on top of the ground intended to isolate and store waste by burying or covering it with soil.

M

Manure: organic matter commonly derived from animal feces, can be used as organic fertilizer in agriculture.

P

Particulates: Microscopic pieces of matter suspended in air or liquid.

Polymers: a substance that has a molecular structure consisting chiefly or entirely of a large number of similar units bonded together.

Putrefaction: the process of rotting or decay of organic matter.

R

Recycling: The process whereby a material (for example, glass, metal, plastic, paper) is diverted from the waste stream and remanufactured into a new product or is used as a raw material substitute.

S

Slag: stony waste matter separated from metals during smelting or refining.

W

Waste diversion: The quantity of materials diverted from disposal facilities and represents the sum of all materials processed for recycling at an off-site recycling or composting facility.

Wastewater: Liquid waste; there are multiple types of wastewater including greywater (generated from washing/bathing), stormwater, blackwater (generated in toilets) and sewage.

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