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LIFE CYCLE ASSESSMENT OF PPE KIT USING OPEN -LCA SOFTWARE

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Abstract - *Due to COVID-19, the demand for Personal Protective Equipment (PPE) kits has increased rapidly. The accumulation of used PPE kits on earth pose a threat to environment and human health. This paper analyses the environmental impact caused by most common PPE items such as face shield, gloves, single use gown, and surgical mask. Here, Life Cycle Assessment of PPE kit has been performed using open LCA software. The results of LCA shows that the single use surgical gown causes the most environmental impact when compared to the other three PPE items. This study also identifies the remedial measures to reduce the impacts caused by the use of PPE kit.*

Key Words: ELCD 3.2 Green delta, LCI, LCIA, Open LCA 1.11.

1. INTRODUCTION

Coronavirus disease also known as COVID-19 is an infectious disease caused by the SARS-CoV-2 virus. It spreads very rapidly among humans by personal contact or by contact with air–water droplets during coughing and sneezing of coronavirus affected person. The COVID-19 pandemic resulted in the loss of human life worldwide and placed the public health under stress. This lead to the rapid increase in the use of Personal Protective Equipment (PPE)kit . Since it is one of the effective measure to reduce the spreading level of coronavirus. The resultant surge in the need for PPE has demanded an increase in PPE production. This resulted in the uncontrolled accumulation of PPE wastes and it becomes a challenge to the waste management system.

The daily disposal of these PPE items from hospitals generates serious waste issues in world especially in developing countries. To protect people from COVID-19 there is a huge need for PPE kit. In order to meet the global need, the production of PPE Kit has expanded. The production, use and disposal of these items cause serious environmental impacts. Proper disposal is needed. Otherwise, the waste management will become more complicated.

In this paper we conducted Life Cycle Assessment of PPE kits in order to identify the potential environmental impacts caused by items such as face shield, gloves, single use gown and surgical mask. The selected environmental impact categories are (a) acidification; (b)Global Warming Potential; (C) Human toxicity; (d) Ozone layer depletion. In addition, this study finds the raw materials required for the production of PPE Kit items and the issues occurring during the disposal. This shows that the introduction of PPE kit to save the life of people from COVID-19 boost the environmental problems. In order to reduce these impacts, we need to establish some sustainable approach.

2. MATERIALS AND METHODS

2.1 Data collection

The data collection strategy for this study was mainly concentrated on the most relevant journal publications related to the COVID-19 outbreak. Furthermore, data and information required for the study are collected from online resources, journals, policy and media reports, and the notifications from Government. The data from these sources have high quality and provides vital information. The collected literatures are from the starting of COVID-19 until the completion of this study. Information regarding the raw materials needed for the production of PPE Kit items, and environmental issues associated with the transportation and disposal of these items are gathered from literature review.

2.2 Methodology

We conducted LCA method as defined in ISO standards in four distinct phases using Open-LCA 1.11.0 software. Main features: Fast and reliable evaluation of sustainability and Life Cycle Assessment.

Certain assumptions made are:

1.Location chosen as Kerala

2.Transportation assumed to be in small lorry by road

3.Distance of transportation to be 210km- Trivandrum to Kochi. Since Trivandrum is capital city of Kerala & Kochi is trade centre.

4.Weight of components for one unit of PPE Kit is considered for input

5.Incineration is taken as end of life based on survey results obtained from hospitals.

Four steps of LCA :

Goal and scope definition

This is the initial and the most important phase of study

It includes

- the expected application
- uses of results
- And to whom results are reported.

The functional unit is a measure of the function of the system to be studied, for relating inputs and outputs these will act as reference. This can be used for the comparison of two different systems.

Life cycle inventory (LCI)

- In this stage, we look into the order of steps in life cycle of product system.it begins with extraction of raw materials with the final disposal. created a flow diagram which shows the major inputs and outputs to the system.
- The database used here is ELCD 3.2greendelta-v2-18
- It involves the data collection and calculation to quantify material and energy inputs and outputs of PPE kit.

Life cycle impact assessment (LCIA)

- Acidification, global warming potential, human toxicity and ozone layer depletion are the selected potential parameters.
- In LCIA, it combines databases from open-LCA nexus in more efficient way
- CML IA baseline is the selected LCIA method

Interpretation

From the results the major issues are identified. The results are based on major environmental problems such as ozone layer depletion, human toxicity and some other parameters.

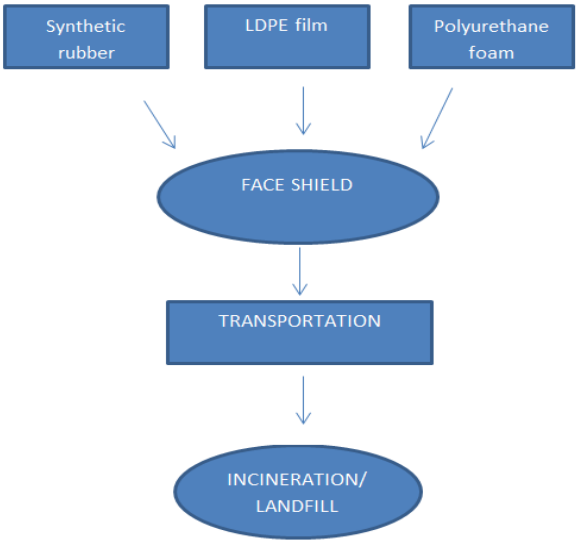


Fig1.system boundaries-Face shield

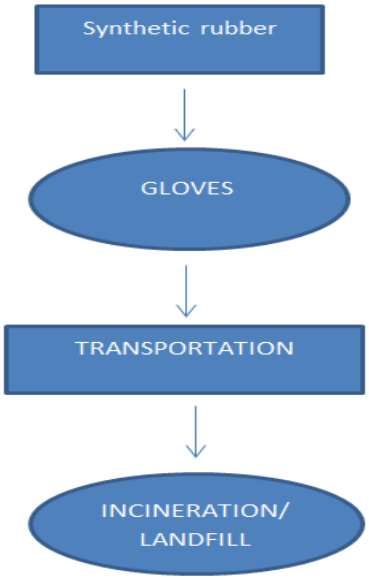


Fig2. System boundaries-gloves

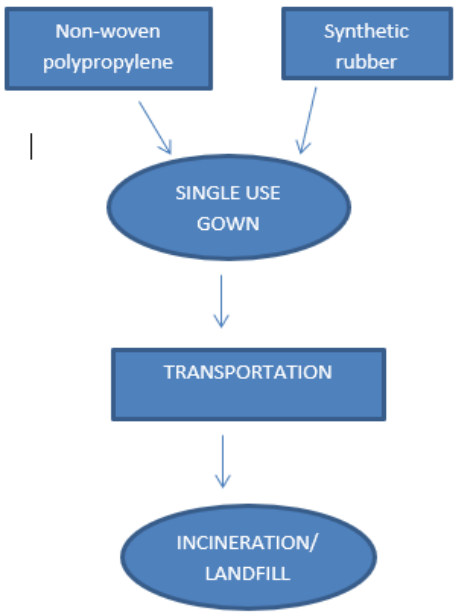


Fig3. System boundaries- single use gown

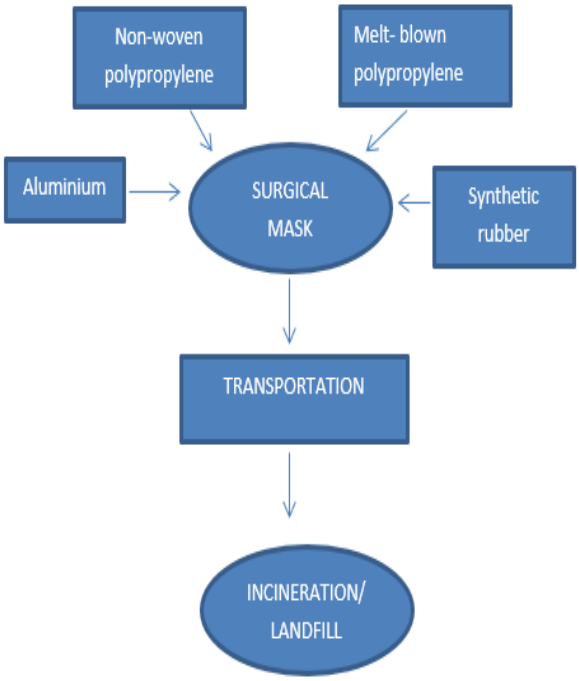


Fig4. System boundaries-surgical mask

Fig1,2,3and4 indicates system boundaries of face shield,gloves,single use gownand surgical mask.

Face shield -Production

INPUT	OUTPUT
LDPE film(0.01853kg), Polyurethane foam(0.00544kg), Synthetic rubber(0.00495kg)	Granulates(LDPE film,PUfoam,SR)(0.02892kg)

Face shield -Transport

INPUT	OUTPUT
Granulates(LDPE film,PUfoam,SR)(0.02892kg)	Granulates(LDPE film,PUfoam,SR)(0.02892kg), transported
Transport in t*KM	

Face shield – End of life

INPUT	OUTPUT
Granulates(LDPE film,PUfoam,SR)(0.02892kg), transported	Landfill/Incerination
Landfill/Incerination	

Fig 5.System flow diagram – Face shield

Gloves -Production

INPUT	OUTPUT
Synthetic rubber(0.00323kg)	Granulates(SR)(0.00323kg)

Gloves -Transport

INPUT	OUTPUT
Granulates(SR)(0.00323kg)	Granulates(SR)(0.00323kg),transported
Transport in t*KM	

Gloves – End of life

INPUT	OUTPUT
Granulates(SR)(0.00323kg),transported	Landfill/Incerination
Landfill/Incerination	

Fig6.System flow diagram - Gloves

Single use gown -Production

INPUT	OUTPUT
Non-woven polypropylene(0.13474kg), Synthetic rubber(0.00772kg)	Granulates(NWPP,SR)(0.14246kg)

Single use gown -Transport

INPUT	OUTPUT
Granulates(NWPP,SR)(0.14246kg)	Granulates(NWPP,SR)(0.14246kg),transported
Transport in t*KM	

Single use gown – End of life

INPUT	OUTPUT
Granulates(NWPP,SR)(0.14246kg),transported	Landfill/Incerination
Landfill/Incerination	

Fig 7.System flow diagram – Single use gown

Surgical mask -Production

INPUT	OUTPUT
Non-woven polypropylene(0.001kg), Melt-blown polypropylene(0.0005kg), Synthetic rubber(0.00028kg), Aluminium(0.00023kg)	Granulates(NWPP,MBPP,SR,AL)(0.00201kg)

Surgical mask -Transport

INPUT	OUTPUT
Granulates(NWPP,MBPP,SR,AL)(0.00201kg)	Granulates(NWPP,MBPP,SR,AL)(0.00201kg), transported
Transport in t*KM	

Surgical mask – End of life

INPUT	OUTPUT
Granulates(NWPP,MBPP,SR,AL)(0.00201kg),transported	Landfill/Incerination
Landfill/Incerination	

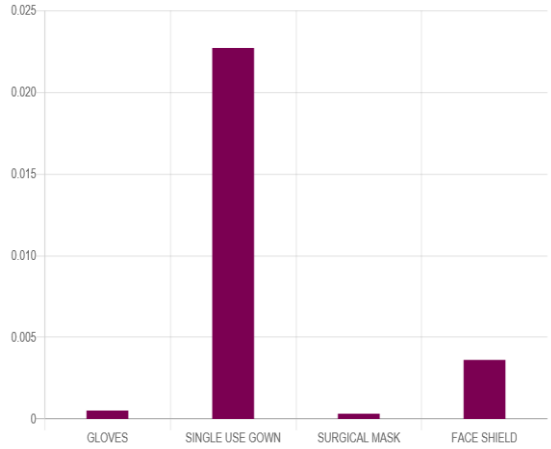
Fig 8.System flow diagram – Surgical mask

Fig5,6,7 and 8 refers system flow diagrams which indicate the impact values taken in the software phase.However, the input values are taken by considering raw material for the production of a single PPE kit.

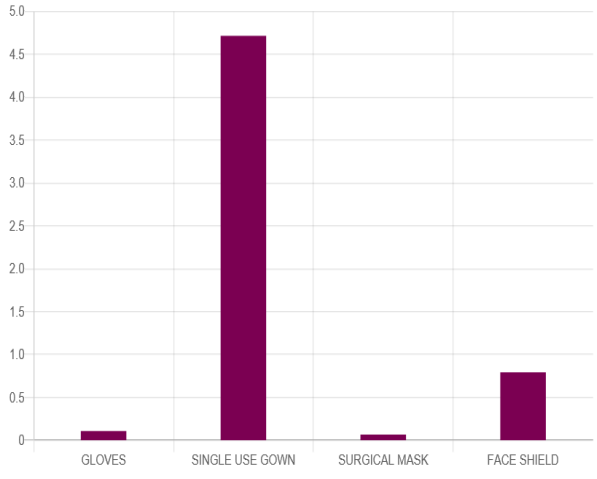
Table-1.Final Results

Indicator	GLOVES	SINGLE USE GOWN	SURGICAL MASK	FACE SHIELD	Unit
Acidification	5.14861e-4	2.27178e-2	3.20394e-4	3.61463e-3	kg SO2 eq
Global warming (GWP100a)	1.06581e-1	4.71621e+0	6.63262e-2	7.91423e-1	kg CO2 eq
Human toxicity	4.82817e-3	2.11305e-1	3.00435e-3	2.76213e-2	kg 1,4-DB eq
Ozone layer depletion (ODP)	1.37373e-9	6.05886e-8	8.54859e-10	1.58949e-9	kg CFC-11 eq

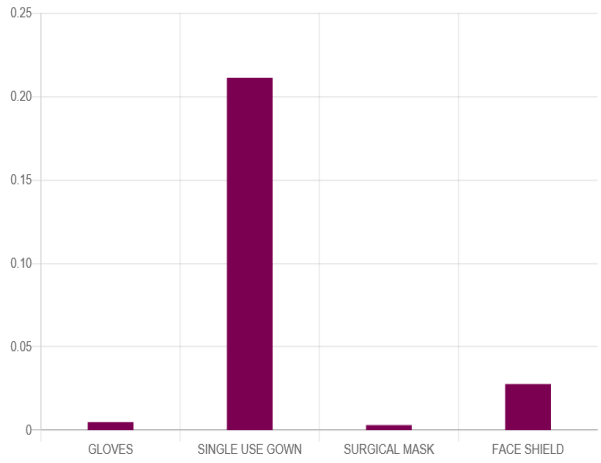
3.RESULTS AND RECOMMENDATIONS



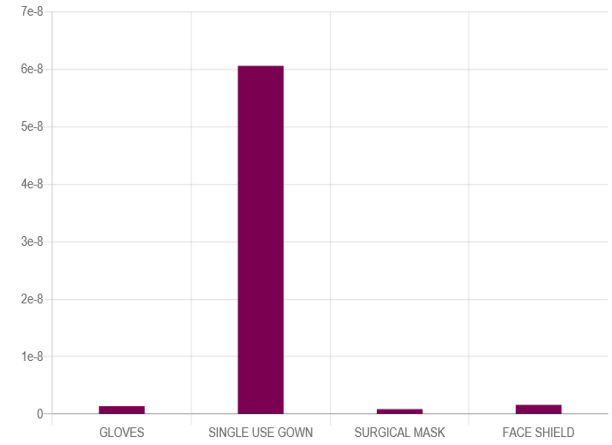
(a)acidification



(b)global warming potential

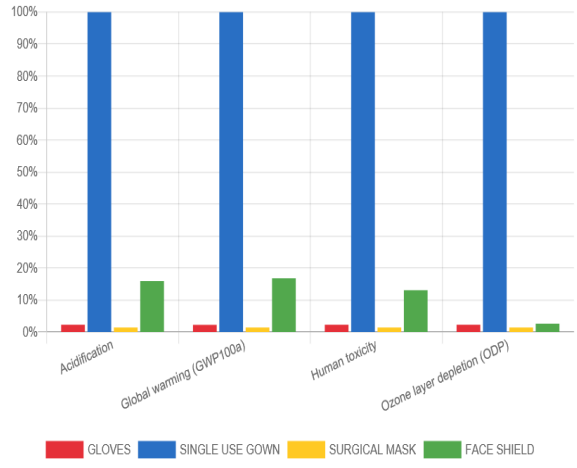


(c)human toxicity



(d)ozone layer depletion

4. CONCLUSIONS



The war against COVID-19 with countries implementing various measures to ensure reduced fatalities and morbidity from this novel coronavirus SARS-CoV-2 is still continuing. With these, the use of PPE kits have increased rapidly, especially by medical practitioners, as a means of protection from this novel coronavirus. While the use is absolutely essential, it is clear that disposal of these PPEs might become a problem in the future. We cannot avoid the use of PPE kit but can search for alternatives or proper disposal methods by knowing its environmental impact, how much impact does it cost ?. There are various components for PPE kit, here in this analysis we have selected the most common components such as single use gown, surgical mask, face shield, gloves. From our life cycle analysis using OPEN LCA software it is clear that Single use gown contribute high impact in the environment than the other components we selected. The single use gown have higher impact for the indicators such as acidification, ozone layer depletion, human toxicity, global warming. Face shield contributes second highest impact. Gloves and Surgical mask have minimal impact comparing to other. There are variations in environmental impact of various components of PPE kit, based on this variations specific disposal methods can use according to their environmental impact.

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