NATIONAL SOCIO-ENVIRONMENTAL SYNTHESIS CENTER

Plastic pollution covers Accra Beach, Ghana. Photo by Muntaka Chasant via Wikimedia Commons, Attribution 4.0.

The Wicked Plastics Problem Lesson

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Overview:

Among all the ways that industrial consumer society is leaving a geological imprint of our culture upon Earth, plastics may be the biggest Anthropocene footprint of all. In just over half a century, the plastics industry has risen to dominance in food packaging; clothing; consumer goods; electronics; and specialty items in medicine, sports, and many other industries. Plastic waste has proliferated across land and sea, creating the bulk of refuse in thousands of landfills, the infamous Pacific Garbage Patch, and the unseen, but potent, microplastics in food chains across the globe. How did we get here?

Plastic is made from the byproducts of petroleum refining, so it is a profitable offshoot of oil and gas production. Plastic is durable, stable, malleable, and light, making it a preferable packaging material to glass, paper, and wood. Cheap virgin plastic production enables the cheap manufacture of fast fashion clothing, which feeds consumer appetites for ever-changing trends. And plastic is often marketed as recyclable, and therefore virtuous; however, recycling only manages 10-20% of plastic waste in the United States, whereas an estimated 11% of plastic waste enters aquatic ecosystems with broad negative effects (Borrelle et al. 2021). Plastic waste is a wicked problem in that:

- Materials science creates myriad molecular structures that cannot be recycled together.
- Corporations and waste managers have inflated consumer belief in recycling without managing its realities.
- The ubiquity of packaging plastics make them difficult to avoid.

- Consumers often opt for convenience over waste reduction.
- The waste of developed countries has long been offshored to developing countries, creating stark environmental inequalities.

This lesson provides an overview of optimal scenarios for the next decade of plastic-waste management. Learners will review recent science that details strategies for waste reduction; research and briefly present findings on a waste-reduction strategy; and synthesize results across strategies. Since virgin plastic production is expected to increase annually for the foreseeable future, the lesson is both ambitious and optimistic. It trains learners on how to select and engage with the most aggressive, systemic reductions in plastic use.

Assumed Prior Knowledge:

Appropriate for undergraduate and graduate learners. More advanced groups may benefit from added class time to develop in-depth synthesis of plastic waste interventions.

Learning Objectives:

- Analyze the structural challenges to reducing and recycling plastic waste.
- Focus in depth on a specific intervention strategy and report on its future development.
- Synthesize existing and theoretical methods to reduce plastic pollution.
- Consider the disciplines of materials science, experimental bioremediation futures, and environmental policy as interdisciplinary engagements with this complex issue.

Key Terms and Concepts:

waste-reduction scenarios; reduce, reuse, recycle; closed loops; materials science; waste policy; landfills; aquatic pollution; e-waste; bioremediation; policy and regulation; environmental justice

The "Hook" (suggestions for quickly engaging students):

Each learner should have brought to the session a piece of plastic waste from their recent past. In groups of three to four, for 5 minutes, have learners share their worst-case and best-case scenarios for the future of that item. A notetaker in each group should list the items and these +/- scenarios. In the time remaining, have learners discuss the benefits and liabilities in the various outcomes of plastic reuse, recycling, landfilling, or waste in aquatic and terrestrial ecosystems.

Photo credit: Wikimedia Commons

Teaching Assignments:

The Wicked Plastics Problem (One 75-minute class with an optional extension)

Note to Instructor: This lesson is condensed to a single 75-minute period, but it could be expanded to two, 75-minute or three, 50-minute class sessions by allowing additional research, preparation, presentation, and discussion time. Learners may also enjoy framing The Hook by considering how the item that they brought in might be restored to usefulness under the progressive new plastics paradigm detailed in the presentations.

1. As preparation for class, have learners read and take notes on the short articles by Smith & Vignieri (2021), Borrelle et al. (2020), and Cornwall (2021), paying special attention to the highlighted portions. Also ask learners to bring to class a piece of plastic waste that they've recently generated—most likely food packaging, but it might be clothing or electronics.

Smith and Vignieri 2021 – Highlighted.pdf

Borrelle et al. 2020 – Highlighted.pdf

Cornwall 2021 – Highlighted.pdf

2. **(10 min.)** After completing The Hook (~5 min.), review major lesson concepts using these PPT slides.

The Wicked Plastics Problem Slides.pptx

3. **(5 min.)** Divide the class into five groups based on the key initiatives from Borrelle et al. (2020) and Cornwall (2021):
    - Group 1 – Reduce or eliminate unnecessary plastics.
    - Group 2 – Set global limits for virgin plastic production.
    - Group 3 – Develop globally aligned standards to recover and recycle plastic by design.
    - Group 4 – Develop and scale plastic processing and recycling.
    - Group 5 – Experiment with plastic digesters: bacterial enzymes and fungi used for bioremediation.

4. **(15 min.)** Have each group conduct internet research on their subtopic. Groups will use this research to develop a short presentation to share with the whole class. Learners may compile useful statistics, progressive policies from leading nations, and case studies of pilot projects that might serve as models for future global adoption. The websites listed below are good places to start, but learners should feel free to use their experience to propel their research strategy.
    - Green Education Foundation – Reducing Plastic Use
    - Grist – Reducing Plastic Production
    - The Guardian – Call For Global Treaty to End "Virgin" Plastic Production
    - Grabiel et al. (2022) – Achieving sustainable production and consumption of virgin plastic polymers
    - Unilever – Rethinking Plastic Packaging
    - Senator Sheldon Whitehouse – REDUCE Act
    - UN Environment Programme – Convention on Plastic Pollution
    - BBC – The World's First "Infinite" Plastic
    - Russell et al. (2011) – Biodegradation of Polyester Polyurethane by Endophytic Fungi
    - Forbes – The Race To Develop Plastic-Eating Bacteria

5. **(15 min.)** Have each group develop a short (5 min.) presentation with specific details of how their strategies of intervention will contribute to the Borrelle et al. (2020) target of a reduction to only 8 metric tons of aquatic waste by 2030. They may include consumer behavior, corporate action, technology, policy, and/or innovations.

6. **(25 min.)** After each group presents (5 min. each), you may want to have a brief synthesis discussion with the remaining class time.

7. As homework, have each group post their presentation to the class discussion board. Have each learner respond to one other group with ideas for how their interventions may be synergetic with the learners' ideas and propel further innovation, policy, and action across categories.

Background Information for the Instructor:

1. Our Plastics Dilemma

- Plastic waste is accumulating rapidly in our environment and will leave a geological signature like fossils or archaeological remains. This special issue of *Science* covers plastic pollution's effect on wildlife and habitats, innovations in upcycling and recycling propelled by materials science, design of plastics for a circular economy, and policy initiatives to combat pollution. This issue will be particularly useful if the lesson is expanded for advanced learners.
- Thorp, H., Bradford, M.M., Vinson, V., Yeston, J.S., & Chong, L.D. (Eds.). (2021). Our Plastics Dilemma [Special Issue]. *Science, 373*(6550). https://www.science.org/toc/science/373/6550

2. Welcome to the Age of Plastic – Plastic Pollution Emissions Working Group

- This interdisciplinary research team aims to quantify the impact of different intervention strategies on reducing the flow of plastic pollution into the environment. They look at an array of global and local policies—plastic bag bans, container deposit schemes, cleanups, recycling infrastructure—and how effective they are at reducing the input of plastic into the environment. They've designed the methods and outputs of their research to inform governments, businesses, and agencies about the most effective strategies to reduce plastic waste, and this information will provide useful examples of what learners could consider in their assignment.
- *Welcome to the Age of Plastic*. (2017). SESYNC. https://www.sesync.org/research/welcome-age-plastic

3. A Guide to Plastic in the Ocean

- This website provides infographics and additional links to causes of marine plastic pollution and remediation efforts. It describes the National Oceanic and Atmospheric Administration's Marine Debris Program and efforts to understand the effects of microplastics on marine habitat and food webs.
- National Ocean Service. (n.d.). *A Guide to Plastic in the Ocean*. National Oceanic and Atmospheric Administration. https://oceanservice.noaa.gov/hazards/marinedebris/plastics-in-the-ocean.html

Related SESYNC Content:

- Scott, H. (2022, December 6). *Green Infrastructure Lesson: Urban Metabolism and Smart Cities*. SESYNC. https://www.sesync.org/resources/green-infrastructure-lesson-urban-metabolism-and-smart-cities
- Scott, H. (2022, December 7). *Green Infrastructure Lesson: Urban Stormwater, Policy, and Justice*. SESYNC. https://www.sesync.org/resources/green-infrastructure-urban-stormwater-policy-and-justice
- Murphy, E.L., Bernard, M., Iacona, G. et al. (2021). A decision framework for estimating the cost of

marine plastic pollution interventions. *Conservation Biology, 36*(2), e13827. https://doi.org/10.1111/cobi.13827

- Plastics Emissions Working Group. (2018). *Evaluating the Impact of Mitigation Strategies for Marine Plastics to Inform Policy: A White Paper*. SESYNC. https://www.sesync.org/research/evaluating-impact-mitigation-strategies-marine-plastics-inform-policy-white-paper
- Scott, H. (2022, June 6). *Integrating Social and Equity Dynamics into Ecological Studies Lesson: The Landfill Case Study*. SESYNC. https://www.sesync.org/resources/integrating-social-and-equity-dynamics-ecological-studies-landfill-case-study

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