Dottorato Nazionale in Sustainable Development and Climate Change

Istituto Universitario di Studi Superiori, Pavia-Ciclo XL

Plastic and microplastics in coastal areas: toward a Zero Pollution vision

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INTRODUCTION

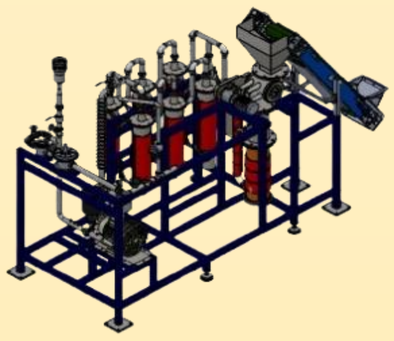
Plastic is a valuable but problematic material, especially for marine ecosystems. It affects nearly all forms of marine life and disrupts ecosystems crucial for climate regulation (1).
Despite increased awareness, recycling remains limited.The global plastic recycling rate rose only from 1.5% in 1990 to about 9% in 2022, while production tripled, exceeding 460 million tonnes per year (2).Millions of tonnes of plastic enter the oceans annually, with only 0.5%–2.5% forming visible surface patches like the Great Pacific Garbage Patch (3; 4). The rest becomes beached, sinks, or disperses across marine environments. This pollution impacts fisheries, aquaculture, and tourism, and also poses risks to human health (5).

AIMS

This project focuses on three main challenges linked to marine plastic pollution:

- The impact on the marine environment
- The lack of effective mitigation strategies
- The valorization of non-recyclable plastics using innovative solutions

The research will focus on analyzing plastic pollution by characterizing the waste found in sediments and surface waters using FTIR spectroscopy, to evaluate its nature and environmental impact. Moving beyond observation, the project explores a practical mitigation strategy: the GreenPlasma technology, a mobile waste-to-energy system mounted on a truck, designed to process non-recyclable plastics directly at pollution hotspots such as beaches.



5kg=32KW/h | 150kg = 130KW/h

SOLVING FONDAZIONE CARIVERONA

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GREENPLASMA TECHNOLOGY

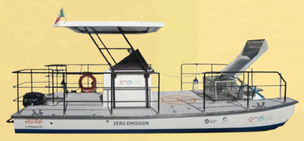
Plastic waste is **shredded** into smaller pieces

+ 700°C

The material is transformed into a syngas due to the high temperatures reached, without producing carbon dioxide due to the absence of oxygen

The syngas is filtered and **cleaned** of all contaminants

The resulting product is a **hydrogen-rich syngas,** used by an electric generator to produce energy



3 CASE STUDIES

1. Port waste
   - Port of Ancona

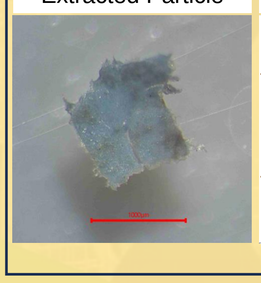
2. Agricultural waste
   - Univpm farm

3. Recycling
   - Univpm

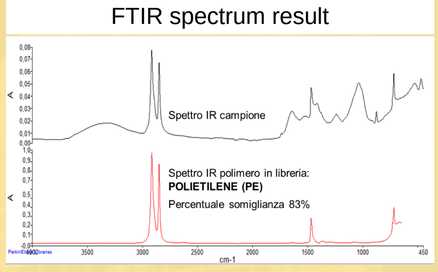
POLYMER CHARACTERIZATION

In order to better understand the energy yield of the several polymers in the different case studies, each typology of the collected waste, is going to be characterized through the Fourier Transaformed Infrared (FTIR) spectroscopy technique.

Extracted Particle

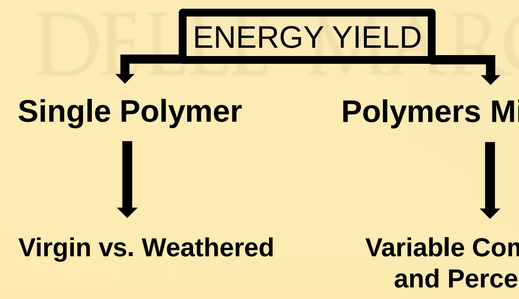


FTIR spectrum result



EXPERIMENTAL APPROACH

The first and most important question this work aims to address is whether the pyro-gasification process has a positive energy balance, in other words, whether it produces more energy than it consumes. The main objective is to quantify the ebergy yield of the GreenPlasma system under different conditions, specific to each of the 3 case studies.



The energy output will be optimized by fine tuning several key parameters, including:

- Process temperature
- Filters temperature
- Duration of the treatment
- Blower velocity
- Size of input fragments

For each setup, a chemical and physical analysis of the produced gases will be carried out, with particular attention to the presence of greenhouse gases, along with the quantification of ''by-products'' such as pyrolysis oils and solid residues.
One of the key goals is to estimate how much waste can be treated per day across the different case studies, and to understand how close this gets to the real-world quantities of plastic waste generated daily, weekly, monthly or annually within those same scenarios, in order to assess the actual impact and potential scalability of the GreenPlasma system.
Lastly, a cost-benefit analysis will also be performed, taking into account not only the energy output but also potential management and maintenance costs over time.

DISSEMINATION

REFERENCES

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2 - OECD (2022) – Global Plastics Outlook: Economic Drivers, Environmental Impacts and Policy Options
3 - Jambeck et al. (2015) – Plastic waste inputs from land into the ocean, Science
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5 - UNESCO (2023) – Plastic pollution facts & figure

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