THE PROBLEM WITH PLASTICS

Plastics are a challenging and problematic part of Ontario municipalities' waste management programs. *Engineering Dimensions* spoke with engineering and waste management experts to explore the havoc plastics play on our planet.

By Adam Sidsworth

Picture this: In November 2018, a rotting 9.5-metre-long sperm whale carcass was found beached in Wakatobi National Park in Southeast Sulawesi, Indonesia. Employees of the park's conservation authority identified roughly 5.9 kilograms of plastic in the animal's stomach, including 115 plastic bottles, 25 plastic bags, two flip-flops, a nylon sack and over 1000 other pieces of plastic. World Wildlife Federation Indonesia stated that the whale's cause of death was undetermined, although one representative described the scene as "truly awful."

Think about this: A 2015 study published in the *Proceedings of the National Academy of Sciences* journal reported that nine out of 10 seabirds most likely have pieces of plastic in their guts, with albatrosses and shearwaters seemingly most prone to eating plastic pieces. Once ingested, the plastic is lodged in birds' digestive tracts, interfering with their ability to eat. And if they regurgitate to their young, they too face the same fate. The study's author, Denise Hardesty, PhD, of Commonwealth Scientific and Industrial Research Organization's Ocean and Atmosphere, used computer forecasting to predict that 99 per cent of seabirds will have plastic in them by 2050. The areas of greatest concern are in the southern hemisphere, particularly Australia and New Zealand, which have the greatest number of bird species.

The location may seem surprising, given that EcoWatch reported that 60 per cent of marine plastic comes from just five countries, all in east and southeast Asia: China, the largest producer; the Philippines; Thailand; Vietnam; and Indonesia. Roughly 8 million metric tonnes of plastic end up in the ocean every year, of which 236,000 metric tonnes are microplastics, tiny pieces of plastic smaller than a human fingernail. Synthetic fibres have been found as deep as 11 kilometres below the ocean's surface—70 per cent of ocean plastics are at the bottom of the ocean—and by 2050, there will be more plastic than fish by weight in the oceans. And there are the five known gyres of plastic, large islands of plastic swarming around the oceans. The Great Pacific Garbage Patch, perhaps

the most famous, exists at the meeting of circular ocean currents formed by the planet's wind currents, which move in a clockwise direction over a 20-million-square-kilometre area. The 80,000-metric-tonne gyre, three times the size of France, contains 1.8 trillion pieces of plastic, most microplastic sized (less than five millimetres long) and is 80 per cent derived from land activity in Asia and North America.

As one study noted, it means that most of the ocean's plastic "is not abandoned fishing gear but plastic bags, milk and water bottles and consumer goods like flip-flops dumped into waterways and washed out to sea." It's problematic on multiple levels: The plastics leach out and absorb pollutants; they block sunlight from reaching plankton and algae, which are at the bottom of many food chains; and, of course, many marine animals apart from birds—think turtles and seals—eat them, mistaking brightly coloured plastic pieces for zooplankton. The problem isn't limited to just animals: A study presented at the 26th United European Gastroenterology Week in Austria in October 2018 reported that people have microplastic in their defecation.

CANADA HAS ITS PLASTIC CONCERNS, TOO

The developed world—Canada included—may have more stringent and enforced environmental protection and waste management policies, yet Canada isn't immune to the plight of plastic. Take this into consideration:

- The Canadian Council of Ministers of the Environment (CCME) notes that only 11 per cent of plastics in Canada is recycled;
- A study led by Peter Ross, PhD, head of the Ocean Pollution Research Program at Vancouver Aquarium Marine Science Centre, discovered plastic in one out of every 34 copepods (small crustaceans) and one in every 17 euphausiids (krill) on Canada's Pacific coast, meaning that juvenile salmon in the Strait of Georgia may be ingesting up to 91 particles of microplastic per day and a humpback whale 300,000 particles;
- Ocean Wise gathered water samples from the waters outside Vancouver's Canada Place and discovered 1258 particles of plastic in one cubic metre of saltwater, 95 per cent of which were fibres, notably polyester, rayon and modified cellulose, which are ingredients in textiles, clothing, curtains and carpets; and
- In Ontario, a University of Toronto research group led by ecologist Chelsea Rochman, PhD, audited the outflow of Toronto's Don River in the summer of 2018 to catalogue the more than 650 kilograms of plastic that annually enters Lake Ontario, counting 21,000 pieces of Styrofoam, 12,500 large plastic fragments, 4000 water bottles, 2700 bottle caps, 1300 food wrappers, 1100 balls and over 900 straws. Rochman noted that with numerous rivers feeding into Lake Ontario, it's important to stop these plastics upstream and prevent them from breaking down into smaller pieces before they enter the Great Lakes and St. Lawrence Seaway.

Although plastic was initially developed at the beginning of the 20th century, it wasn't until after the Second World War that it was mass produced and widely marketed. Since then, the production of plastic has increased exponentially, from roughly 1.5 million metric tonnes globally in 1950 to roughly 335 million metric tonnes globally in 2016. The Canadian Plastics Industry Association (CPIA), an industry advocacy organization, reports that plastics is a $24.3 billion industry employing 82,000 people across the country.

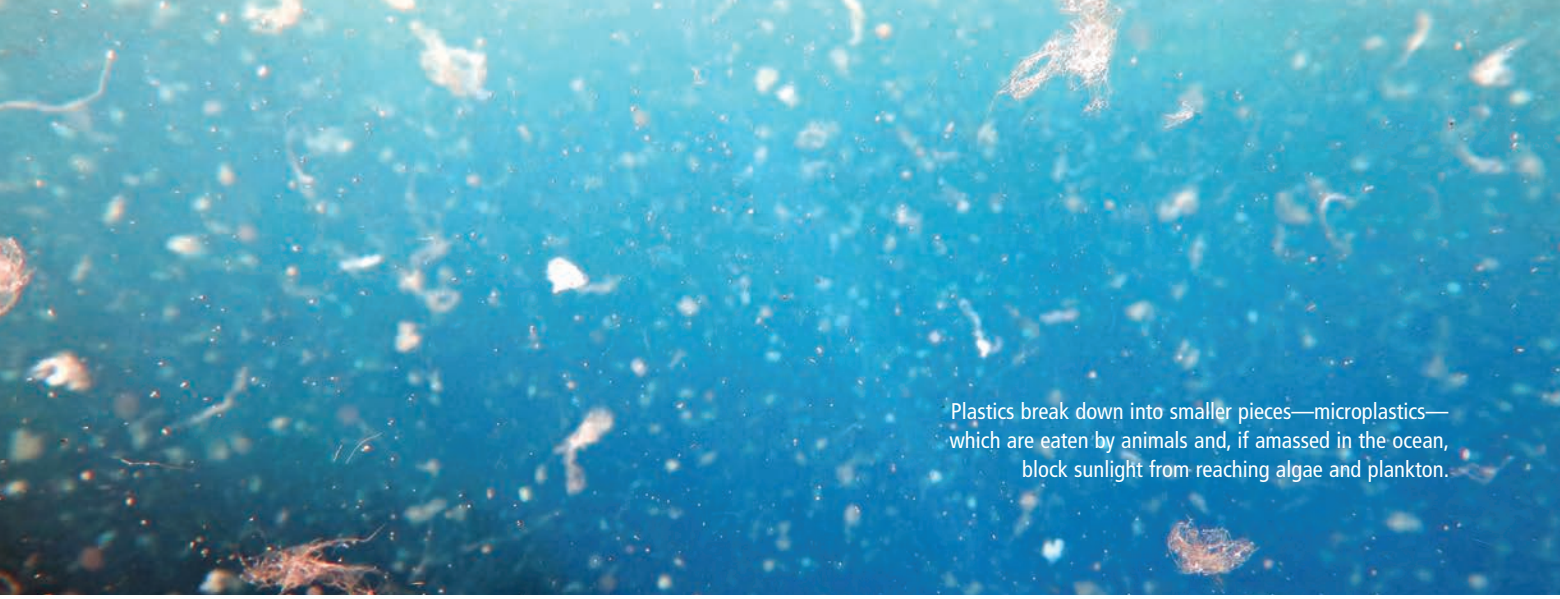
Most plastics produced today are fossil fuel–derived polymers, usually carbon combined with oxygen. The problem is it doesn't biodegrade; instead, it breaks down into smaller and smaller pieces, becoming microplastics. But plastics pose challenges unlike other waste material not only because it doesn't biodegrade but also because there isn't one single kind of plastic. Polyethylene terephthalate (PET) and (HDPE) are typically recycled by most municipal recycling programs, yet polyvinyl chloride (PVC) and low-density polyethylene (LDPE)—think of your standard plastic shopping bag—can be recycled but typically aren't for a variety of reasons, including market demand and municipal sorting technology.

"Rigid plastics like PET and HDPE, used for laundry detergent or beverage containers, are valued, as they have more applications for recyclers," says Jo-Anne St. Godard, executive director of Recycling Council of Ontario (RCO), a 40-year-old non-profit organization whose members represent the "entire value chain of production, manufacturing, retailing, distribution and consumers." RCO specializes in policy development, research and programs that bring awareness to waste issues and works with private and public organizations to create solutions. RCO began with a focus on recycling operations in the 1980s and expanded its mandate to "support governments [in developing] more effective policies that focus equally on reduction as they do with recycling."

St. Godard speaks further of the difficulty dealing with plastic: "Most of the plastic on the market today is derived from fossil fuels, which is a non-renewable resource." She recognizes the diversity of plastic material in so many everyday items and points out that the lack of recycling options for some plastic types has made them prevalent in landfill and as litter in waterways. Although CPIA says that the light weight of plastic makes it more fuel friendly to ship than other products, St. Godard notes the energy- and resource-intensive nature of plastic production and observes that the solutions to plastic waste should include reduced consumption, as well as designing products and packaging with material that can be successfully collected and recycled. In other words, reduce, reuse, recycle, in that order of preference.

MUNICIPAL WASTE MANAGEMENT IN ONTARIO

The same versatility in plastic observed by St. Godard has also been observed by Jon Arsenault, P.Eng., director, waste management services for the Region of Waterloo. "Glass, metal and aluminum can be challenging, but they're very [broadly speaking] similar to collect and recycle," he says.



Plastics break down into smaller pieces—microplastics—which are eaten by animals and, if amassed in the ocean, block sunlight from reaching algae and plankton.

Arsenault notes that plastics are far more complex and can be put into seven broad categories. "Anything derived from ethanol tends to repolymerize and is more easily recyclable, but there are others that are much more difficult," he explains. "The challenge for us is that although we promote the collection of certain types of plastic, we receive many more kinds of materials because the consumer sees the mobius loop on the plastic packaging and assumes it's readily recyclable, so we do our best to separate by hand or machine. Within the different types, such as PET, there are different colours, like black, making it more difficult to market, or reducing the demand for the material. Or it reduces the price because some of these types of plastic are considered contamination by some processors. It's a real challenge."

Because he's using words like "price" and "demand," Arsenault may sound like he's running a business more than a municipal waste management service for a medium-sized Ontario municipality. That's because municipal recycling and businesses have a symbiotic recycling relationship, with municipalities collecting recyclable materials from residences and contractors bidding to buy them as a source of product material. "Because we market our own materials, anything we tell our residents can be recycled we make sure we have a market for the material, even if it's a negative market, meaning in some cases we pay processors to recycle it properly," Arsenault says. "But it's better than ending up in the landfill."

Nadine Kerr, P.Eng., manager, processing operations, for the City of Toronto, concurs. Kerr notes that Toronto "accepts all non-black plastic containers, bottles, jugs, films and expanded polystyrene in the recycling program," including plastic tubs, and lids, food containers, bottles and jugs, foam expanded polystyrene and film plastic. Kerr adds that Toronto sends its recyclables to a private contractor, which sorts and bales the plastics into the following commodities:

- #1 PET (e.g. rigid drink bottles, food jars, clamshells);
- #2 HDPE (e.g. rigid milk and juice containers, shampoo bottles, laundry detergent bottles);
- #4 LDPE (e.g. plastic bags, overwrap);
- #5–7 MRP, or mixed rigid plastics (e.g. all remaining rigid plastics, such as yogurt and margarine containers); and
- #6 FEP, or foam expanded polystyrene (e.g. packaging, some food service containers).

The values of PET and HDPE are fairly consistent. However, "the value of rigid plastics will depend on the makeup of the bales," Kerr says. "Currently there is a higher percentage of polypropylene in those bales, making that product more sought after by re-processors."

Kerr says there is no feasible reason why most, if not all, plastics can't be recycled. However, "before it can be added to the recycling program, there needs to be a market willing to buy it," she says. "Only then can the question of collection and sorting be visited and the cost analyzed." The problem is also partially the sorting technology: "Some plastic products are difficult to separate from other recyclables," she explains. Plastic film—grocery bags—are one. "The city's program is a single-stream recycling program, so all recyclables go into one bin and are then separated into the various commodities at material recovery facilities that employ both people and technology to sort products," she says. "A vacuum system is used to sort film plastics. As it runs on a conveyor belt, sorters pick it up and throw it up to the vacuum system; however, there is a lot of film, piece wise, so sorters are not able to capture all the film as it goes by. Film can then end up further down the system and get wrapped around machinery. It's also flat and light and may flow in with paper product and becomes a contaminant for paper bales." But there is another reason plastic bags aren't typically recycled: demand. "Finding markets can be a challenge for some lower-value plastics, such as expanded polystyrene and film," Kerr says.

A PLASTICS RE-PROCESSOR'S PERSPECTIVE

Eadaoin Quinn is the director of business development at EFS-plastics, a re-processor located in Listowel, Ontario, that specializes in recycling mixed rigid plastics and—notably—plastic film. EFS-plastics buys plastic from municipalities from across North America; once municipalities sort their recycling materials by type into industry-standard bales, EFS-plastics buys them to process into useable plastic goods. EFS-plastics is one of a few post-consumer recyclers capable of accepting plastic film to develop into a recycled consumer product. "We have the physical capacity to recycle

An example of how plastics are placed into bales in preparation for recycling. Re-processors want plastics sorted into seven broad categories of plastic. In Ontario, PET and HDPE are widely recycled, but PVC and LDPE are not.

The mobius loop found on many plastic products, which, according to Jon Arsenault, P.Eng., can mislead consumers as to which plastics are accepted in their municipal recycling program.

more plastic bags, but we just don't have enough demand from film producers to include post-consumer recycled content in their bags," Quinn explains. "If we want to see more plastic bags getting recycled, the demand from bag producers needs to grow."

Quinn notes that EFS-plastics has the flexibility to accept plastic bags and other plastic film because they, unlike many others in their industry, keep almost everything internal: EFS-plastics uses a mostly automated wet wash system that minimizes manual labour and speeds up their recycling process, making EFS-plastics perhaps more efficient than many of its competitors. "We have a team [with an engineering background] here to design and upgrade our equipment (as market demands change)," Quinn explains. "Of course, there are small components that we buy from other places, but our system is unique." In fact, EFS-plastics has two operating lines, one for rigid plastics and one for plastic film. And because EFS-plastics is largely automated, it can produce recycled plastic pellets in a wide colour spectrum, making the plastic they do sell more profitable.

"There are thousands of types of plastic; however, there are the seven broad categories of plastic [used by the plastic packaging industries]," Quinn notes. "Although they do represent some commonly used plastic types, these designations are somewhat arbitrary. It isn't technically harder to recycle one material compared to another; rather, it's market demand. The ability to recycle a particular type of plastic comes down to demand. For example, many manufacturers use recycled PET to make new water bottles, but there are very few using recycle LDPE to make new plastic bags. It's demand that makes water bottles more 'recyclable' than plastic bags."

Quinn thinks the ability to make the plastic industry truly circular may be a shift in attitude. "There's always a way to melt [plastic down] and turn it into a reusable form," Quinn observes. "It's just comes down to who's going to pay for it and who's going to purchase it. We're always trying to get out that message for big companies looking to recycle more to buy more recycled product. If we don't have an end market for what we're making, we can't process it. It's important to think of that full circle."

So long as the circular movement of plastics remains tied to profits, there may not be a 100-per-cent environmentally friendly solution to plastics. Kerr notes that from a municipal waste management perspective, the biggest concern is contamination, but she acknowledges that re-processors (buyers) expect and forgive some contamination. "If the PET container has a lid on it made of HDPE, the PET buyer may categorize this as a contaminant in the bale," she explains. "Fortunately, PET buyers expect to receive some PET bottles with the HDPE cap on. But what if the producer of the bottle changes the lid to metal? At the re-processor's facility, it could cause problems. Producers are changing packaging at an ever-alarming rate and rarely consult the waste management world to determine if the new packaging can be realistically collected, sorted, re-processed and ultimately recycled."

THE RESPONSIBILITY OF THE PLASTICS PRODUCER

In Ontario, most waste management is conducted at the municipal level, with municipalities collecting waste from residents but typically not from the private sector. And this may limit waste management professionals' influence. "We can't influence to the degree that the province or the federal government can," Arsenault adds. "[We have to] put the onus on the producers to be responsible for designing of the packaging right through to end use, with the expectation that they design for the environment, and for efficiency and for the marketplace. Municipalities are the last line of defence. If they come to us, and we say, 'This isn't recyclable; this is litter,' it's not an easy decision or necessarily a popular one to make. There's this whole thing of greenwashing where a product is introduced, and it has a label on it that says it's recyclable when it's not, or if it is, would cost too much money to recycle."

Arsenault, who sits on the board of directors of the Ontario Waste Management Association, which represents companies and organizations in both the private and public sectors, is also a member of the Regional Public Works Commissioners of Ontario and the Association of Municipalities Ontario. These organizations, Arsenault says, have been advocating that producers should be responsible so that taxpayers aren't left on the hook to deal with the

EFS-plastics produces plastic pellets in a wide variety of colours, as pictured here.

EFS-plastics is in Listowel, Ontario, and recycles post-consumer plastics and re-processes them into pellets for manufacturers. EFS-plastics is capable of recycling plastic film, using its fully automated system.

products, with limited to no ability to control how to deal with them.

At present, the cost to fund recycling is shared 50/50 between municipalities and producers of some items, including plastic packaging. However, both Arsenault and Kerr are encouraged by the success of the province's introduction of the *Waste Free Ontario Act*, which consists of the *Resource Recovery and Circular Economy Act* and *Waste Diversion Transition Act* and encourages Ontario to move towards a circular economy. "The heart of this is having producers be responsible for the end-of-life management of their products and packaging," Kerr says. Arsenault also looks beyond the province, noting that the CCME, the umbrella organization of federal, provincial and territorial ministers of the environment, introduced its Strategy on Zero Plastic Waste in November 2018. The initiative aims to, among other things, influence plastic product design for greater durability and reuse, significantly increase the responsible use of single-use plastics and expand collection systems to keep all plastic products in the economy and out of the environment. Nationally, the federal government seems ready to bring the awareness of plastics to a national platform. In June 2018, Prime Minister Justin Trudeau used his presidency of the G7 to introduce the Ocean Plastics Charter, which aims to work with industry to move towards a completely reusable and recyclable plastic industry by 2030, significantly reduce single-use plastics, increase recycled content in all plastics to at least 50 per cent by 2030 and reduce the leakage of plastics into the environment. Unfortunately, it's non-binding and wasn't endorsed by the United States and Japan.

THE RESPONSIBILITY OF ONTARIO'S ENGINEERS

PEO recently updated its *Solid Waste Management Guideline* for professional engineers who are involved in solid waste management projects and/or those retaining engineering services in solid waste management, principally the planning, design, construction, commissioning, operation, monitoring and/or closure of non-hazardous waste. It is a thorough document that helps engineers navigate Ontario's environmental laws, notably the *Environmental Protection Act* and *Environmental Assessment Act*, but, importantly, aside from providing engineers with sage advice, it also reminds them of their obligations: "The duty to report is an essential component of an engineer's commitment to professionalism. In fact, most engineers are fulfilling this duty daily when they identify designs, processes and procedures that are unsafe, unhealthy or uneconomical (which is detrimental to the public welfare), and then act to correct these problems."

Plastic doesn't have an easy solution, and given its prevalence, it's unlikely to disappear anytime soon, so innovation may lie in maintaining a circular life for plastic while making sure it doesn't leak into the environment. Arsenault observes the innovative role of engineers: "It goes beyond plastic. It's not just about one type of product. It's about life-cycle analysis studies, and that's something that engineers look at all the time in different areas. At a municipal level, it can be challenging, as we're balancing keeping ratepayers' taxes low while trying to keep up with innovation. It's hard to pinpoint specific innovation, and there are plenty of plastics that are recyclable, but it can come at a huge cost. Being the home of the blue box—it started in Kitchener—we've tried streamlining our sorting plants so we can react to the continuing changes in the marketplace, but this is a significant challenge. However, there's a significant opportunity for technological changes, specifically for the major producers of plastic products." **e**