



TERRACYCLE LIFE CYCLE ASSESSMENT SUMMARY

Flexible Film Recycling



TABLE OF CONTENTS

1

Introduction

2

Executive Summary

3

Models & Performance Overview

TABLE OF CONTENTS

1

Introduction

2

Executive Summary

3

Models & Performance Overview

TERRACYCLE'S LIFE CYCLE ASSESSMENT (LCA) PROCESS



SimaPro

TOOLS

TerraCycle LCAs are modeled using SimaPro® LCA software by Prè consultants. As part of the SimaPro platform, TerraCycle has access to many global databases like Ecoinvent, IDEA, DATASMART, and more.



STANDARDS

TerraCycle makes best effort to conduct LCAs according to the ISO standards ISO14040 and 14044. Our LCAs are one-of-a-kind and require careful consideration of scope, allocation methods and other details.

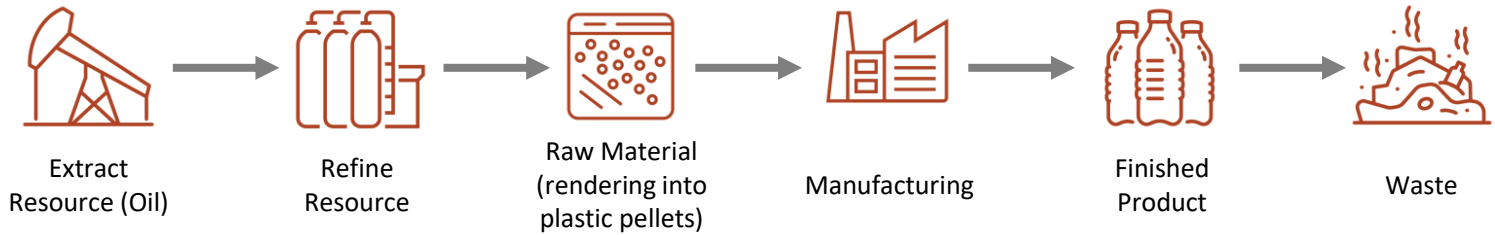


CONSULTATION

TerraCycle works with an external consultant Long Trail Sustainability (www.ltsexperts.com) to review the ISO compliance and validate our LCAs.

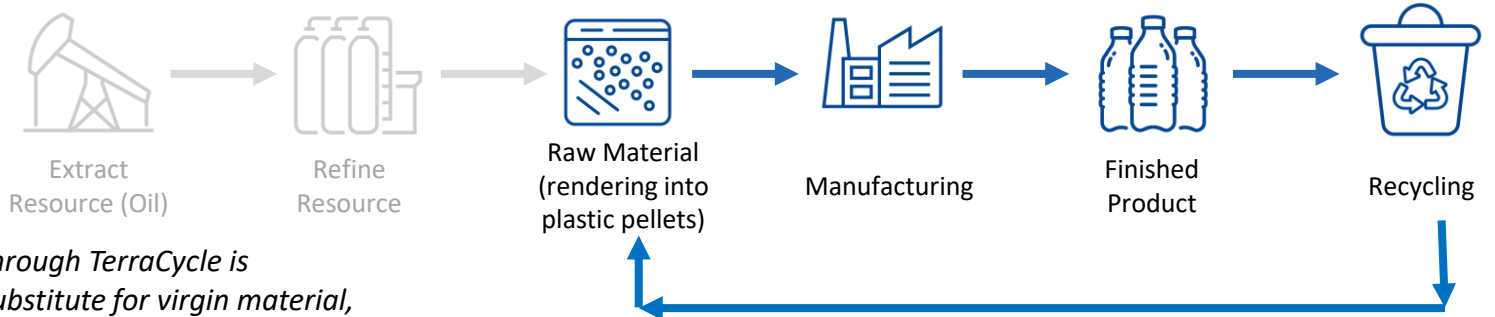
REDUCING ENVIRONMENTAL IMPACT

Linear System Flow



The biggest driver of environmental impact stems from virgin material extraction and production as well as the externalities of landfilling / incineration.

Circular System Flow



The material collected through TerraCycle is processed and used to substitute for virgin material, reducing the need to extract new raw materials.

Recycling proves to have lower environmental impact compared to landfill because the reduction in resource extraction outweighs the transportation externalities.

TABLE OF CONTENTS

1

Introduction

2

Executive Summary

3

Models & Performance Overview

Scope of Flexible Films LCA (Comparing TC models Vs Municipal models)

Flexible Films

- Multi Layer Packaging (Snack / Candy bar wrappers)

Recycling Process

- Based on the composition of the multi layered post-consumer flexible films, were collected, shredded and extruded to make pellets.

Final Product

- The pellets were injection molded to make frisbees

TerraCycle Programs

- TC Freight, TC Mail in, TC Public Collection, TC ZWB (Large & Medium)

Municipal Programs

- Landfill, Incineration

Functional Unit

- The Collection, Transportation and End-of-Life Waste Management of 100kg of Post-Consumer Flexible Film Waste and the Associated Production of 485 Frisbees

KEY FINDINGS FROM THE LCA

The Flexible Film LCA evaluated and compared TerraCycle Recycling Programs with Traditional Municipal Waste Management Models in the following environmental impact categories:

- Global Warming Potential
- Ozone Formulation & Human Health
- Freshwater Eutrophication
- Freshwater Ecotoxicity
- Human Carcinogenic Toxicity
- Human Non-Carcinogenic Toxicity
- Fossil Resource Scarcity
- Water Consumption

Key Results: All TerraCycle Models assessed in this study have lower environmental impacts than the municipal waste management processes. **TerraCycle Models reduce key impact indicators by a collective average of >45% when compared to Traditional Waste Management (Landfill and Incineration).**

TABLE OF CONTENTS

1

Introduction

2

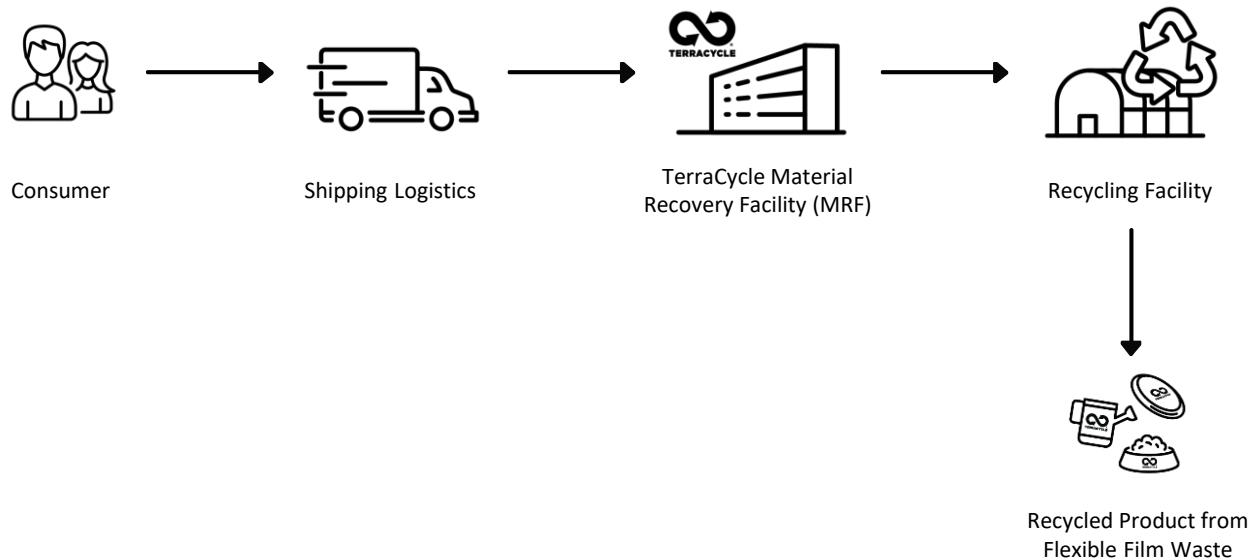
Executive Summary

3

Models & Performance Overview

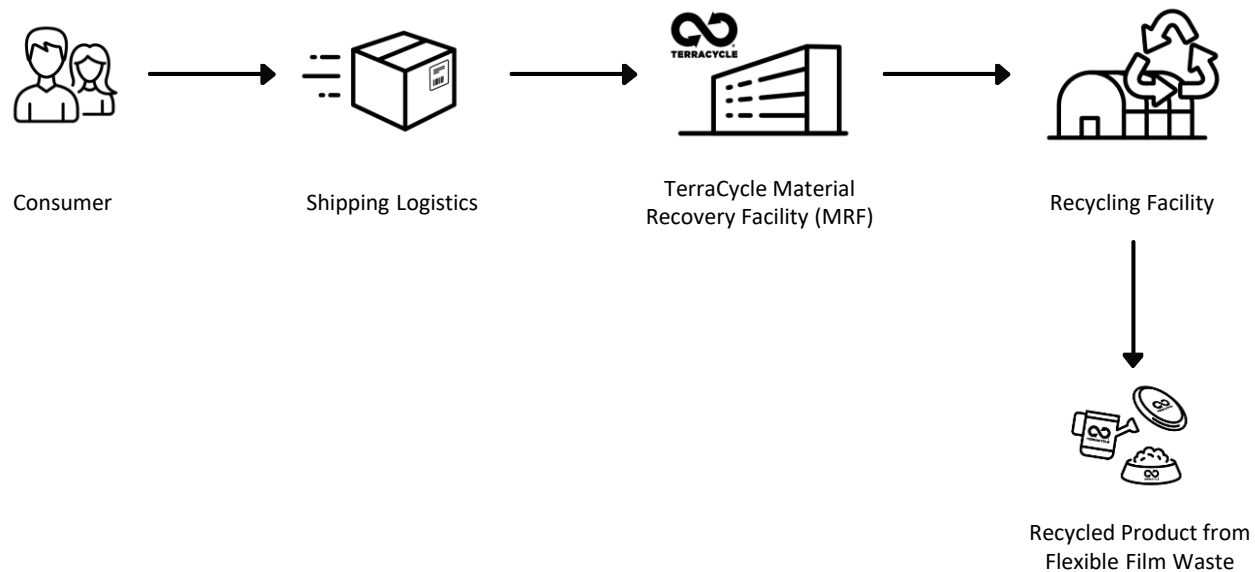
1. TERRACYCLE FREIGHT RECYCLING MODEL

In this model, consumers collect a specific waste category at a centralized location or their facility. The collected waste is aggregated and shipped to the TerraCycle Material Recovery Facility through freight logistics to be sorted by material composition. From the MRF, the material is sent to a processing facility to be recycled before the manufacture of the final products.



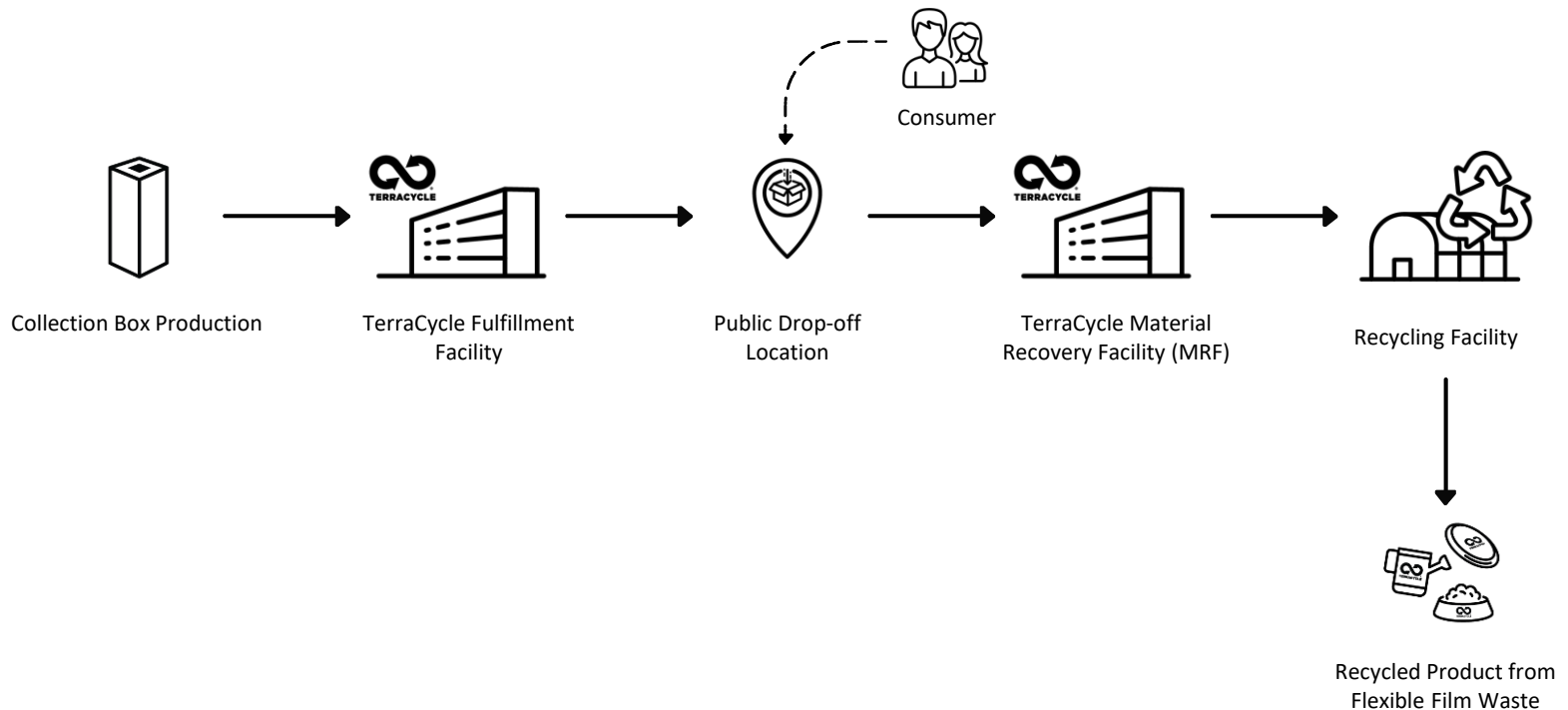
2. TERRACYCLE MAIL IN MODEL

In this model, consumers collect and send their waste to the TerraCycle Material Recovery Facility by downloading a shipping label from the TerraCycle website. Once received at the MRF, the waste is sorted and aggregated by material composition. From the MRF, the material is sent to a processing facility to be recycled before the manufacture of the final products.



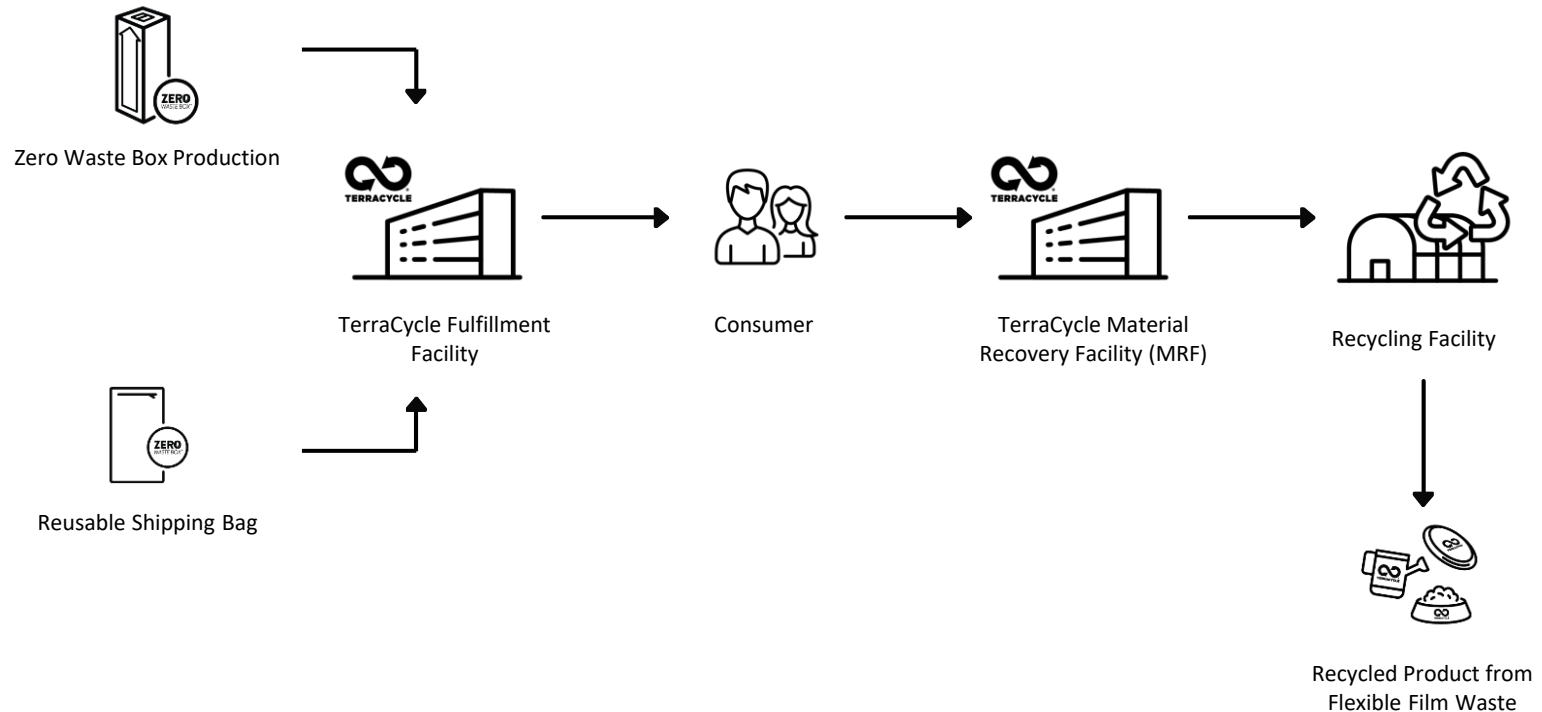
3. TERRACYCLE PUBLIC COLLECTION MODEL

In this model, a TerraCycle brand partner sponsors a public collection location where consumers can recycle their waste in a customized collection box. Once the collection box at the location is full, it is shipped to the TerraCycle Material Recovery Facility for sortation by material composition. Then, the material is sent to a processing facility to be recycled before the manufacture of the final products.



4. TERRACYCLE ZERO WASTE BOX (ZWB) MODEL

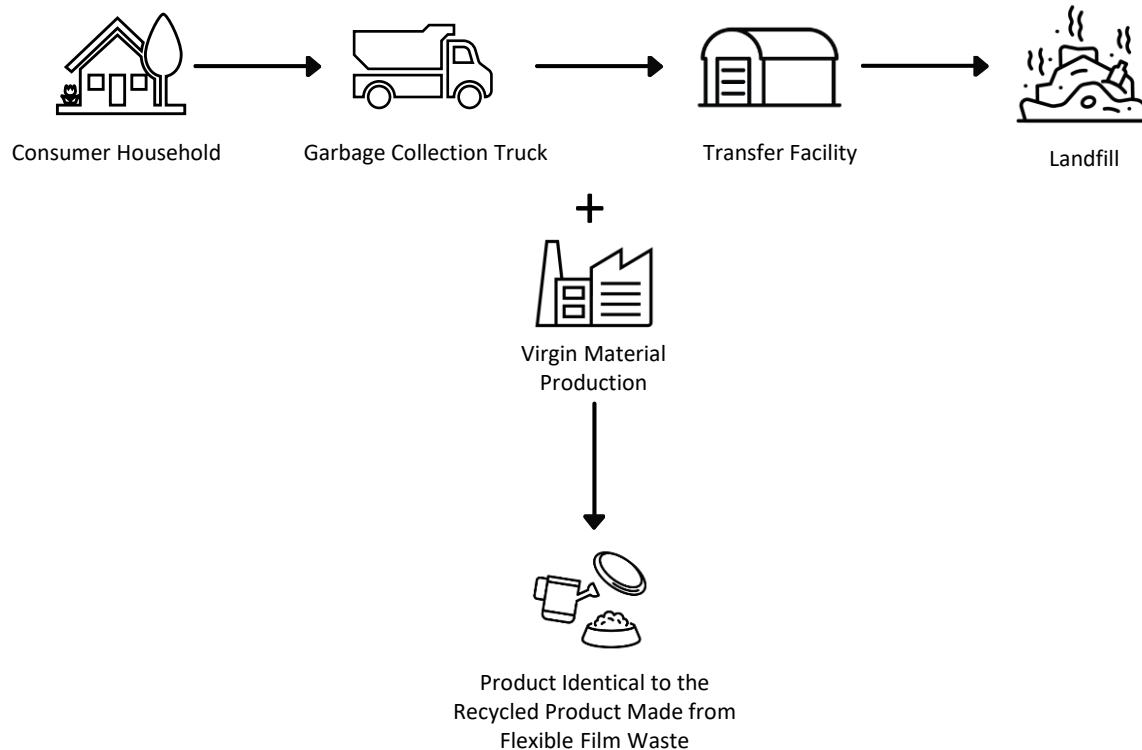
In this model, consumers purchase a waste-specific or category-specific Zero Waste Box online. Consumers collect their waste in the Zero Waste Box and ship it to the TerraCycle Material Recovery Facility when full. Once received at the MRF, the waste is sorted and aggregated by material composition. Then, the material is sent to a processing facility to be recycled before the manufacture of the final products.



TRADITIONAL WASTE MANAGEMENT: MUNICIPAL LANDFILLING

In this model, a garbage collection truck collects the waste from the consumer's household and disposes the collected waste at a Transfer Facility/Tipping Floor before it is sent to landfill.

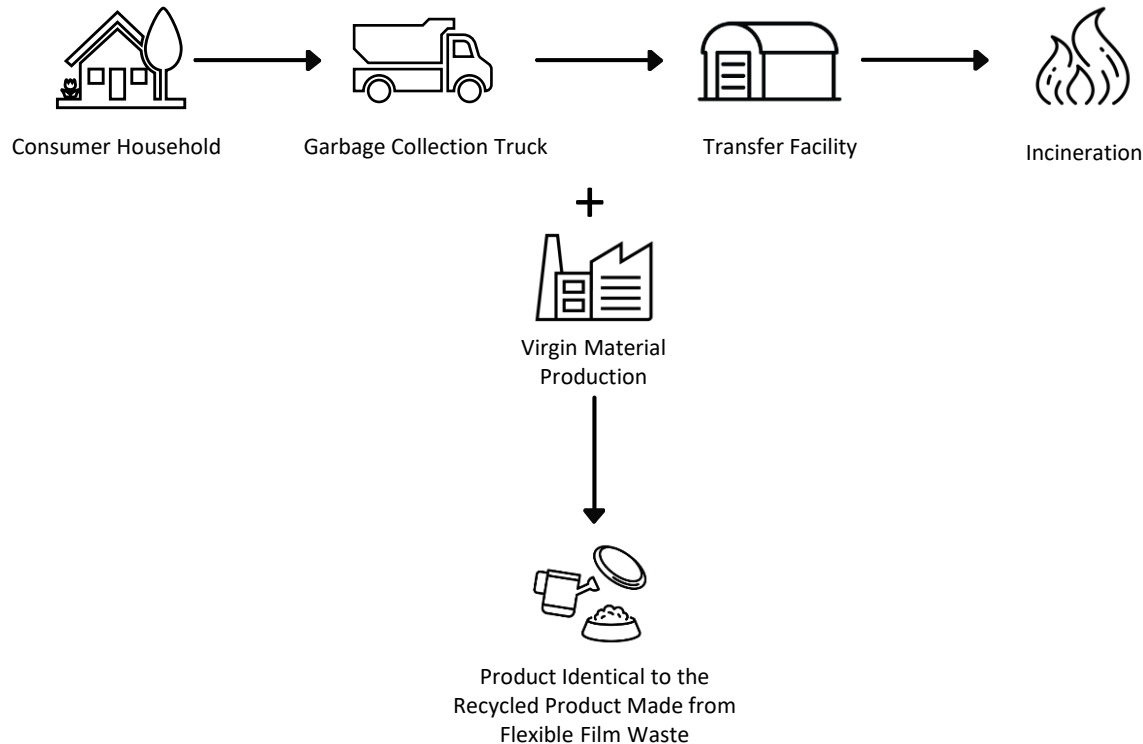
Note: Virgin Material Production is added to the boundary for fair comparison of the models.



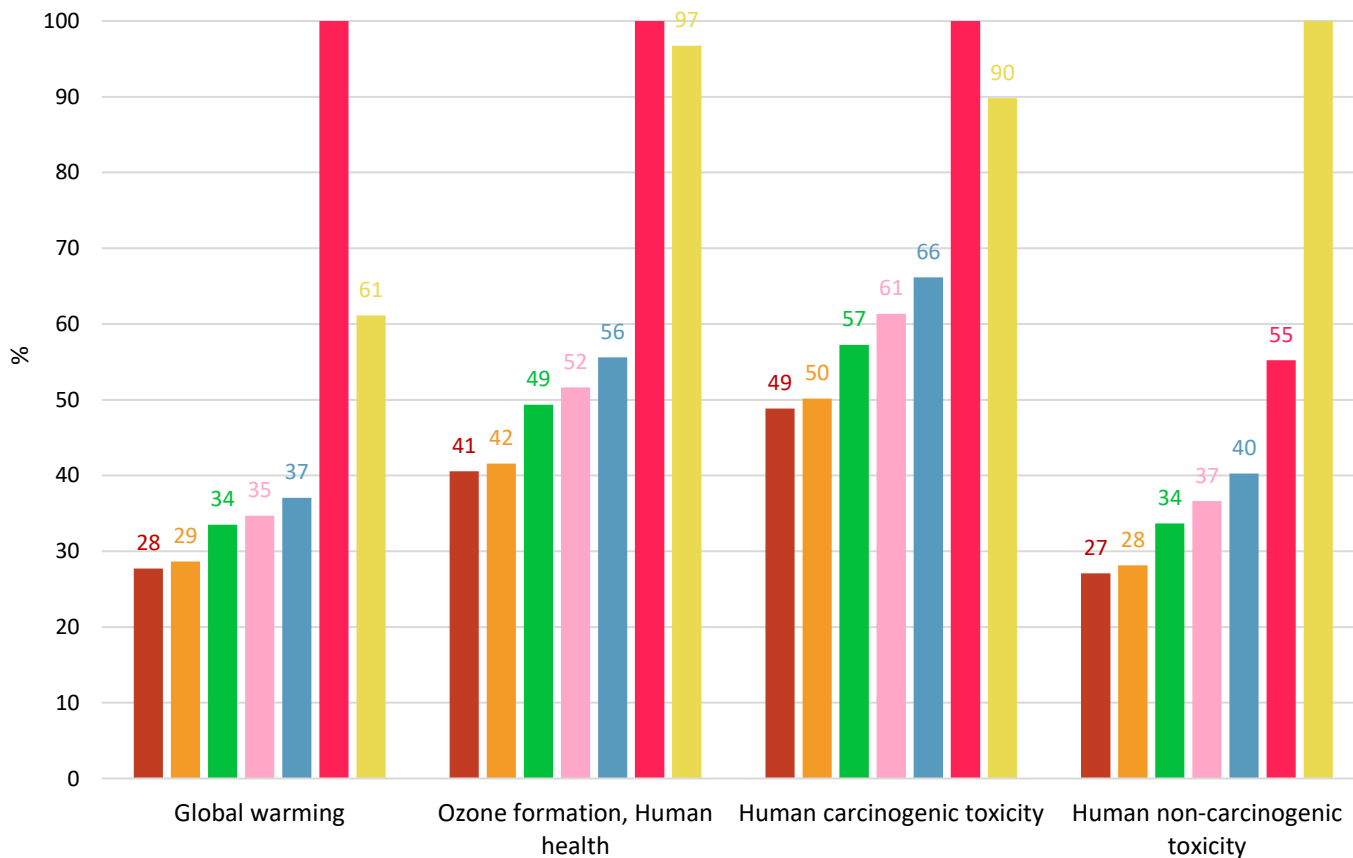
TRADITIONAL WASTE MANAGEMENT: MUNICIPAL INCINERATION

In this model, a garbage collection truck collects the waste from the consumer's household and disposes the collected waste at a Transfer Facility/Tipping Floor before it is sent to incineration.

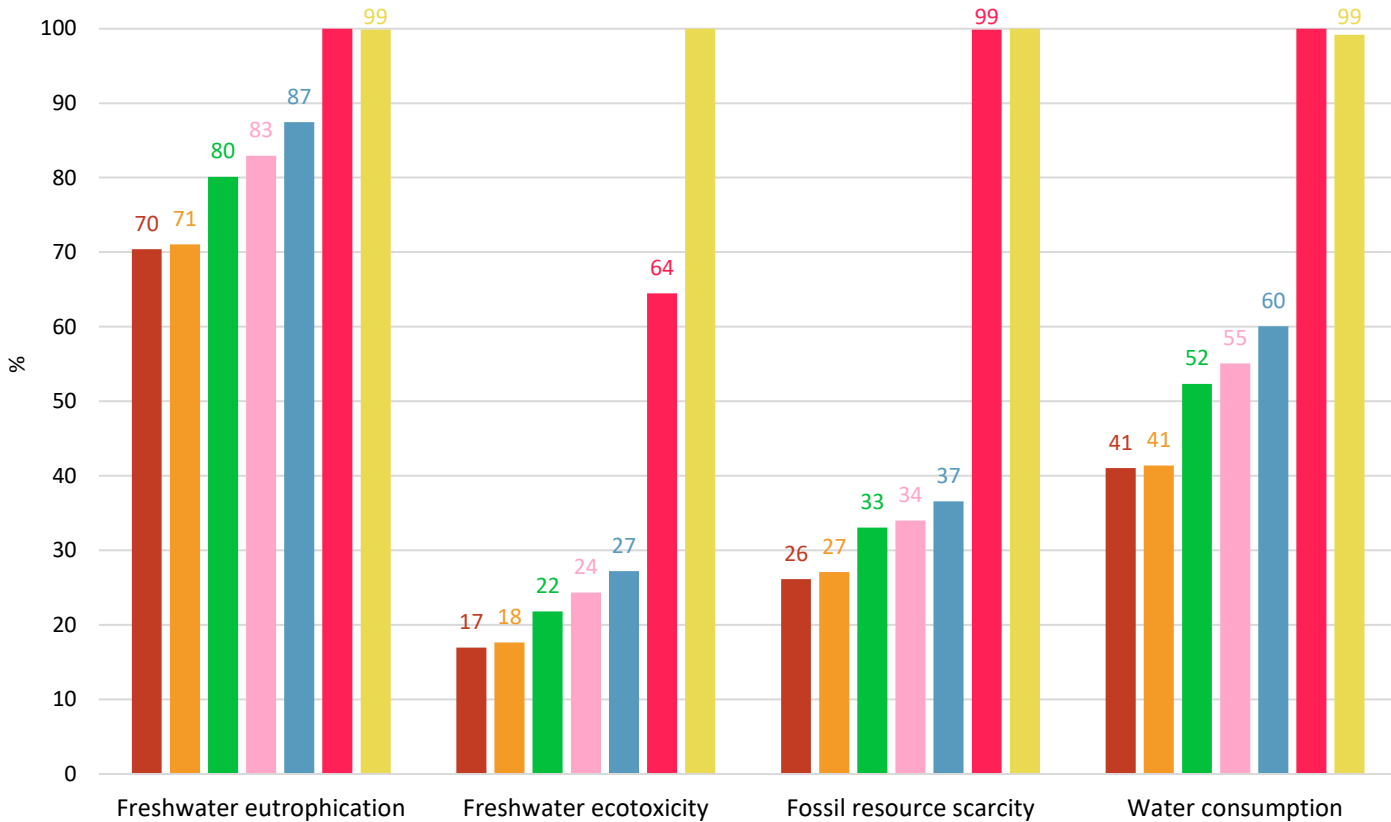
Note: Virgin Material Production is added to the boundary for fair comparison of the models.



MODEL COMPARISON: Characterized comparison of all models for all impacts (Part 1)

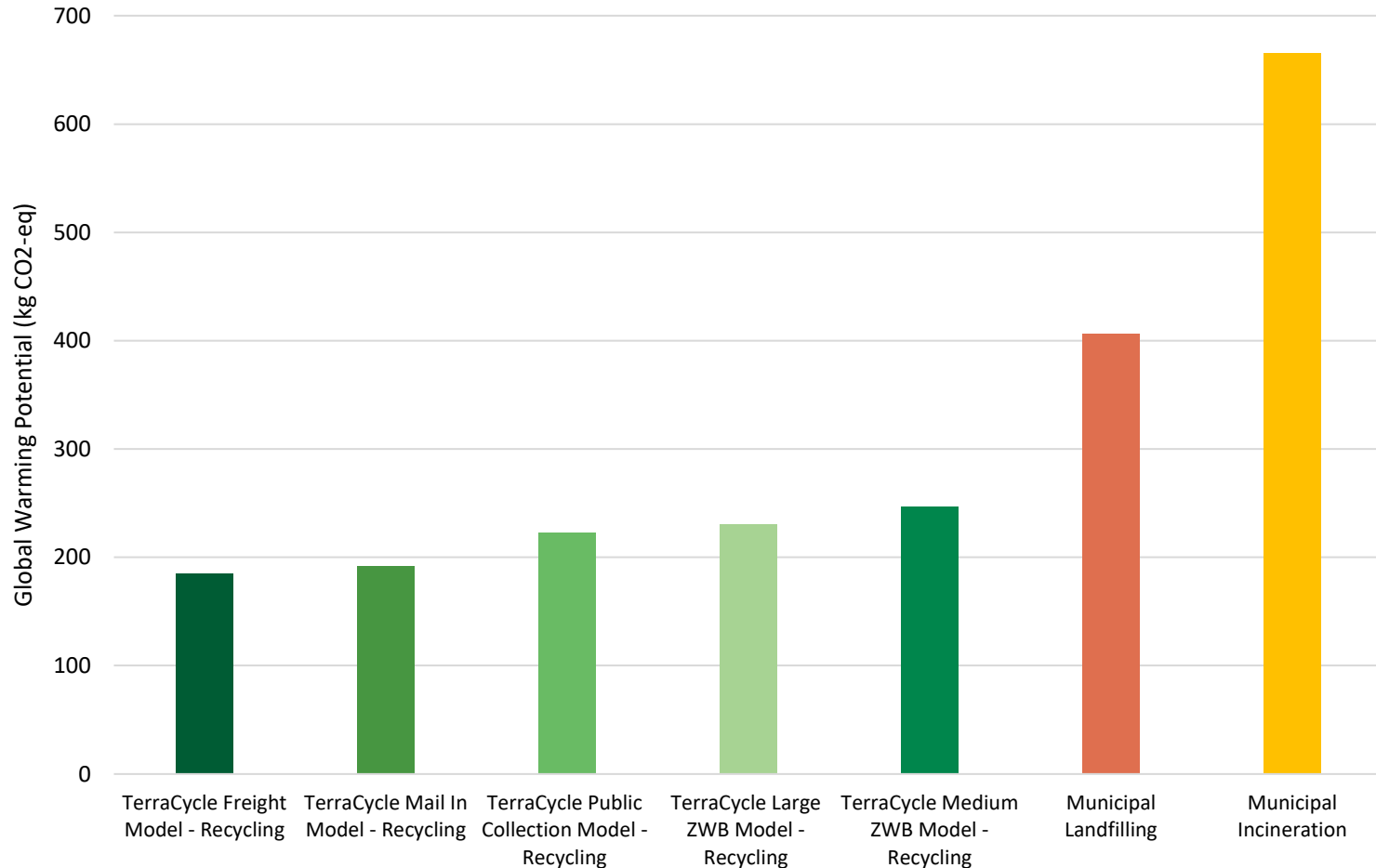


MODEL COMPARISON: Characterized comparison of all models for all impacts (Part 2)



MODEL COMPARISON: GLOBAL WARMING POTENTIAL

All TerraCycle models drive environmental savings compared to the municipal models. TerraCycle's Recycling Models have a >40% reduction in Global Warming Potential compared to Municipal Waste Management Models.

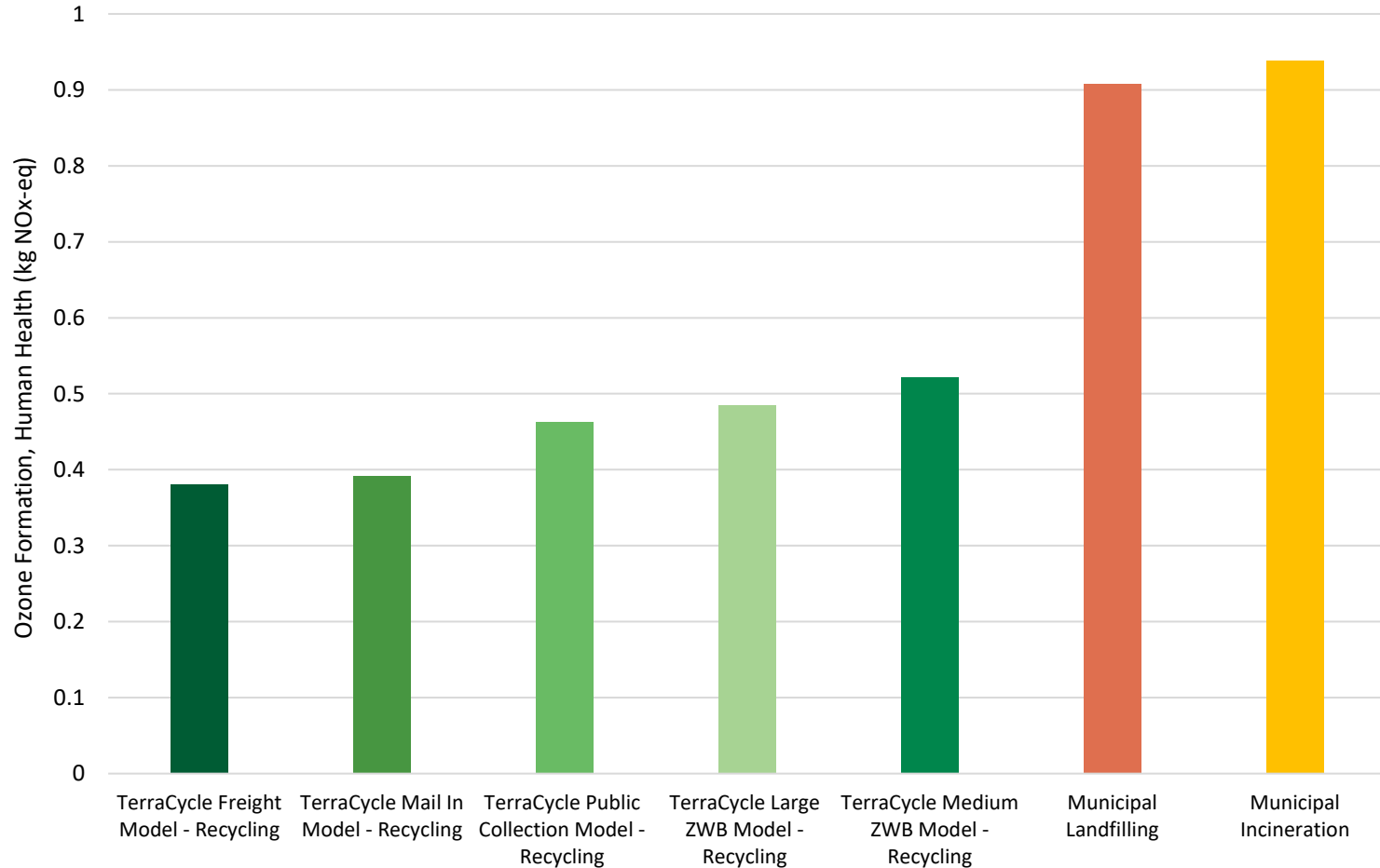


Global Warming Potential (GWP): The GWP metric evaluates and normalizes different gas emissions to the air and the net effect on the atmospheric warming over 100 years. The units for this GWP-100 is expressed in terms of kilograms of Carbon Dioxide equivalent, or kg CO2-eq.



MODEL COMPARISON: OZONE FORMATION, HUMAN HEALTH

All TerraCycle models drive environmental savings compared to the municipal models. TerraCycle's Recycling Models have a >40% reduction in Ozone Formation & Human Health compared to Municipal Waste Management Models.

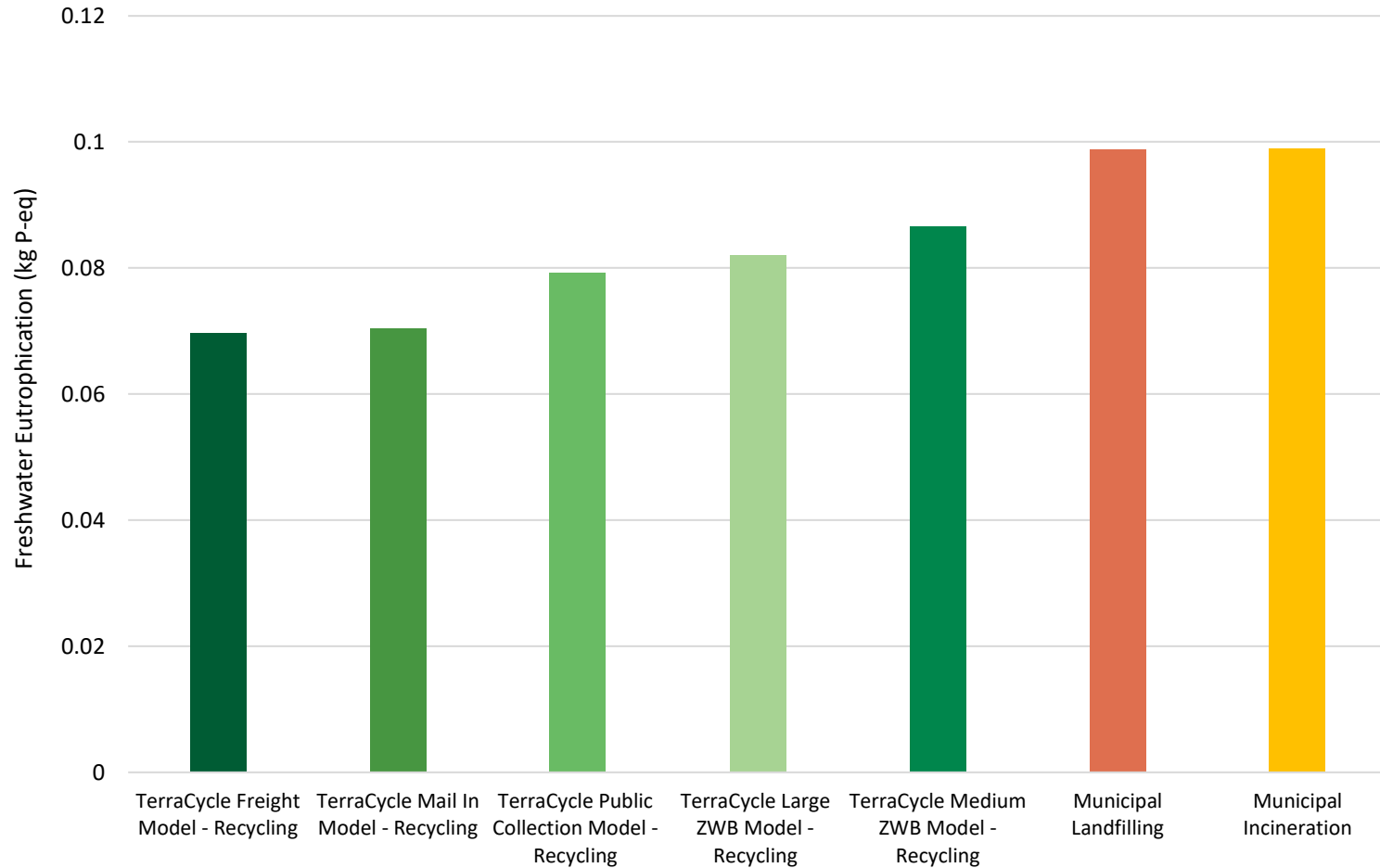


Ozone Formation, Human Health: This impact category focuses on the unnatural generation of Ozone (O₃) gas and the associations with human respiratory problems and damage to plant life. Ozone is often generated from the reaction of Nitrogen Oxides (NO_x) and other Volatile Organic Compounds (VOCs), chemicals that are generated from combustion in automobiles and other industrial sources.



MODEL COMPARISON: FRESHWATER EUTROPHICATION

All TerraCycle models drive environmental savings compared to the municipal models. TerraCycle's Recycling Models have a >15% reduction in Freshwater Eutrophication compared to Municipal Waste Management Models.

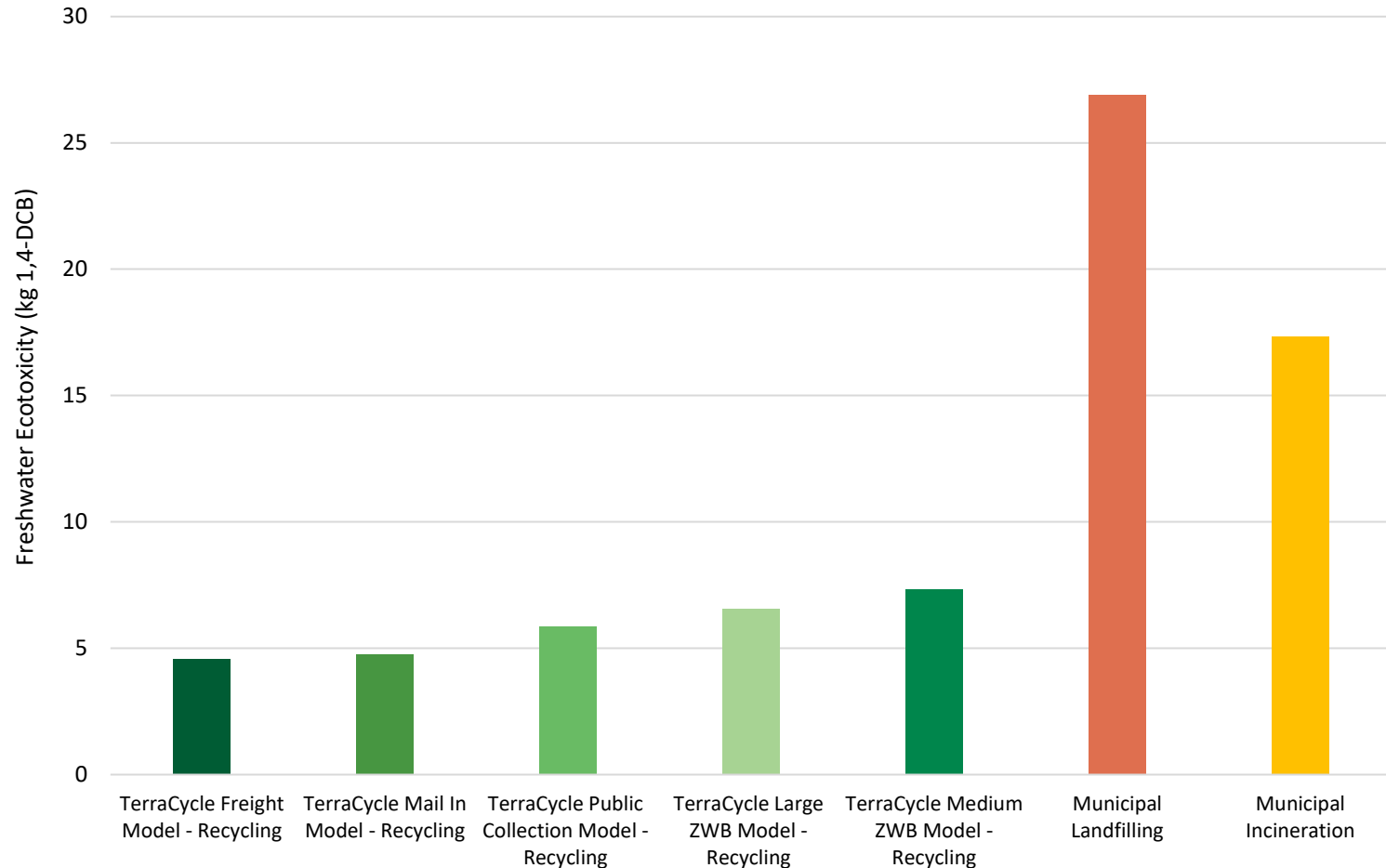


Freshwater Eutrophication: Freshwater eutrophication is caused by Phosphorous (P) discharges from human activities, especially agricultural use of P fertilizer. It describes the potential of discharged substances to produce phytoplankton biomass with respect to the P content of the emitted substance. The impact of eutrophication potential is quantified in mass units of phosphorous equivalents (i.e., kg P eq.).



MODEL COMPARISON: FRESHWATER ECOTOXICITY

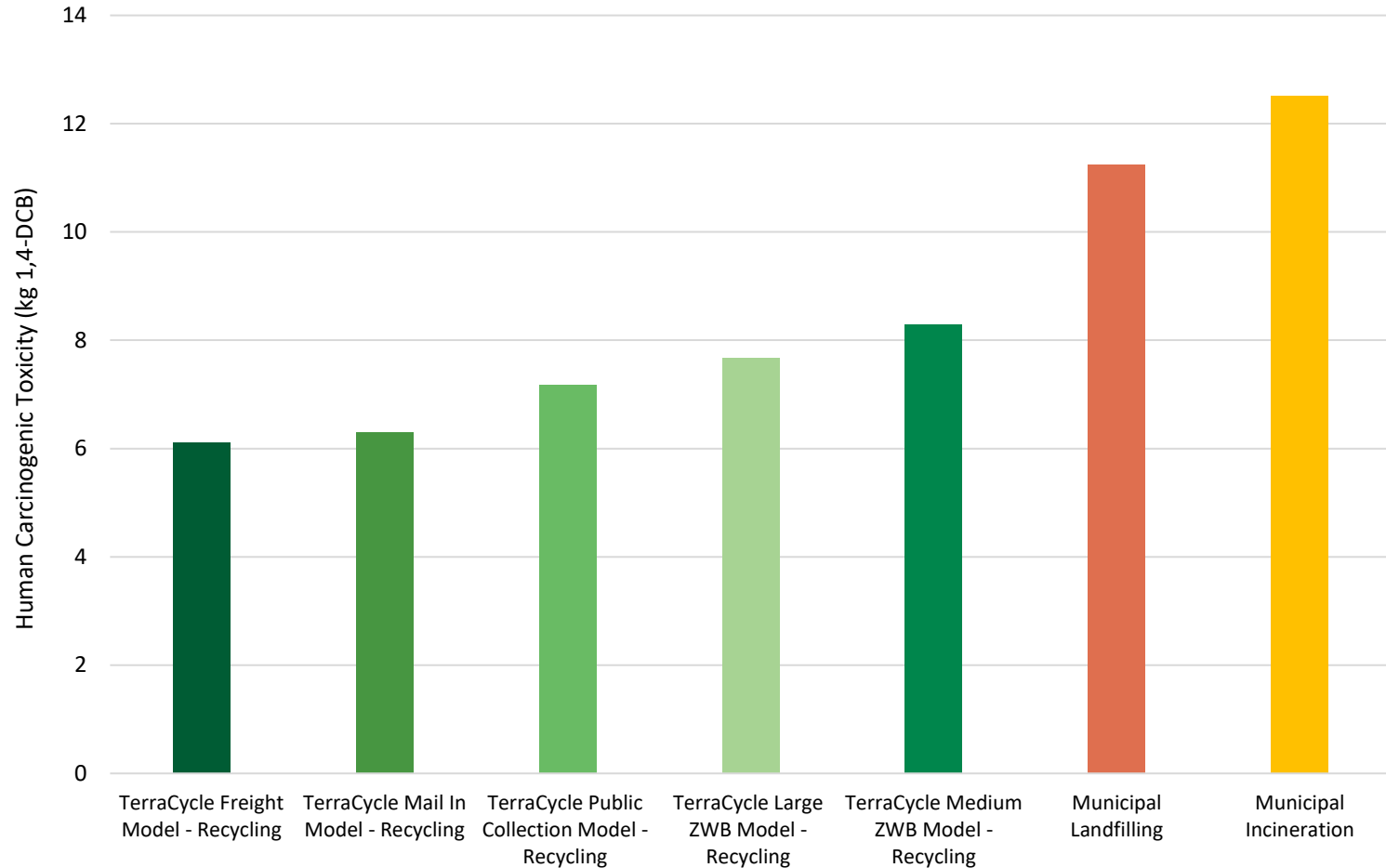
All TerraCycle models drive environmental savings compared to the municipal models. TerraCycle's Recycling Models have a >60% reduction in Freshwater Ecotoxicity compared to Municipal Waste Management Models.



Freshwater Ecotoxicity: This toxicity evaluation determines the distribution of a chemical in a model environment and accounts for several exposure routes, including inhalation, ingestion of produce, fish and meat, and dermal contact with water and soil. The toxic substances generated are compared with 1,4-dichlorobenzene (to urban air for human toxicity, to freshwater for freshwater ecotoxicity) as a reference. (i.e., kg 1,4-DCB equivalents).

MODEL COMPARISON: HUMAN CARCINOGENIC TOXICITY

All TerraCycle models drive environmental savings compared to the municipal models. TerraCycle's Recycling Models have a >25% reduction in Human Carcinogenic Toxicity compared to Municipal Waste Management Models.

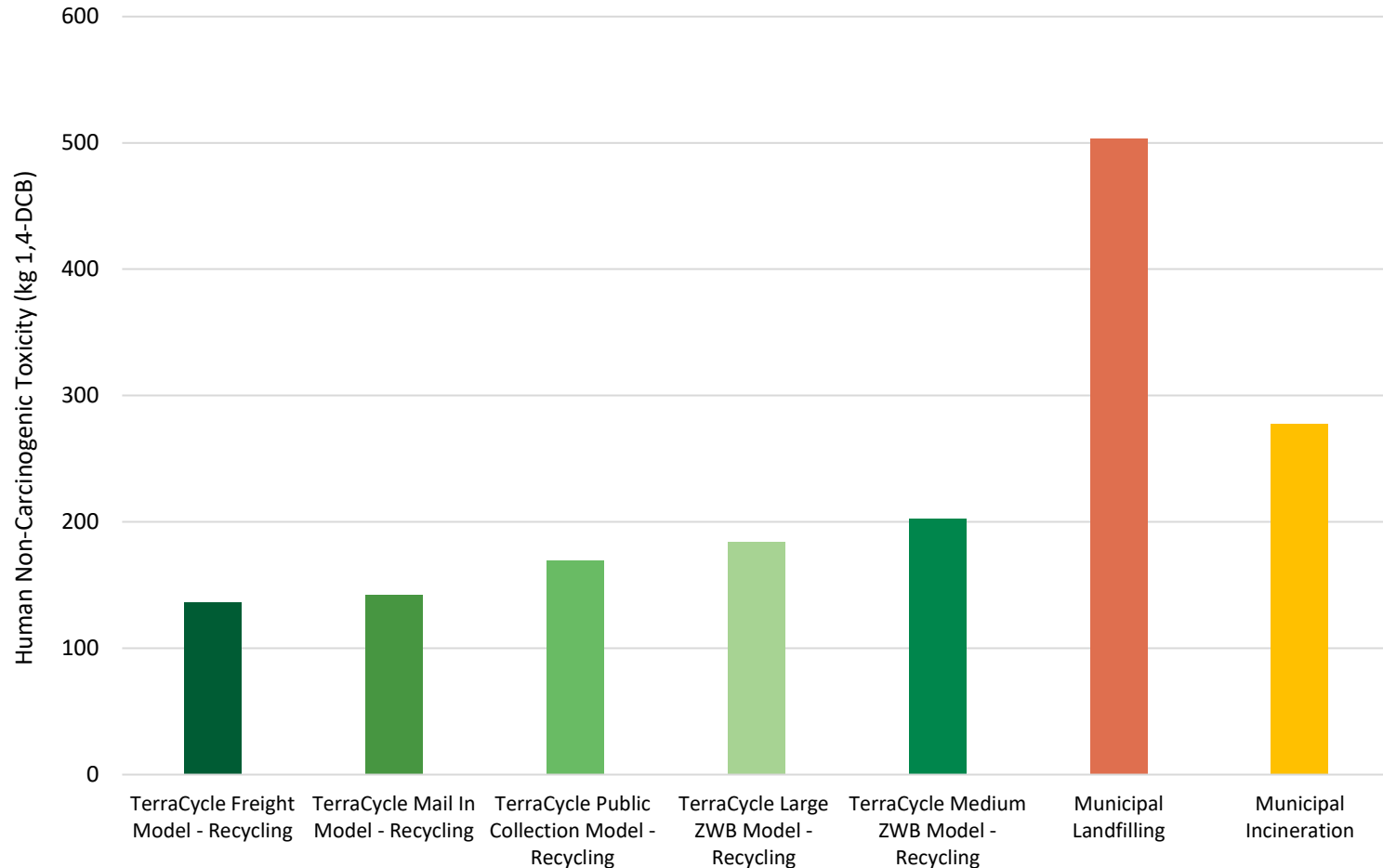


Human Carcinogenic Toxicity: This toxicity evaluation determines the distribution of a chemical in a model environment and accounts for several exposure routes, including inhalation, ingestion of produce, fish and meat, and dermal contact with water and soil. The toxic substances generated are compared with 1,4-dichlorobenzene (to urban air for human toxicity, to freshwater for freshwater ecotoxicity) as a reference. (i.e., kg 1,4-DCB equivalents).



MODEL COMPARISON: HUMAN NON-CARCINOGENIC TOXICITY

All TerraCycle models drive environmental savings compared to the municipal models. TerraCycle's Recycling Models have a >30% reduction in Human Non-Carcinogenic Toxicity compared to Municipal Waste Management Models.

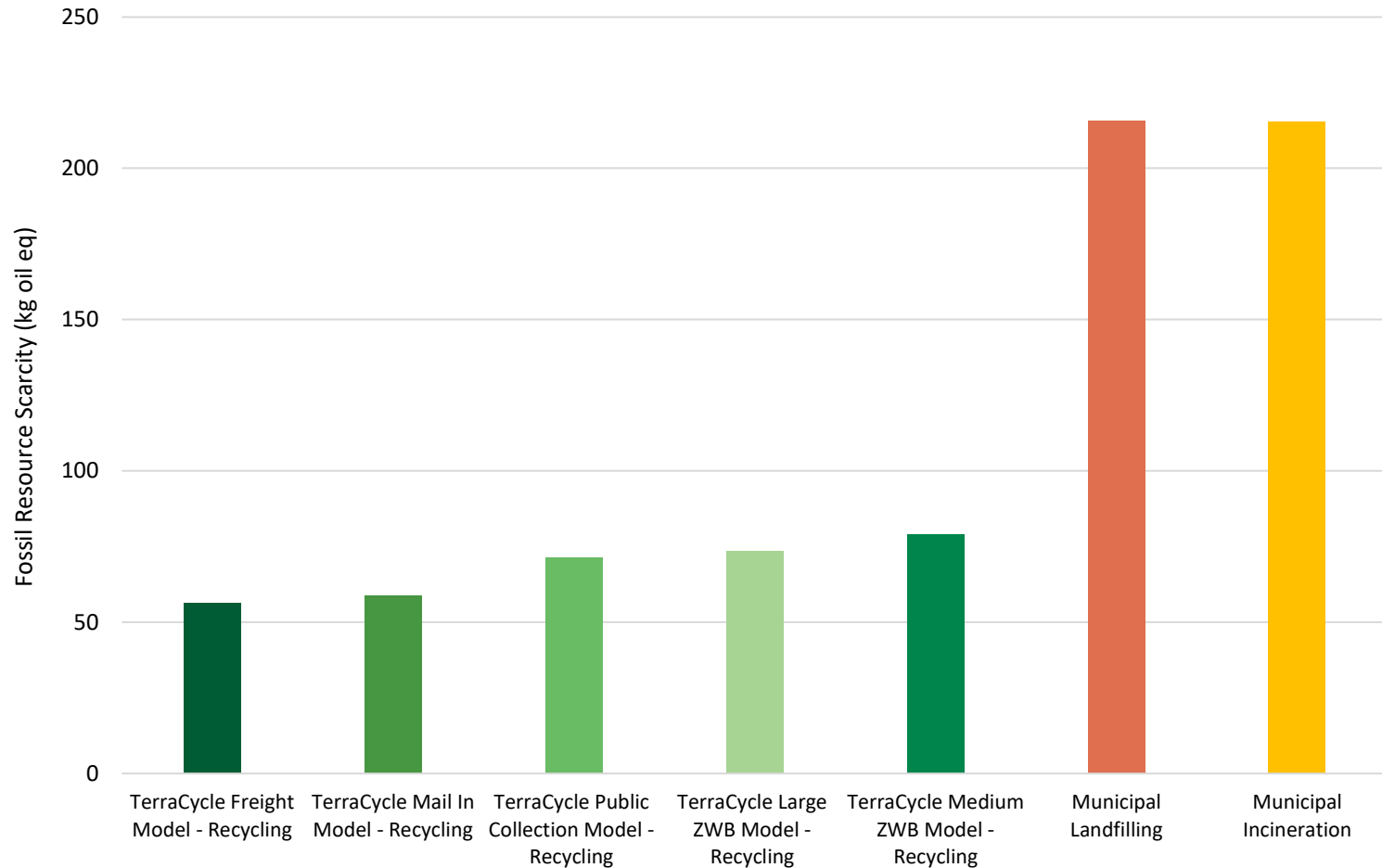


Human Non-Carcinogenic Toxicity: This toxicity evaluation determines the distribution of a chemical in a model environment and accounts for several exposure routes, including inhalation, ingestion of produce, fish and meat, and dermal contact with water and soil. The toxic substances generated are compared with 1,4-dichlorinebenzene (to urban air for human toxicity, to freshwater for freshwater ecotoxicity) as a reference. (i.e., kg 1,4-DCB equivalents).



MODEL COMPARISON: FOSSIL RESOURCE SCARCITY

All TerraCycle models drive environmental savings compared to the municipal models. TerraCycle's Recycling Models have a >60% reduction in 'Fossil Resource Scarcity' compared to Municipal Waste Management Models.

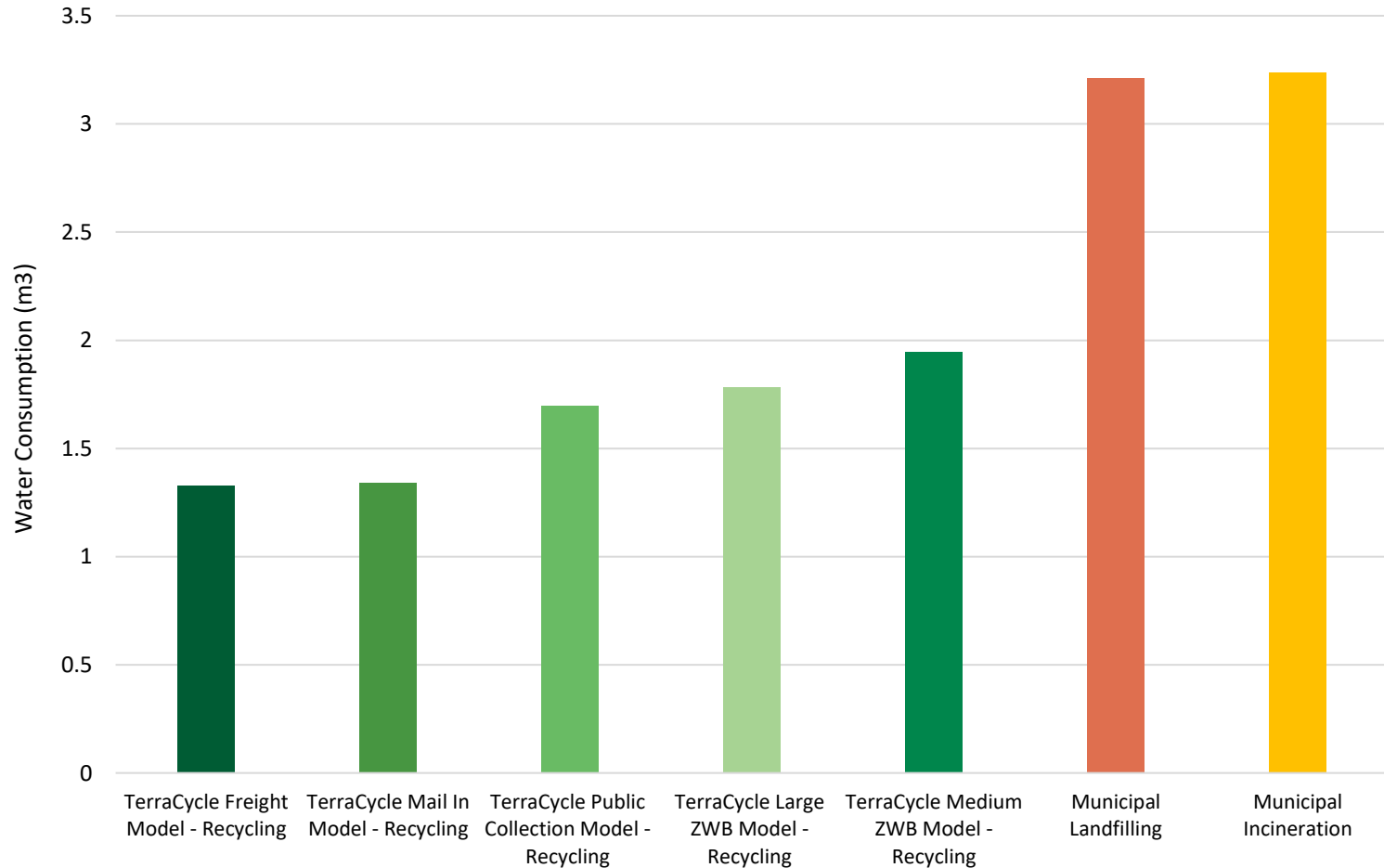


Fossil Resource Scarcity: Fossil Resource Scarcity roughly equates to the amount of fossil resources consumed during a process. It is measured in terms of Fossil Depletion Potential (FDP). This FDP is expressed in terms of kg of an oil-equivalent product. These are specific units to non-renewable energy sources like coal, oil, natural gas, and other fossil fuels.



MODEL COMPARISON: WATER CONSUMPTION

All TerraCycle models drive environmental savings compared to the municipal models. TerraCycle's Recycling Models have a >40% reduction in Water Consumption compared to Municipal Waste Management Models.



Water Consumption: Fresh Water is a scarce resource in many parts of the world, and as the global population grows, management of these limited waters will become more important. The water depletion simply expresses the total amount of fresh water that is used in a process.



Flexible Film Model Comparison

Characterized comparison of all models for all impacts

| Impact category | Unit | Freight Model | Mail In Model | Public Collection | ZWB - Large | ZWB - Medium | Municipal Incineration | Municipal Landfilling |
|---------------------------------|------------|---------------|---------------|-------------------|-------------|--------------|------------------------|-----------------------|
| Global Warming Potential | kg CO2 eq | 184.40 | 191.38 | 222.80 | 230.58 | 246.34 | 664.85 | 406.54 |
| Ozone formation, Human health | kg NOx eq | 0.38 | 0.39 | 0.46 | 0.48 | 0.52 | 0.94 | 0.91 |
| Freshwater eutrophication | kg P eq | 0.07 | 0.07 | 0.08 | 0.08 | 0.09 | 0.10 | 0.10 |
| Freshwater ecotoxicity | kg 1,4-DCB | 4.56 | 4.76 | 5.86 | 6.55 | 7.32 | 17.34 | 26.89 |
| Human carcinogenic toxicity | kg 1,4-DCB | 6.12 | 6.30 | 7.17 | 7.68 | 8.28 | 12.52 | 11.25 |
| Human non-carcinogenic toxicity | kg 1,4-DCB | 136.33 | 142.28 | 169.37 | 184.35 | 202.56 | 277.70 | 503.07 |
| Fossil resource scarcity | kg oil eq | 56.40 | 58.73 | 71.30 | 73.31 | 78.89 | 215.33 | 215.63 |
| Water consumption | m3 | 1.33 | 1.34 | 1.70 | 1.78 | 1.95 | 3.24 | 3.21 |

The impacts are quantified for each category based on characterization factors used by SimaPro. Results confirm that the TerraCycle models have lesser environmental impacts across all the categories. ReCiPe Midpoint was used as the methodology for this study.

Flexible Film Model Comparison

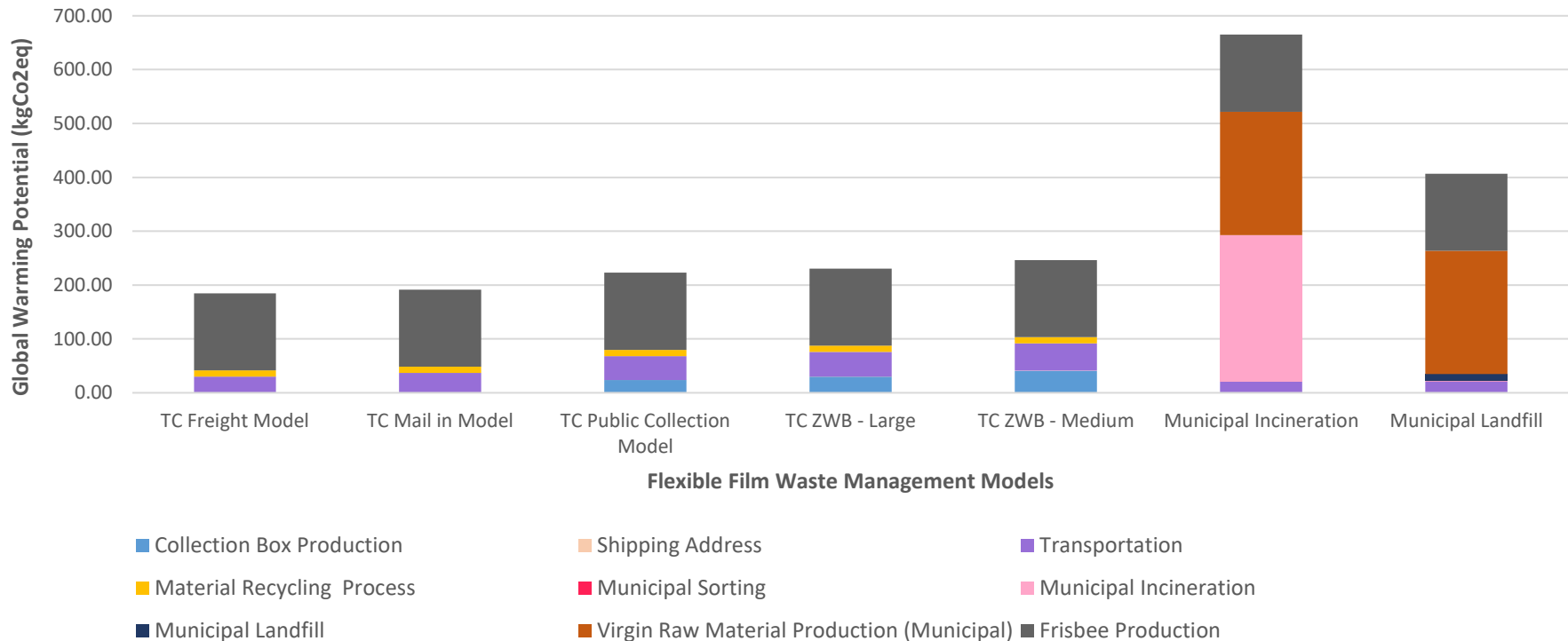
Global Warming Potential / Carbon Emissions Reduction in TC models compared to Municipal Models

| Impact category | Unit | Freight Model | Mail In Model | Public Collection | ZWB - Large | ZWB - Medium | Municipal Incineration | Municipal Landfilling |
|---|-----------|---------------|---------------|-------------------|-------------|--------------|------------------------|-----------------------|
| Global Warming Potential | kg CO2 eq | 184.40 | 191.38 | 222.80 | 230.58 | 246.34 | 664.85 | 406.54 |
| % Reduction from Municipal Incineration | | 72.26 | 71.21 | 66.49 | 65.32 | 62.95 | | |
| % Reduction from Municipal Landfill | | 54.64 | 52.92 | 45.20 | 43.28 | 39.41 | | |

The Global Warming Potential / Carbon Emissions for TC models is on average 68% less than the municipal incineration model, and about 47% less than the municipal landfill model.

Global Warming Potential Impacts

Comparing Global Warming Potential (GWP) for all models, based on processes involved

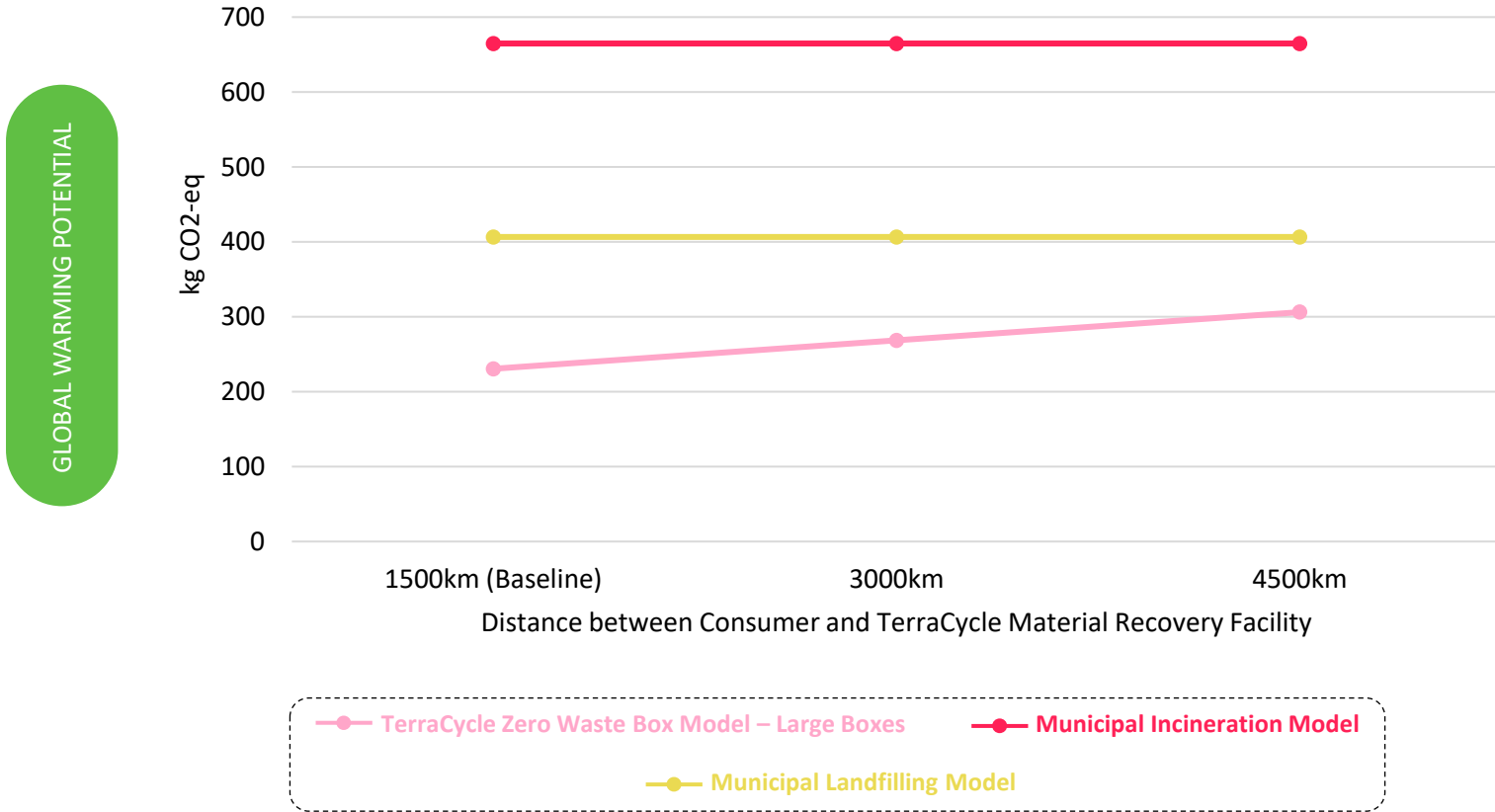


- Grey denoting the impact due to frisbee production process, is the same for any feedstock (virgin / recycled content) and so can be ignored for comparison.
- Pink denoting incineration has the highest GWP, due to the energy required for incineration and the resulting emissions.
- Orange denoting the production of virgin raw material (polypropylene) to make frisbees, has high GWP in the municipal models. This is due to the extraction & processing of fossil fuels for the polymer production.

Proved claim: The combined impacts of transportation (purple), collection box production (Blue) & recycling (yellow) in the TC models is much lesser than the impacts from virgin polymer production.

Sample Sensitivity Analysis

Distance between the Consumer to the TerraCycle Material Recovery Facility – TerraCycle Zero Waste Box Recycling Model (Large Boxes)



Due to a wide consumer base for TerraCycle’s ZWB program, the distance between the consumer to the MRF might vary. Hence a sensitivity analysis was conducted. This shows that the GWP impact increases slightly with increased transportation distance between consumer & MRF but is still significantly less than the municipal impacts.

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