N95 Mask

LCA Analysis & Comparison with Surgical Masks

Group -1

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Selected Product - 3M 9504 INV Mask

Objectives

The main objectives of the study are:

- To conduct a Life Cycle Assessment (LCA) of the **reusable 3M 9504 INV mask**
- To assess its environmental impact
- To compare its environmental impact with that of a **disposable 3-ply surgical mask**

Functional Unit

Functional Unit (FU) of the reusable 3M mask is:

FU = for a person, per 30 uses, where each use is for a maximum of 12 hours

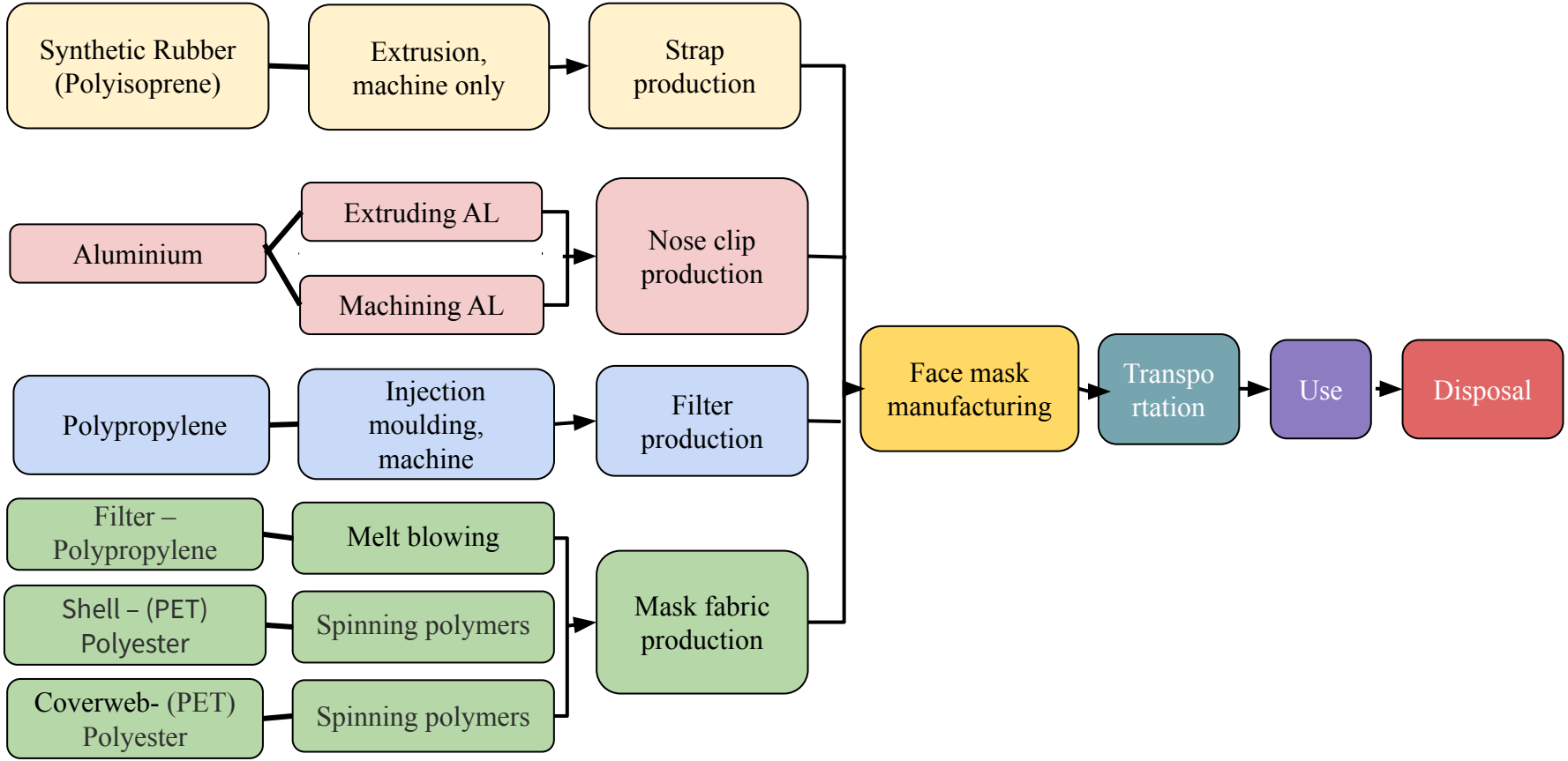
System Boundary - Cradle to Grave

The assessment data includes all phases from production (including material production and part production), transport, sterilisation to end-of-life of the life cycle of product 3M 9504 INV Mask.

- Each mask will be used by a person for a maximum of 12 hours for 30 days and disposed.
- Usage of mask is being considered in case of the Indian population.
- The 3M 9504 INV mask is considered to be manufactured by 3M India (Pune facility) and approved by BIS.
- The 3M Standard 3-Ply Mask with Earloop is considered to be manufactured by 3M India (Pune facility)
- Mask is being used for solid particulates and liquid mists environment in concentrations not exceeding 10x PEL/OEL.
- LCA is conducted with help of idematLightLCA software.

Note: In general, the N95 mask is exclusively used for pollution protection and the surgical mask for medical purpose. But recently, both the masks are being interchangeably used for protection against COVID-19 disease. Hence, the LCA is conducted considering the COVID-19 pandemic situation.

BIS = Bureau of Indian Standards *PEL = Permissible Exposure Limit* *OEL = Occupational Exposure Limit*



Our System Boundary for LCA of 3M 9504 INV Mask

Materials

NOSE CLIP
Aluminium (0.5g)

FILTER
Polypropylene
(2g)

STRAP
Polyisoprene(0.5g)

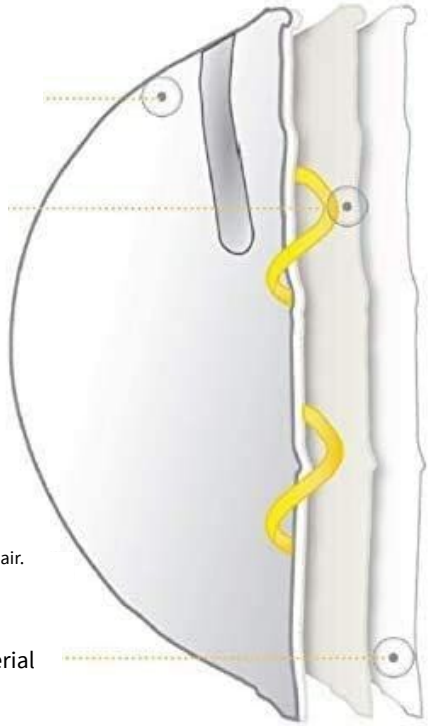
MASK
- Filter – Polypropylene (4g)
- Shell – Polyester (2.5g)
- Coverweb – Polyester (2.5g)

Outside layer
Non-woven, synthetic polyester material

Middle layer
Polypropylene meltblown fiber filter material
(this layer does all the filtration)

Meltdown material magnified 100 times.
Each fibre is typically 1/100th the width of a human hair.

Inside layer
Non-woven, synthetic polyester material

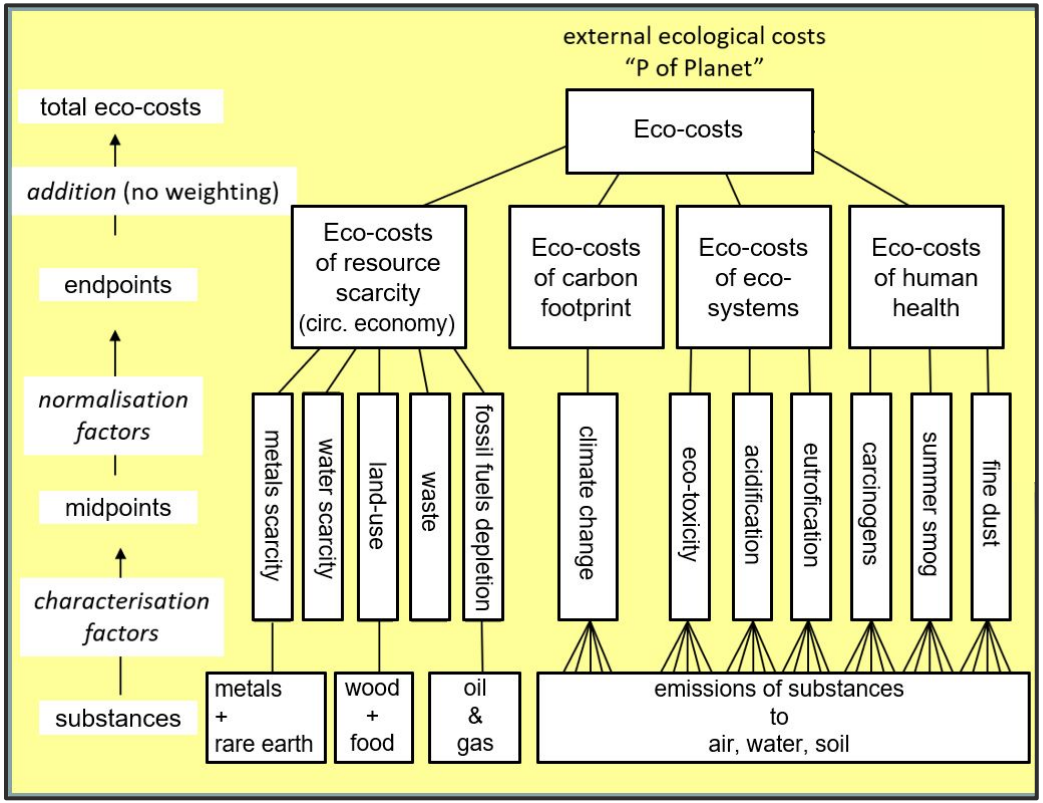


Production Processes

Production processes considered are as follows:

- For Aluminium - Extruding and machining to form aluminium strips
- For the Polypropylene filter - Injection moulding using machine
- For Polyisoprene rubber strap - Extruding and machining
- For mask's middle layer made of Polypropylene - Melt blowing
- For the other two Polyester layers of the mask - Spinning for polymers

Selected Indicators

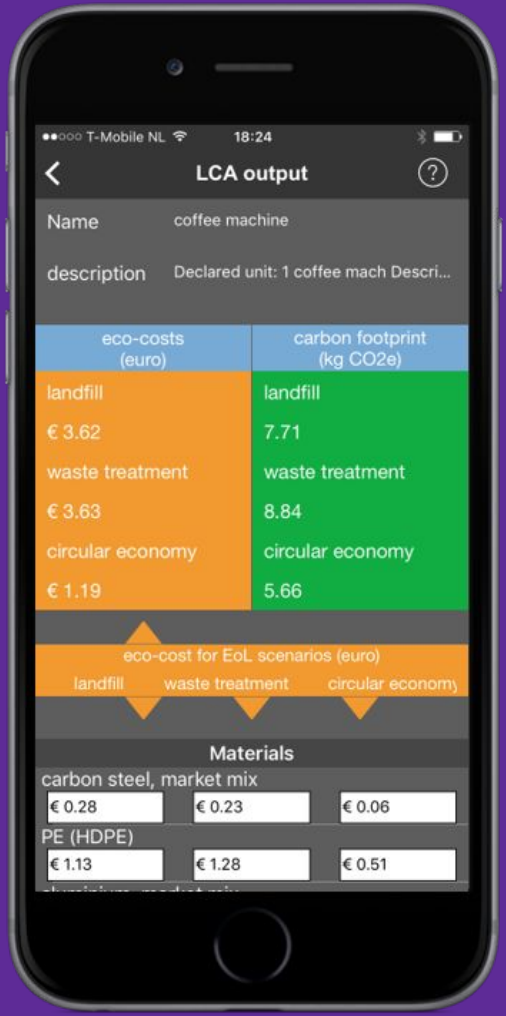


The analysis of all emissions of a life cycle results in a long list of toxic substances. These are the various 'single indicators' for LCA. Such a long list of emissions does not make sense, so the list has to be 'compressed' to 1 'single indicator'. Eco-costs is such an indicator.

In our LCA, we have accounted for the following eco-costs:

1. Resource depletion
2. Eco-toxicity
3. Human Health
4. Carbon Footprint

Calculating using IdematLightLCA App



Calculation

Component	Material	Process	Amount (g)	Eco-costs (per kg)	Eco-costs (€)	Carbon footprint (per kg)	Carbon footprint (kg)
	Aluminium, virgin			2.720	0.0014	7.270	0.0036
		Extruding AL		0.130	0.0001	0.676	0.0003
Nose clip		Machining AL	0.5	0.014	0.0000	0.067	0.0000
	Polypropylene (PP)			1.190	0.0024	1.630	0.0033
Filter		Injection moulding, machine	2	0.081	0.0002	0.382	0.0008
	Polyisoprene rubber			1.730	0.0009	5.960	0.0030
Strap		Extrusion, machine only	0.5	0.022	0.0000	0.103	0.0001
	Polypropylene (PP)			1.190	0.0048	1.630	0.0065
Mask Filter		Melt blowing*	4	0.087	0.0003	0.410	0.0016
	(PET) Polyester			1.070	0.0027	2.120	0.0053
Mask Shell		Spinning polymers	2.5	0.087	0.0002	0.410	0.0010
	(PET) Polyester			1.070	0.0027	2.120	0.0053
Mask Coverweb		Spinning polymers	2.5	0.087	0.0002	0.410	0.0010
					0.0157		**0.0319**

** process considered were same as 'spinning polymers' due to lack of the specific option in the IdematLightLCA App*

Assumption

- **Transportation costs** for the 3M 9504 INV mask and the Surgical masks can be considered to be the same, hence we neglect that from the comparison.
- **Sterilization costs** for sanitizing the 3M 9504 INV mask after every use can be neglected.

  Hence, we are taking into account the end-of-life eco-costs only.

€ 0.0157

or ₹1.37

0.0319 kg

Eco-costs

Eco-costs are a measure to express the amount of costs which will be used to deploy processes that reduce the environmental pollution and materials depletion in our world to a level which is in line with the carrying capacity of our earth.

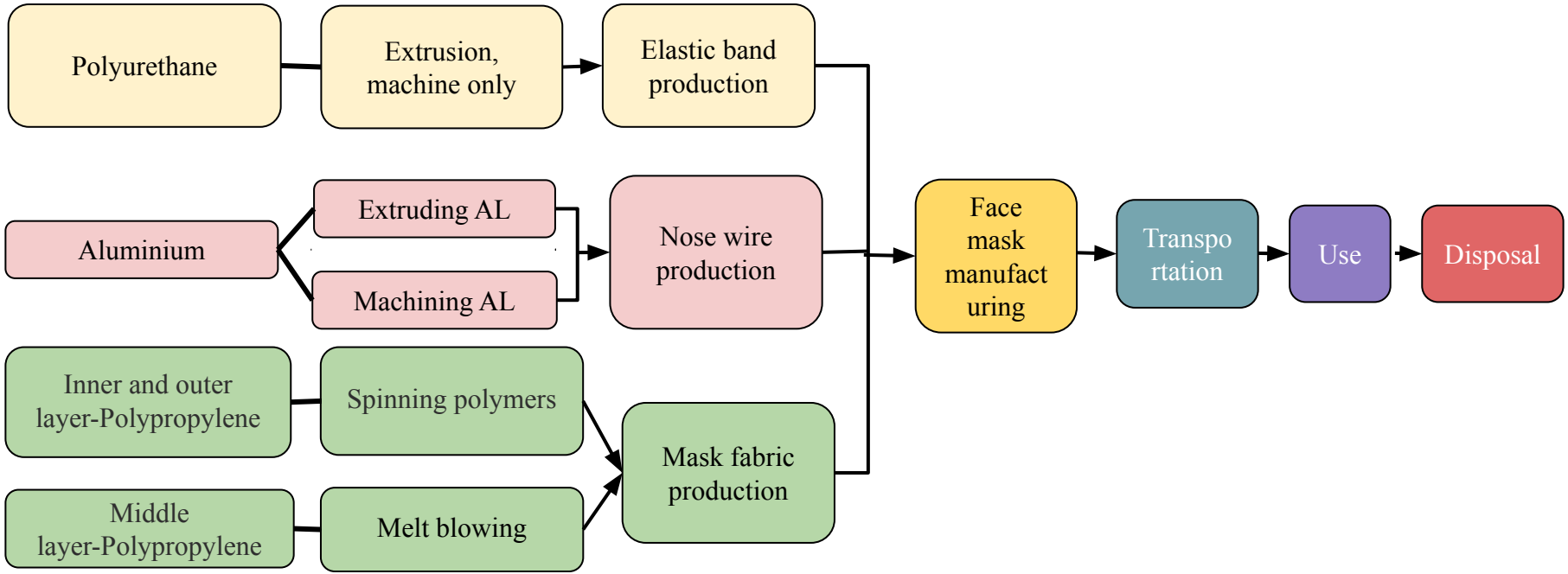
Carbon Footprint

A carbon footprint is the total amount of greenhouse gases (including carbon dioxide and methane) that are generated by our actions.

for one 3M 9504 INV Mask

Comparing it with Surgical Masks

3-Ply Surgical Mask



Our System Boundary for LCA of surgical mask

Materials

NOSE WIRE
Aluminium (0.18g)

STRAP
Polyurethane (0.25g)

MASK
- Inner layer – Polypropylene (0.82g)
- Middle layer – Polypropylene (0.82g)
- Outer layer – Polypropylene (0.82g)

Production Processes

Production processes considered are as follows:

- For Aluminium - Extruding and machining to form aluminium wires
- For Polyurethane rubber strap - Extruding and machining
- For mask's middle layer made of Polypropylene - Melt blowing
- For the other two Polypropylene layers of the mask - Spinning for polymers

Calculation

Component	Material	Process	Amount (g)	Eco-costs (per kg)	Eco-costs (€)	Carbon footprint (per kg)	Carbon footprint (kg)
	Aluminium, virgin			2.720	0.0005	7.270	0.0013
		Extruding AL		0.130	0.0000	0.676	0.0001
Nose wire		Machining AL	0.18	0.014	0.0000	0.067	0.0000
	Polyurethane, flexfoam MDI			1.170	0.0003	3.560	0.0009
Elastic bands		Extrusion, machine only	0.25	0.022	0.0000	0.103	0.0000
	Polypropylene (PP)		2.45	1.190	0.0029	1.630	0.0040
		Spinning polymers	1.63	0.154	0.0003	0.728	0.0012
Mask		Melt blowing*	0.82	0.087	0.0001	0.410	0.0003
					0.0041		**0.0079**

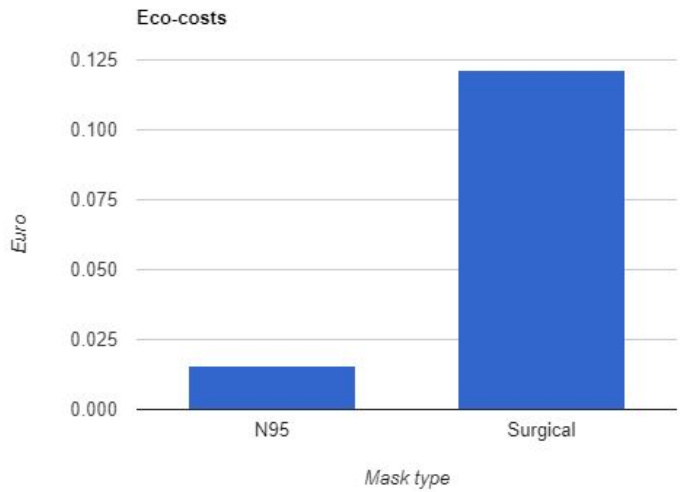
To compare it with 30 uses of the N95 mask, the above eco-cost and carbon footprint values will be multiplied with 30:

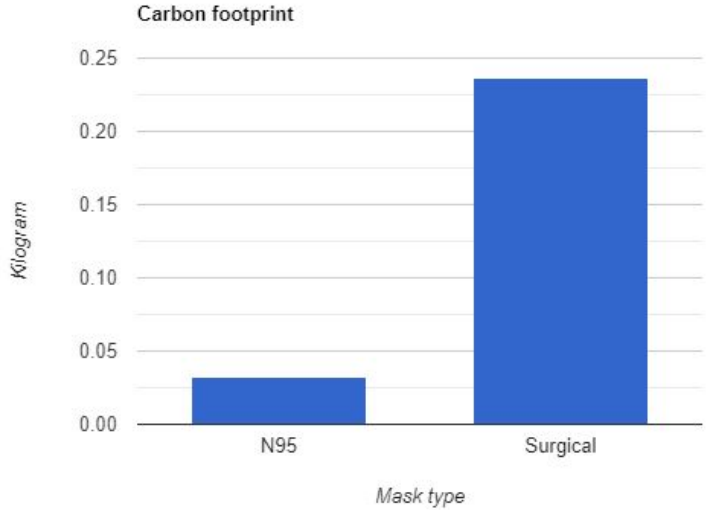
Net Eco-costs = 0.0041*30 = <u>€ 0.1215</u>

Net Carbon Footprint = 0.0079*30 = <u>0.2362 kg</u>

** process considered were same as 'spinning polymers' due to lack of the specific option in the IdematLightLCA App*

Results





The environmental impact of the N95 mask is less than that of Surgical masks.

References

1. https://ecochain.com/knowledge/footprint-face-masks-comparison/
2. https://5.imimg.com/data5/YF/TQ/OM/ANDROID-57261798/product-jpeg-500x500.jpg
3. https://www.thehindu.com/business/3m-india-steps-up-production-of-respirators-surgical-masks-sanitisers/article31274127.ece
4. Aluminium quality - https://issuu.com/dollygao/docs/aluminum_strip_for_face_masks, https://www.azom.com/article.aspx?ArticleID=6587#:~:text=Aluminium%20%2F%20Aluminum%201060%20alloy%20is,with%20good%20corrosion%20resistance%20characteristic.
5. https://www.ecocostsvalue.com/eco-costs/
6. https://www.mdpi.com/2071-1050/12/24/10245/htm