

Plastics & Climate Change: The Connections

Xia (Alice) Zhu

Research Director, The Plastics & Climate Project

PhD Candidate, University of Toronto

I respectfully acknowledge that I live & work on the traditional territory of many nations including the Mississaugas of the Credit, the Anishnabeg, the Chippewa, the Haudenosaunee and the Wendat peoples

How I got involved



Sampling for microplastic pollution in San Francisco Bay, California, August 2017



Global Day of Action
COP26, Toronto, Canada,
November 2021

What we'll cover

An overview of the plastic & climate issues

The connections between plastics & climate change

What we know, don't know

- Greenhouse gas emissions from the plastics lifecycle
- Interference to carbon cycle
- Interference to Earth's radiation budget

Q & A

Our dependence on plastic coupled with the state of the world's waste management systems has resulted in a global environmental issue



Waste dumped onto beaches in India

Plastic has negative effects on ecosystems, wildlife, and us



Cocktail of contaminants associated with plastic debris (Rochman, 2015)

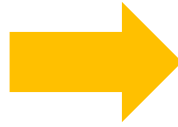


Turtle entangled in marine plastic debris (Discovery, 2018)

Plastic is made of fossil carbon



Industry emissions
(LeBoutillier on Unsplash)



Plastic nurdles or pre-production pellets
(Cloutier, 2010)

Climate change: a sister problem to plastic pollution



“Recent changes in the climate are widespread, rapid, and intensifying, and unprecedented in thousands of years.”

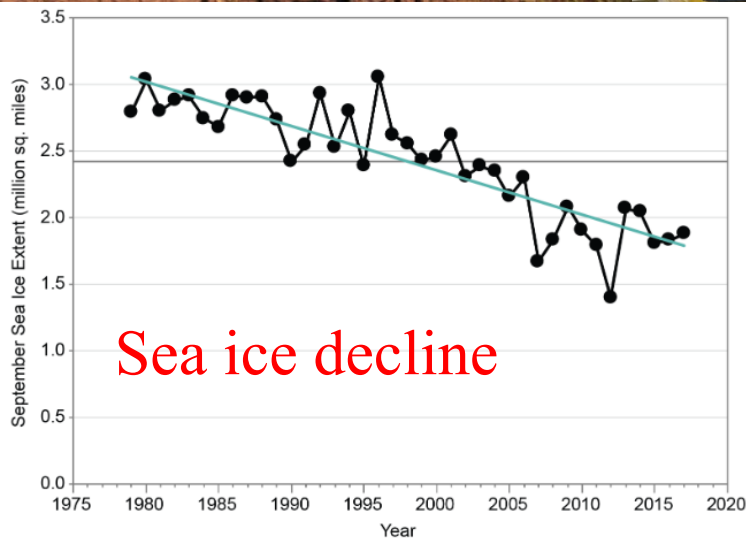
- Intergovernmental Panel on Climate Change (2021)

Global warming leads to climate destabilization, and exacerbates extremes

Wet places get wetter, dry places get drier



Increase in frequency and severity of extreme weather events



Not just earth and meteorological impacts: social impacts



And impacts are not felt the same around the world

“Failing to recognize the intimate connections between these issues not only makes tackling these issues inefficient, but may also undermine efforts on both fronts.”

“Moving forward, we should... tackle these two issues together — the opportunities to do so are plentiful.”

Zhu, *The Conversation* (2021)

Plastics & Climate Change

The knowns and unknowns

Plastic & Climate Impacts – The Big Questions/Data Gaps

Three broad categories of impacts

- Emissions of greenhouse gases across the **plastics lifecycle**
- Interference with **carbon cycling**, in particular carbon sequestration by natural carbon sinks
- Interference with **Earth's radiation budget**

Major knowledge gaps across all categories

Ultimate goal: estimate plastic's contribution to global temperature rise.

Is this possible? What are the gaps that need to be filled before this can be achieved?

Impact #1

GHG emissions across the plastics lifecycle



Greenhouse gas emissions from industry (LeBoutillier on Unsplash)

Emissions of greenhouse gases across the plastics lifecycle



From extraction of fossil fuels to end-of-life treatment or leakage into the environment, plastic generates GHGs

By 2050, GHG emissions from plastics lifecycle equivalent of emissions from 615 coal plants

CIEL (2019)

Greenhouse gas emissions from the plastics lifecycle

- Extraction
- Refinement
- Raw building block/monomer formation
- Formation of virgin pellets
- Product Formation/Conversion
- Transportation & Consumption
- End-of-life treatment: incineration, recycling, open burning, landfill, composting
- Leakage into the Environment

most well-studied
steps of plastics
lifecycle globally

Missing information for
“difficult-to-calculate” steps of lifecycle

Impact #2

Impacts on carbon cycling (terrestrial, coastal, and marine)



Microplastic particles in zooplankton from Cole et al. (2013)

Terrestrial Sinks

Studies discuss impact to soil microbial communities, soil properties, & soil DOC

Microbial communities observed to shift with plastic pollution in soil

Coastal Sinks

MPs may disrupt carbon sequestration of blue carbon ecosystems

MP contamination converted coastal marshes & mudflats from net C sink to C source

Marine Sinks

Poses risks to marine photosynthetic organisms, zooplankton, which play important roles in the marine carbon cycle

May affect how much carbon the ocean stores by altering how carbon sinks through the ocean column

In general, paucity of studies + studies not done with climate objective in mind

Impact #3

Impacts on Earth's radiation budget



Environmental plastics can alter the albedo and melting rate of ice and snow. (Desgagnes on Unsplash)

GHGs are not the only factor that causes warming or cooling of the Earth, called “radiative forcing” parameters

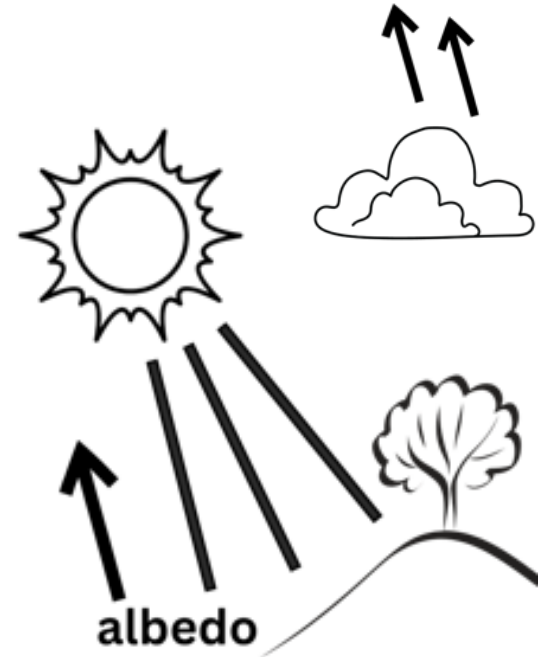
The three other major radiative forcing parameters are **aerosols**, **clouds**, and **albedo**



(Roman Studio,
Moment, & Getty
Images)

Radiative impacts of plastic pollution

- “Aerosolized” plastic particles are suspended in the atmosphere
- Current estimate of direct radiative forcing by microplastic aerosols is relatively small (Revell et al., 2021)
- As plastic production and inputs into environment increase, radiative effects are likely to increase



No other global radiative forcing estimates exist (cloud, albedo)

Summary

Recap, Significance, Next Steps

Summary of knowns and unknowns

Lifecycle GHG emissions

Lack of studies that quantify emissions of GHGs from the consumption, transportation, landfill, composting, and environmental degradation steps of the plastics lifecycle

Impacts to natural carbon sinks

- Need more studies that investigate how plastics may be **altering the carbon sequestration abilities** of blue carbon ecosystems
- Most now are **speculative**
- Need **laboratory experiments, in-situ measurements to validate the output of theoretical models, and calculations** that directly connect study outputs to global average temperature rise
 - Change in soil properties, toxicity to zooplankton, concentration of aerosolized plastic particles

Radiative impacts

- Most studies **were not conducted with the primary objective of understanding impacts to climate** in mind
- In dire need of more radiative forcing estimates for environmental plastics

Overall...

We are far from having a conclusive picture of the significance of the impact of plastics on climate change

Next Steps

The Plastic & Climate Project – identifying the gaps to ultimately determine plastics' role in global average temperature rise

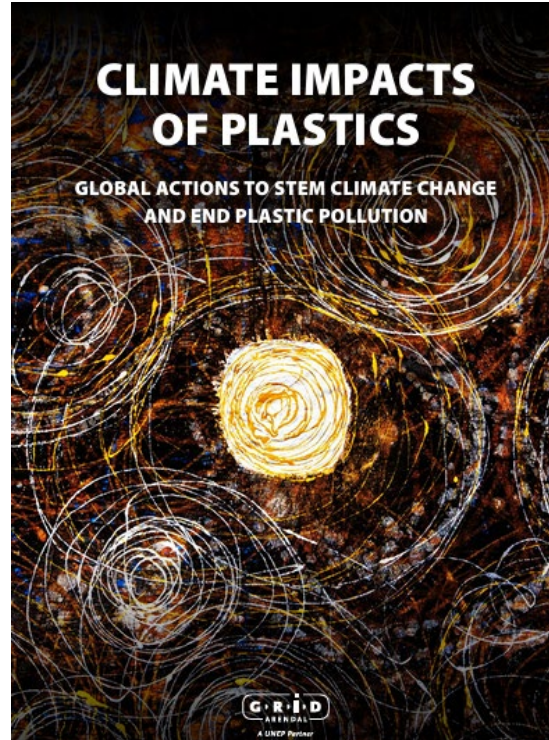
We are conducting a literature review to identify what we know and don't know. After the literature review is complete, we will:

- Develop a **research agenda** to fill data gaps
- Develop **policy recommendations**
- **Disseminate findings** to generate support for necessary research & inclusion in models/scenarios
- Host a **public repository**

Resources



United States



Synergies between Paris Agreement and Plastics Treaty



Global

The Plastic & Climate Project

plasticsandclimate.com

Alice Zhu

Research Director

alicexia.zhu@mail.utoronto.ca

Holly Kaufman

Executive Director

holly@plasticsandclimate.com



@AliceXiaZhu



alicexiazhu.com