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Curriculum Units by Fellows of the National Initiative
2023 Volume IV: Environmental Justice

Plastic, Plastic Everywhere

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Introduction and Rationale

In Samuel Taylor Coleridge's poem, "The Ancient Mariner", the sailor and his men are surrounded by ocean water but cannot relieve their thirst. The famous line from the poem, "Water, water everywhere, nor any drop to drink" depicts being in the midst of something but not being able to partake in the very thing one is surrounded by. If Coleridge were to rewrite this poem in 2050, the sailor might say, "plastic, plastic everywhere" because it would not be merely the salt in oceanwater that made it undrinkable, but the overabundance of plastic pollution. The sailors might be reluctant to eat the fish from the sea as microplastics have permeated the marine ecosystems and food chains.[1] They may sail upon a gyre swirling plastic debris, and traverse across the estimated 51 trillion pieces of microplastics on the ocean's surface.[2] When they reach the shore of their destination, they could see plastic waste blanketing the sand. And when they walk through their villages, they could see mountainlike landfills of plastic. For Coleridge's sailors, the problem of having more plastic than fish in the ocean in the year 2050 would be the most shocking.[3]

Coleridge's sailors are fictional, but the projections and estimations of plastic pollution on the environment, especially the ocean are very real and dire. The life cycle of plastic from production, to use, and to its disposal poses a danger to the planet. Fossil fuels are taken from the earth to create plastic. By the end of plastic's life cycle, it is littered on land or reaches the ocean, wreaking havoc on the environment. Because of the chemical properties of most plastic, it is not biodegradable. Plastic is created from fossil fuels, and 99% of all plastic is created using crude oil.[4] Globally, 380 metric tons of plastic is produced a year and 40% of the plastic is single-use plastic.[5] The life span of single use plastic is short lived, and it is difficult to recycle.[6] When it is improperly managed, plastic waste is discarded in landfills and can leak from waste management systems. The discarded plastic waste travels through the environment changing ecosystems. Plastic pollution also emits greenhouse gases contributing to global warming.

Like Coleridge's sailors, students will discover the pervasiveness of plastic pollution in the world. Plastic use is emersed into daily life. Individually, people are reliant upon plastic for a range of items such as food packaging, plastic straws, water bottles, food containers, and plastic shopping bags. Plastic production and use are interconnected worldwide. Plastic is produced in the United States and exported to other countries. The US also imports plastic from other countries. Students will learn how pervasive plastic is in everyday life, the range of plastic products, and the global connectiveness of plastic production, distribution, and use.

Most of the unit will concentrate on pollution in the ocean. However, to explain the impacts of social and environmental justice, the results of plastic pollution on land and in the air, as well as the ocean, will be addressed. The ocean is a topic that a wide range of students find interesting in the 5th grade. From the mysterious creatures that live in the deep sea, to ocean exploration, kids are fascinated by the ocean. Students will learn about the environmental impact humans have on the ocean and the disproportionate impact plastic pollution has on developing nations and coastal regions. Lastly, throughout the unit students will learn some of the efforts being made to mitigate plastic pollution.

School Demographics

I teach 5th grade at an elementary school in Tulsa, Oklahoma. Our school is in midtown, with a diverse population. About half of the students live in the school's neighborhood and the other half comes from all over the city. Our school district has made an effort to emphasize social emotional learning and social justice in classrooms. The aim is for students to build empathy and connect coursework to real world problems and solutions. My students are developing their personal identities, and they are interested in learning about the world. This environmental justice unit will not only meet their science academic standards, but also show them the disproportional social impact and injustices caused by plastic pollution.

The topic of plastic pollution is an environmental issue that upper elementary students can easily relate to and understand. Recycling clubs and programs are popular in elementary schools across the United States. Our school has a Recycling Club. The 5th graders are assigned to a classroom, and they are responsible for taking the recycling bin to the recycling receptacle outside. The Recycling Club gives students a sense of purpose as they help their school community. Being environmentally and socially conscious is popular, even among elementary students. Students use reusable water bottles religiously. Reusable water bottle sales were valued at $8.64 billion dollars in 2021 and expected to increase 4.3% the following year.[7] Even curriculum companies have recognized the relevance environmentalism has for students as there are units on protecting the environment in our district's reading and science mandated curriculum programs. The seeds of environmental justice are planted for students and this unit will build on their interests and academic needs.

Content Objectives

How Plastic is Created

The chemical makeup of plastic makes it indestructible and resistant to degradation. Plastic is made of organic molecules (monomers) joined together by covalent bonds to form a chain (polymers). These chains can also be "crosslinked". The long chains of crosslinked polymers create strong bonds that give plastic its durability.[8] During refinement, the monomers of plastic are produced using crude oil and natural gas from the ground as a raw material. In this process, fossil fuels are broken down into monomers such as ethylene from crude oil and propylene from natural gas. Next, the ethylene and propylene are bonded together to form polymers called resins. These resins are formed into plastic preproduction pellets called nurdles. The nurdles are sent to

manufacturers and are heated and molded into different types of plastic products.[9]

Over the past half century, plastic has been used to create a wide range of products used across the globe. The makeup of plastic makes it both strong enough to endure a variety of elements, but also malleable to mold into different shapes. The chemical properties of plastic are low density, flexibility, transparency, chemical resistance, and stability.[10] Plastic can be transparent and filled up with brightly colored sports drinks to be marketable for consumers. Pipelines made of plastic are stable and durable.[11] More than 300 different types of plastics are made.[12] The two largest categories of plastic are packaging and consumer institutional products. Packaging includes bottles, jars, vials, drums, pails, cans, barrels, baskets, food containers, and caps. Consumer and institutional products include cups, toys, sporting goods, personal care items, healthcare, and medical items.[13] The uses of plastic seem endless which is why producing and selling plastic has grown into a multibillion-dollar industry. The global market for plastic was valued at $600 billion dollars in 2022 and is expected to grow at 4% from 2023 to 2030.

The advancement of the plastic industry began in the 1950s. After World War II, plastic production grew exponentially. During the war, plastic was used in new ways to create plastic helmets, water-resistant vinyl raincoats, and parachutes.[14] Following the war, the plastic industry shifted from making war materials to consumer products. Americans were eager to buy appliances, clothing, and furniture, which were made from plastic. TV dinners grew in popularity which required lots of packaging, also made from plastic. As consumerism ingrained itself in American culture, the demand for plastic grew. This growth in demand in plastic products is not limited to the United States. Over the decades, global demand for plastic materials grew from producing 2 million tons per year in 1950 to producing 460 million tons per year in 2019 (Figure 1).

Although plastic can be recycled, new plastic is cheaper to produce, partly because the fossil fuel industry benefits from tax subsides. In 2015, the International Monetary Fund calculated U.S. energy subsidies to amount to $649 billion, with 80% going to natural gas and crude oil.[15] Much of the public communication on plastic pollution has centered on individual choices. The public has been urged through campaigns to utilize reusable shopping bags, reusable water bottles, and to eliminate plastic straws. Changes to individual behavioral patterns is not enough to shift the impacts of plastic pollution. In order for structural change to occur, international agreements are needed. In 2022, 175 nations agreed to begin writing a UN plastic treaty to fight waste globally.[16]

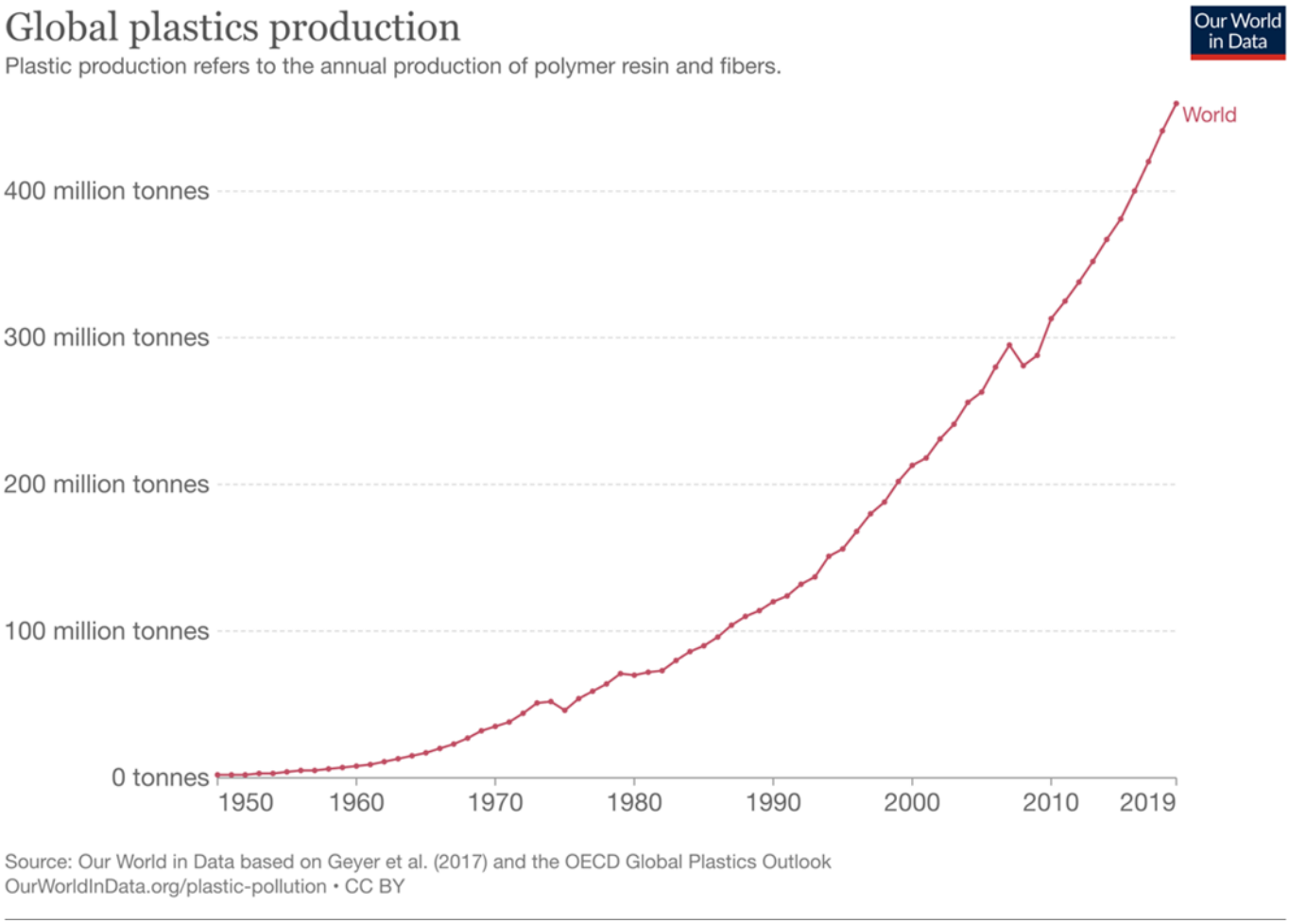

Figure 1. Global plastic production has dramatically increased over the last 70 years.[17]

Single Use Plastic

The rapid increase in plastic utilization largely comes from the increase in single use plastics. Single use plastics are products that are designed to be used once and then discarded. For example, disposable water bottles and plastic packaging are everyday products. Single use products account for 50 percent of all plastic production globally.[18] Plastic packaging makes up 40 percent of all single use plastics. Along with packaging, plastic shopping bags and containers are the top two categories in the United States. In the US more than 100 billion single use shopping bags were used in 2014. Single use plastic is ubiquitous and largely contributes to growing plastic pollution crisis.

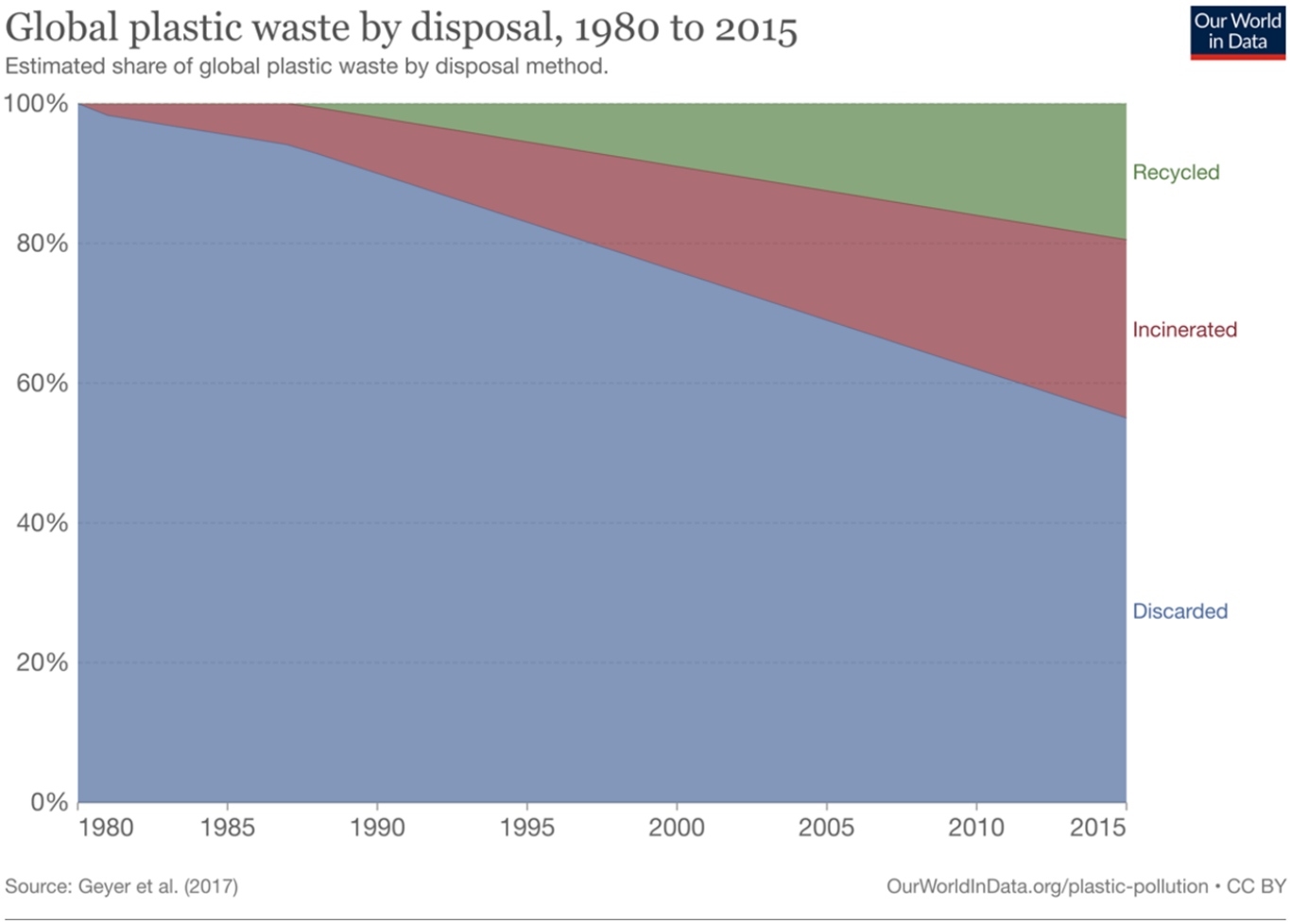

Figure 2. Global plastic waste disposal from 1980 to 2015.[19]

Where Does Plastic Go?

A common misconception is that the majority of plastic is recycled. With the exception of the 12% that has been incinerated, all the plastic ever created is still on Earth. Globally, 79% of plastic waste is in a landfill or dumped and 12% is recycled (Figure 2).[20] Discarded plastic can end up in solid waste management systems. In wealthy nations, the waste management systems are stronger. In nations with weaker waste management systems, plastic waste leaks into the environment. The plastic can travel to the coastline or ocean. Lastly, plastic breaks down into tiny pieces called microplastics and travels to the surface of the ocean and throughout ecosystems.

Recycling and Waste Management

In the 1980s – 1990s there was growing concern in the public about plastic waste. Prior to the 1980s plastic waste was only discarded. The sight of litter along beaches and other public places brewed angst in the public. The first Earth Day was in 1970, and there was a growing American counterculture towards the Vietnam war and environmental issues such as air pollution, land use, and global warming.[21] The first Earth Day was a large environmental protest including millions of people across the United States and the world. To address the public backlash, the plastic industry launched campaigns to promote public responsibility. The industry lobbied legislatures to pass laws requiring a symbol on plastic to indicate its recyclability. The purpose of the

symbols was to encourage individuals to put their waste in recycling bins.[22]

The highly recognizable recycling symbol is a triangle with a resin number in the center. The resin number represents a category of plastic and makes sorting plastic simpler. Certain types of plastic are easier and more beneficial to recycle than others. For example, water bottles and milk jugs are simple to recycle, but most packaging is not and while food containers and packaging may have a recycling symbol, many municipal recycling plants will not recycle them. The recycling process produces plastic of lesser quality than the original, known as downcycling. Lesser quality plastic is harder to sell.[23]

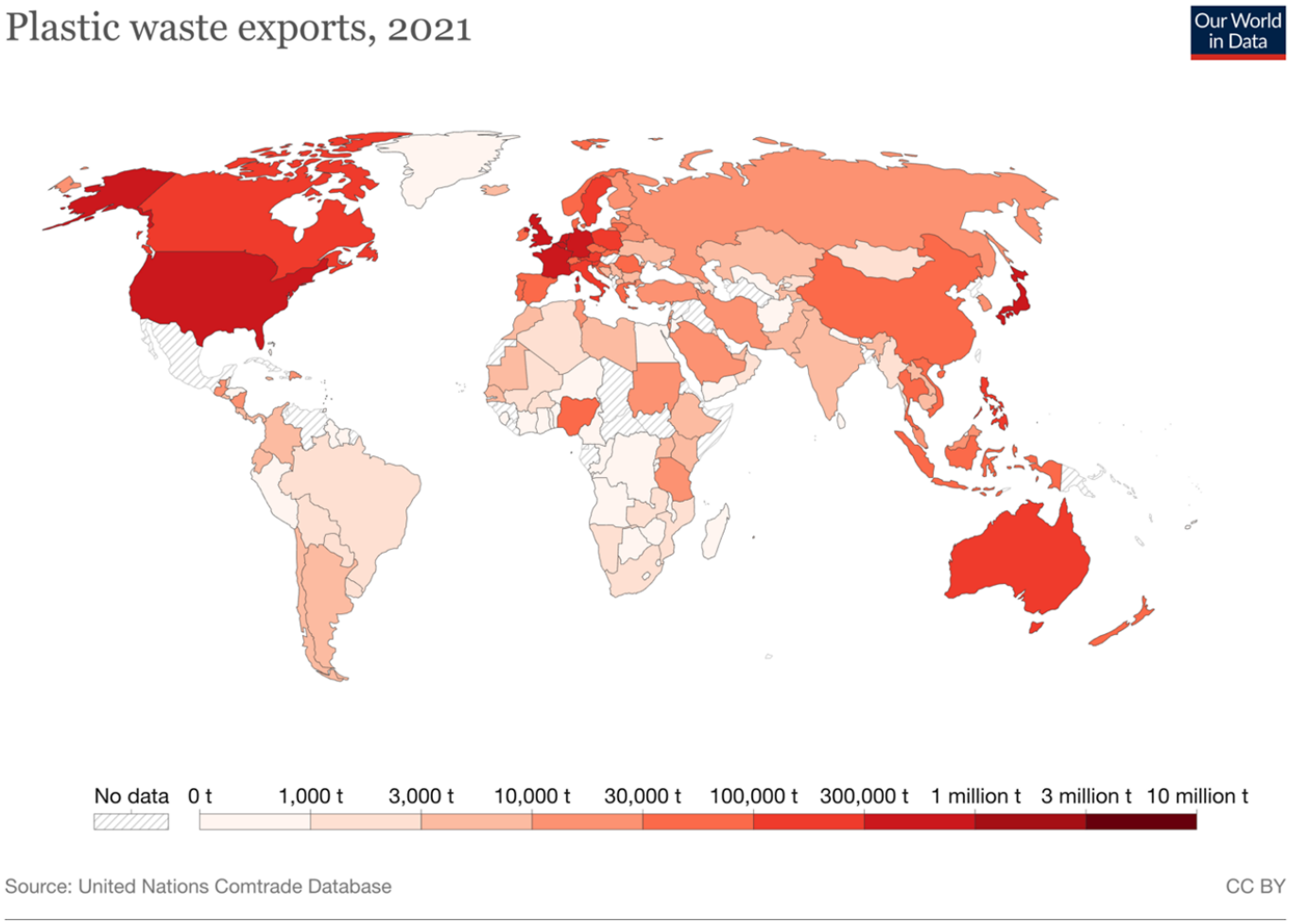

Figure 3. Global plastic waste exports in 2021.[24]

Disproportionate Burdens

Developing nations disproportionately bear the brunt of plastic pollution. The United States, Australia, and European nations trade their plastic waste to Asian and African nations (Figure 3). While China has imported the most plastic of any country, in 2018, China adopted a new policy refusing plastic waste from other countries.[25] The following year, The Basel Convention attempted to scale back international trading of plastic waste. Over 180 countries passed agreements to limit exports of plastic waste from wealthy nations. The United States Congress did not pass legislations to ratify the agreement. Without signing the agreement there are no consequences for US companies that still export plastic waste. The receiving nations accept the imports because they can repurpose the materials into new goods.

Although China's new policy decreased global trade of plastic by 50%, other nations in Asia such as, Malaysia, Vietnam, Indonesia, and India increased their plastic imports. African nations such as Ghana, Uganda, Tanzania, Ethiopia, Senegal, Zambia and Kenya are also now flooded with plastic waste. The receiving nations have inadequate waste management and have difficulty recycling the plastic. Unfortunately, plastic fills waterways, clogs roads and fields, and mixes into animal feed. Zambia has experienced many cholera outbreaks due to plastic clogged drainage systems.[26]

The presence of plastic recycling facilities in developing countries has given rise to waste pickers. Waste pickers sell plastic bottles and waste to private recycling companies. The work is extremely dangerous and time consuming. For instance, waste pickers working in a Nairobi dump can find plastic bottles with discarded syringes, broken glass, feces, fragments of cellphone cases, remote controls, shoe soles, trinkets, toys, pouches, clamshells, bags, and countless unrecognizable shreds of thin plastic fill.[27] Young children search the dump daily for scraps with hope of earning money for their families or to pay for school. Waste pickers make very little, about 4 cents U.S. per kilogram of plastic.

Figure 4. Plastic debris on a beach in Indonesia.[28]

The weak recycling systems and waste management infrastructure in receiving nations also impacts coastal regions. Coastal communities are impacted economically. The aesthetics of polluted beaches deters tourists (Figure 4). Coastal areas depend on pristine, inviting beaches for tourism. However, tourists' litter and exasperate the litter problem.[29] The plastic debris on beaches adversely affects the tourism industry, leading to a loss of output, revenue, and employment. Beach cleanup is costly for any coastal town. In 2012, local

governments in 90 towns in Washington, Oregon, and California spent an estimated $500 million dollars on beach cleanups.[30] Towns in developing nations do not have the economic resources to invest in consistent beach cleanup. More trash appears soon after a beach cleanup.

The Ocean

Plastic enters the ocean from land, rivers, and abandoned fishing equipment. 80 percent of the plastic in the ocean comes from land (Figure 5). Half of all plastic pollution comes from five countries in the same geographic region: China, Indonesia, The Philippines, Thailand, and Vietnam.[31] Wealthy nations have a higher rate of plastic use than lower income nations. However, plastic waste enters the oceans the most in lower income countries because of the lack of waste management system. In middle-income countries, more people have the ability to purchase products that inevitably become waste. These nations have the economies that produce their own plastic pollution, but still lack the resources to discard the plastic waste properly and safely. Waste is disposed of in dumpsites, landfills, or by illegal dumping.[32] Dumpsites are known to add 1.1–1.3 million tons of marine plastic every year.[33] Thailand alone has 2,380 dumpsites. Over 970 dumpsites are located near bodies of water or along the coastline. Waste at two dumpsites in Thailand were studied and found that plastic waste was 45.25% and 39.12% of the total waste.[34]

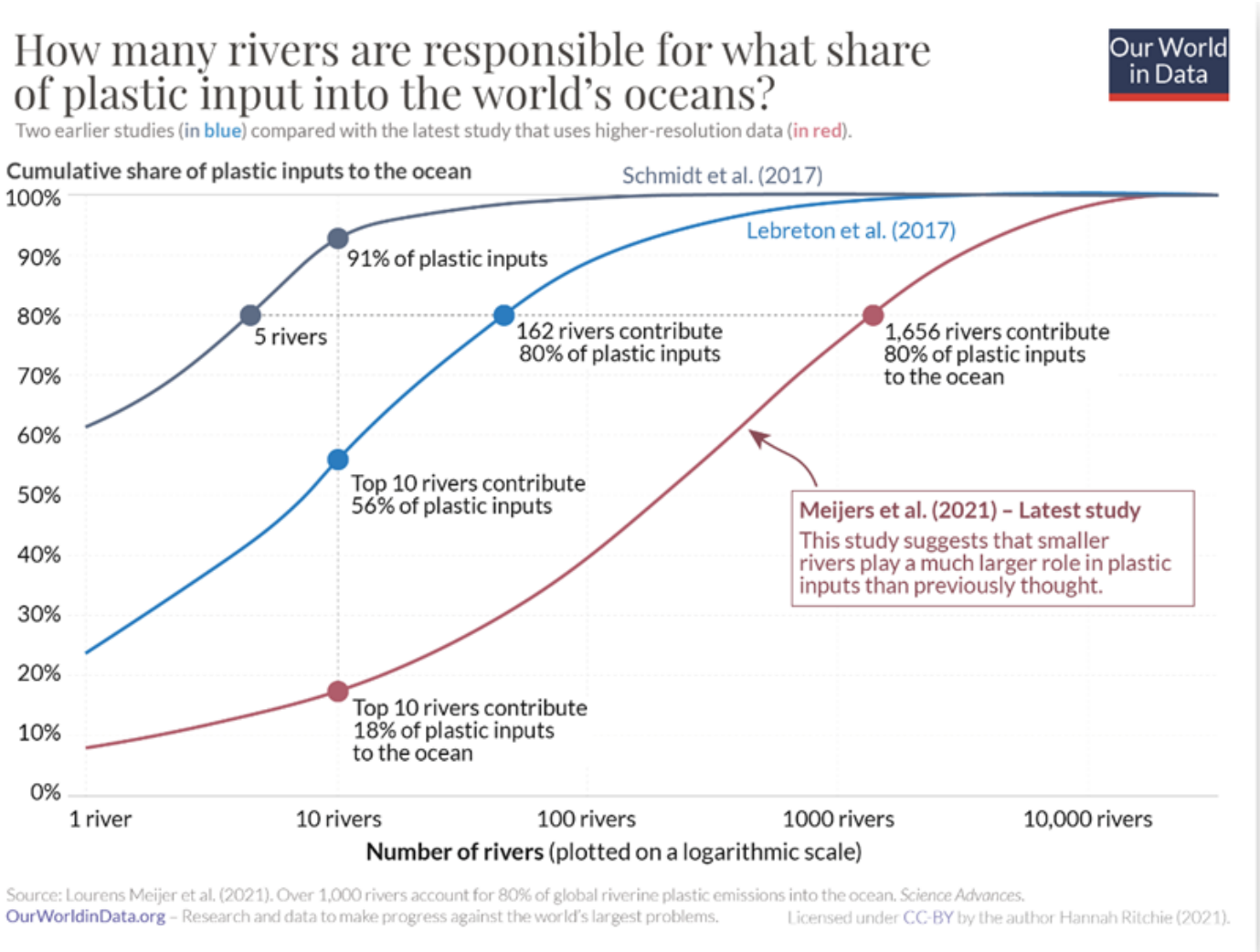

Figure 5: Percentage of plastic debris the enters the ocean from rivers.[35]

The plastic debris leaks from waste systems to rivers. Recent studies indicate that smaller rivers play a bigger role in emitting plastic, which makes mitigation efforts more challenging (Figure 5). Now 1,656 rivers are estimated to contribute 80% of plastic into the ocean. The Philippines accounts for 36 percent of all plastic input into the ocean and seven of the top ten rivers that leak plastic into the ocean are in the Philippines. Most of the population in the Philippines lives along the coastlines.

Once the plastic is emitted to the ocean, it is difficult to retrieve. Plastic debris can fill up with water and reaches the ocean floor. Bottles from the 1960's have been found on the seabed.[36] Plastic bottles are estimated to last for thousands of years at the bottom of the ocean. The lack of light and less oxygen at the bottom of the ocean makes the plastic decay very slowly. Plastic also floats along the ocean's surface. Large quantities of floating plastic debris end up in garbage patches. Around 60% of all plastic created is less dense than seawater, which makes it easy to travel the ocean's surface via winds and currents. Large systems of rotating currents are called gyres. Within the gyres are patches of plastic debris swirling around. These gyres are referred as garbage patches.[37] There are five gyres in the ocean. One in the Indian, and two each in the Atlantic and Pacific Oceans.

The most well-known garbage patch is the Great Pacific Garbage Patch (GPGP) located between California and Hawaii. In the GPGP, it is predicted that at least 79 thousand tons of ocean plastic are floating inside an area of 1.6 million kilometers.[38] A study of the GPGP found plastic fragments from containers, bottles, lids, eel trap cones, oyster spacers, ropers, and fishing nets. Debris origins dated back as far as 1977, and nine different languages were identified. Marine equipment makes up the 46% of the GPGP cluster.[39] There is evidence that plastic pollution levels are increasing within the GPGP. Although plastic flows out of the GPGP, plastic flows into the gyre at a greater rate. The Great Pacific Garbage Patch is not a literal patch of litter floating on the ocean like an island. Instead, the trash is scattered over large areas of the ocean from the surface down to the ocean floor.

Microplastics

Scientists only know where 1% of the plastic is in the ocean. The majority of plastic has been physically broken down into small pieces, called microplastics. Microplastics are about a third of a millimeter in diameter. The amount of microplastics in the ocean is unknown. At this small size, microplastics are impossible to retrieve from the ocean. As a result, the microplastics become part of the marine ecosystem. Microplastics are in permanent transit in the ocean and has become part marine ecosystems. Once in the environment, microplastics are transported through the ocean currents and the air. Microplastics have been found all over the world, from the arctic, to Mount Everest, and at the bottom of the Mariana Trench.[40]

Microplastics can also be transported via the food web, from prey to predators. Studies have found that as microplastics travel through the ocean, they can adsorb other chemicals in the ocean. When plankton eat the microplastics, it transfers chemicals to marine animals. Microplastics have been found in thousands of species.[41] Microplastics may have an adverse effect on the developmental reproduction pattern of marine organisms.[42] In a study by marine biologist, Chelsea Rochman, plastic was found in a third of fish and one fourth of oysters from Californian and Indonesian fish markets.

Teaching Strategies

The essential question for students to answer throughout the unit will be: Where does our trash go? Students will be challenged to think about the environmental and sociological impacts of the plastic pollution generated in wealthy nations and how they impact lower income and poorer nations. In this unit, students will learn the cycle of plastic production and lack of proper disposal in the United States and globally. Students will understand that humans take materials from the Earth to create plastic. Then they dump these materials back into the environment, but in the form of plastic.

Close Reading

Students will read news articles on plastic pollution nationally and globally. News articles adapted for kids can be found on resources like Newsela, ReadWorks, and Scholastic News. Students will read closely to make inferences and draw conclusions. Students can take notes using a graphic organizer.

Data Analysis

Using Our World in Data, students will view graphs, charts, and data showing trends in the United States, UK, and Australia of recycling, plastic production, and plastic usage. Then students will compare the data with middle income and low-income nations. Students will use the data to compare how different countries contribute more or less to the plastic pollution crisis. Students will also view data on the countries that are impacted the most and the least by plastic pollution. Through a guided discussion students will share their findings on the inequities of plastic pollution.

Gallery Walk

A gallery walk is a strategy to preview a new topic or to spark a class discussion. I will have photos showing the impacts of plastic pollution across the globe. Photos can depict landfills, marine life, and garbage patches. A question will be posed for them to answer under each photo. Students can work with a partner or individually as they walk around the room filling in their notetaker sheet. The notetaker sheet should have the images and questions making it simple for students to follow. Teachers can set a timer and have students go to the first station for a set time period. Then when the timer alerts them, they switch and go to the next station and fill out their notetaker. Once all of the students have completed the gallery walk, the class will discuss their questions and answers.

Teaching Activities

The Great Water Bottle Journey: Reverse Narrative

In a reverse narrative, the plot is revealed in reverse order. Using this strategy, students will follow the journey of a plastic water bottle. They will be given the end of their bottle's journey. The bottle could end on the ocean's floor, in the Great Pacific Garbage Patch, on a coastline, a landfill, or broken down into microplastics floating along the ocean's surface or inside of marine wildlife. The students will create a visual

representation depicting the steps of how the water bottle reached its location. The visual representation could be a comic strip, an infographic, or a poster.

Sorting Data Collection and Graphing

Students will utilize our Recycling Club to collect data about our school community. Oftentimes items are placed in the recycling bin that the recycling center cannot use. Students will learn what the appropriate items are to put in the recycling bins. Then they will investigate the recycling bins in our classrooms. They can sort the plastic in the classroom bins to see how many items end up in the bin that are not supposed to be there. They can make graphs to represent the data that they collect. Lastly, they will make posters based on their data to educate their schoolmates on the proper materials to place in the recycling bins.

Resources

Key Vocabulary for Students

- *Circular Economy:* in a circular economy, products are designed in a way that makes it easy for them to be reused and repaired. When a product reaches the end of their cycle, they can be taken apart and made into new products.
- *Coastal Communities:* small villages and towns located near the sea and ocean are coastal communities. Many people who live there have jobs that rely on sea related activities. For example, tourist attractions, resort hotel operators, fishers, and scuba divers rely on the sea.
- *Derelict Fishing Gear:* fishing equipment that is lost or discarded in the ocean is derelict fishing gear. Large and small items from fishing companies or individual fishers are left in the ocean. Fishing gear can be lines, buoys, rope, nets, pots, traps, and floats are examples.
- *Ecosystem:* all of the plants and animals living in an area and their interactions with their physical environment
- *International Environmental Dumping:* the practice of taking waste from one country and shipping it to another.
- *Fossil Fuels:* materials that are made from ancient plants, animals, other living things. Petroleum, coal, and natural gases are examples.
- *Ghostfishing:* when derelict fishing gear is left in the ocean, marine animals get trapped in the nets and traps.
- *Global Climate Change:* the long-term changes in temperature and weather patterns
- *Global Warming:* the rise of global temperatures due to the increasing concentrations of greenhouse gases in the atmosphere
- *Great Pacific Garbage Patch:* a collection of marine debris in the North Pacific Ocean
- *Greenhouse Gases:* gases in the atmosphere that trap heat from the sun. Water vapor, cabon dioxide,

methane, ozone, nitrous oxide, and chlorofluorocarbons are examples.

- *Incineration:* disposing waste by burning it to ashes
- *Leakage:* waste that is not properly managed and leaks into the environment
- *Littering:* garbage left that ends up in the ground, lakes, or ocean: plastic bottles, plastic bags, tins, wrappers, glass etc.
- *Macroplastic:* large plastic waste that ends up in the environment and slowly breaks down into small pieces.
- *Marine Debris:* litter that ends up in the ocean.
- *Microplastic:* tiny plastic particles that are smaller than 5 millimeters.
- *Ocean Pollution:a combination of chemicals and trash, most of which comes from land sources and is washed or blown into the ocean.*
- *Plastic:* a durable material that is made by people that can be molded into any shape
- *Plastic Pollution:* plastic left on the ground as litter often blows into creeks and rivers, and eventually ends up in the ocean.
- *Polymer:* large molecules that are made up of chains of small molecules
- *Recycling, upcycling, and downcycling:* taking waste materials and changing them into new objects; when materials are upcycled, they are recycled into higher quality of plastic, downcycled materials are recycled into lesser quality materials than the original product.
- *Resin number:* the number in the center of the recycling label that tells the type of plastic of the item.
- *Single Use Plastic:* plastic that is designed to be used once and then thrown away.
- *Sustainability:* protecting and conserving global ecosystems and natural environments
- *Waste Management System:* the collection, treatment, and disposal of waste material
- *Waste Picker:* a person who finds recycled materials thrown away by others to sell to recycling plants.

Trade Books for Students

- *What a Waste: Trash, Recycling, and Protecting our Planet (Protect the Planet)* written by Jess French
- *Kids vs. Plastic: Ditch the straw and find the pollution solution to bottles, bags, and other single-use plastics written by Julie Beer*
- *One Plastic Bag: Isatou Ceesay and the Recycling Women of the Gambia* written by Miranda Paul
- *This Class Can Save the Planet* written by Stacy Tornio
- *The Mess that We Made* written by Michelle Lord
- *Plastic Pollution A Variety Of Facts Children's Earth Sciences Book* written by Bold Kids
- *An Earth-Bot's Solution to Plastic Pollution* written by Russell Ayto
- *Trash Vortex: How Plastic Pollution Is Choking the World's Oceans* written by Danielle Smith-Llera
- *The Last Straw: Kids vs. Plastics* written by Susan Hood

Reading Lists for Teachers

The Plasticology Project: The chilling reality of plastic pollution and what we can do about it written by Dr. Paul Harvey

Plastic Soup: An atlas of ocean pollution written by Michiel Roscam Abbing

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Appendix on Implementing District Standards

Next Generation Science Standards (NGSS)

- 5-PS1-3. Make observations and measurements to identify materials based on their properties.
- 5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

Oklahoma Academic Standards for Math

- 5.D.1.1 Find the measures of central tendency (i.e., mean, median, mode) and range of a set of data. Understand that the mean is a “leveling out” or central balance point of the data.
- 5.D.1.2 Create and analyze line and double-bar graphs with increments of whole numbers, fractions, and decimals.

Oklahoma Academic Standards for Social Studies

- 3.B.4-5.2 Create and use maps, data graphs and charts, photographs, and other geographic representations to explain spatial relationships of physical and human places.
- 3.B.4-5.3 Analyze the impact of human and physical features of the Earth by drawing conclusions from digital representations, such as aerial photographs and satellite images
- 3.C.4-5.1 Interpret and draw conclusions from economic data on charts and graphs.

Oklahoma Academic Standards for English Language Arts

- 5.2.R.4 Students will summarize facts and details from an informational text.
- 5.3.W.1 Students will compose narratives reflecting real or imagined experiences.
- 5.3.W.2 Students will compose informative essays.

Endnotes

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[1] (Green Planet Films 2016)

[2] (Zhao 2022)

[3] (Tiller 2018)

[4] (National Academies of Sciences, Engineering, and Medicine 2022)

[5] (Rochman 2020)

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