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TITLE

Eco-Thermal Energy Recovery and Soil-Based Emission Filtration from Plastic Waste Using ORC Combustion

ABSTRACT

The increasing accumulation of plastic waste—including polyethylene (PE), polypropylene (PP), polystyrene (PS), polyethylene terephthalate (PET), and polyvinyl chloride (PVC)—poses major environmental threats. Improper burning and disposal lead to toxic emissions and soil and water contamination. This project presents an integrated solution using an Organic Rankine Cycle (ORC) combustion system to convert assorted plastic waste into energy, supported by a soil-based vertical filtration system for emissions treatment.

We utilize an ORC-based combustion system operating at a burn rate of 200 kg/hour. The system is compatible with various plastic types, each with unique calorific values. A 5m x 5m x 7m underground filtration chamber (175 m^3 volume) is filled with stratified layers of soil, sand, clay, zeolite, and activated carbon. Emitted gases are injected from the bottom using a 2 HP pump and naturally filtered as they pass upward through the medium.

Plastic Composition in Municipal Waste (Typical Estimates):

Plastic Type	Approx. % in Waste Plastics	Calorific Value (MJ/kg)
PE (LDPE/HDPE)	35%	42-46
PP	25%	46
PS	10%	41
PET	15%	23
PVC	10%	17
Others	5%	Varies

Key Components:

- ✓ **Fuel:** Mixed plastic waste (PE, PP, PS, PET, PVC)
- ✓ **Burn Rate:** 200 kg/hour
- ✓ **Filtration Unit:** 175 cubic meter soil-based vertical filter
- ✓ **Pump:** 2 HP air compressor to drive gas through soil layers
- ✓ **Filter Media:** Clay, sand, activated carbon, zeolite, and topsoil

Calculations:

- ✓ **Average Calorific Value:** Weighted average ~38.6 MJ/kg
- ✓ **Energy Output Estimate:**

- ✧ 200 kg/hr × 38.6 MJ = 7720 MJ/hr = ~2144 kWh (thermal)
- ✧ Assuming 20% ORC efficiency: ~429 kWh electrical output/hour

- ✓ **Filter Capacity:**

- ✧ With proper packing, estimated pollutant removal efficiency: 80–90%
- ✧ Daily filtration of up to 1000–1200 kg plastic combustion gases feasible with this setup

✓ **Carbon Capture Potential & Soil Reuse:**

✧ The filtration soil absorbs soot, microplastics, and semi-volatile carbon compounds
✧ After saturation, this carbon-rich soil can be:

❖ Used in construction (compressed into carbon bricks)
❖ Repurposed as a biochar-like soil conditioner (after testing for toxicity)
❖ Processed further for carbon recovery or containment

Advantages:

❖ Handles multiple plastic types and waste streams
❖ Decentralized waste management and power generation
❖ Soil acts as low-cost, natural gas scrubber
❖ Reduces landfill load and harmful atmospheric emissions

Conclusion

This project offers an innovative and scalable solution to plastic waste management, combining energy recovery with environmental filtration. Its natural gas filtering through layered soil and carbon-sequestering reuse options make it a sustainable alternative to conventional plastic disposal. The system accommodates a variety of plastic waste and supports urban, rural, or industrial implementation.