Achieving Net-Zero Lab Waste @ Caltech
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What is Waste Value (WV)?

\[ \text{Waste Value (WV)} = \text{Waste Fraction} \times (\text{Disposal Cost} + \text{Environmental Cost} - \text{Recycle Cost}) \]

- Waste Value can be calculated for each type of waste (single-use plastics, cardboard, etc.), from each source (labs, facilities, etc.)
- "Waste Fraction" is the fraction of a waste source of a specific type
- "Disposal Cost" is the cost to properly dispose of that source or send to a landfill
- "Environmental Cost" is the cost of the damage of that source to the environment
- "Recycle Cost" is the cost to recycle or reuse that source—the cost of the sustainable alternative

Why is it important?

- Hazardous Waste accounts for only 6% of total waste generated (by weight), but more than 85% of yearly disposal costs
- The dangerous nature of chemical and contaminated waste makes it difficult and costly to throw away or store in compliance with state and federal regulations
- Labs are a significant source of waste:
  - A 2015 study at University of Exeter found that their Bioscience Department produced as much as 280 tons of plastic waste per year
  - For every ton of plastic waste recycled, 5,774 kWh of energy is saved
- "Waste Value" can be used to identify sources of waste with greatest impact, direct decision of whether to recycle/reuse or mitigate generation of that source

- A positive WV indicates recycle costs outweigh disposal costs (these sources should be mitigated)
- A negative WV indicates disposal costs and cost to environment are high enough that recycling is financially viable

WV Case #1: Plastic Pipet Tips

**Assumptions**
- 100% polypropylene pipet tips
- Waste Fraction: pipet tips comprise 10-50% of total hazardous waste by weight
- Disposal Cost: average cost as 5 hazardous waste disposal for 2018 / tons of waste
- Environmental Cost: quantities monetary impact of...
  - climate pollution, ozone depletion, ocean acidification, and eutrophication
  - excludes marine, human, terrestrial toxicity
- Recycle Cost:
  - recycling/reuse method: Grenova TipNovus pipet tip cleaning machine

**Sources of Uncertainty**
- Waste Fraction: actual fraction unknown
- Environmental Cost: uncertainty in materials cost for PP manufacturing, significant uncertainty in assigning a cost to ecosystem services
- Recycle Cost:
  - % savings achieved by pipet tip reuse (estimated 30-50%)
  - # machines needed (depends on waste fraction)
  - # employees needed (assumed 5 employee can operate 3 machines performing 4 wash cycles per machine per hour, working at 60-80% efficiency = 22,118 - 19,995 tips cleaned/employee/day)

WV: Next Steps

Obtain more specific, accurate data on lab waste

1. First month:
   - Labs record all waste generated (solvent bottles, gloves, tips, centrifuge tubes, etc.)
   - Rank labs by amount of waste
2. Second month:
   - Labs employ sustainable options to reduce waste
   - Compare with other labs to reduce waste the most for a prize & recognition

How can you contribute?

Be mindful of your lab waste:
- Only place contaminated waste in hazardous waste disposal bins
- Do not mix solvents
- Be mindful of your lab waste

Label your solvent waste:
- The top two labels are most important
  - Contact Max Christian to learn about Green Labs!