LIFE CYCLE ASSESSMENT OF COTTON Vs SURGICAL FACE MASK USING OPEN-LCA SOFTWARE

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Abstract –*The World is under COVID 19 pandemic. One measure being considered by many countries is the mandatory wearing of face masks by the general population so that reducing the spread of the virus to enable the restart the freedom of movement and the economy. However, environmental and health impacts of using face masks attracted attention worldwide. This paper has compared environmental impacts of disposable and reusable mask during their life cycles by using Open LCA Software. The results of our simplified LCA revealed that the cotton masks were performing better than the surgical masks. This paper also aims to identify the relevant ecological factors in order to support decision making on how textile masks could be designed in a more sustainable manner.*

Key Words: **Cotton vs surgical mask, ELCD 3.2, LCI, LCIA, Open LCA 1.10.3.**

1. INTRODUCTION

The COVID-19 pandemic, also known as the corona virus disease pandemic, is an ongoing global pandemic caused by severe acute respiratory syndrome coronavirus 2 (ie; SARS-CoV-2). Infection with SARS-CoV-2 is most predominately transmitted through respiratory droplets generated. Masks were currently employed to reduce this spreading level of coronavirus and save lives. The experts are now suggesting people wear double masks to prevent chances of infection of COVID-19. As per studies, double masking could decrease the infection chances and cut severity rates by as much as 85-95%.

COVID-19 creates extra challenges in waste management in developing countries. With the growing global demand for face masks, the issue of their environmental sustainability arises. The increasing use of masks considerably increases mask production, and it consumes the greatest amount of energy. The inappropriate handling of healthcare waste may cause serious public health consequences and a significant impact on the environment. The effective management of coronavirus infectious waste has been identified as a key area of concern by regulatory agencies in India, with the release of waste handling–treatment–disposal guidelines generated during treatment–diagnosis–quarantine of COVID-19 patients.

To identify relevant ecological factors to support decision-making on how textile masks could be designed more sustainably, we conducted a simplified Life Cycle Assessment (LCA) comparing surgical masks and 2-layered cotton masks. Furthermore, a comprehensive review was conducted to find the material contents in the mask, impact on the mask wastes and suggest a sustainable upcycling solution to the mask waste. This indicates that the current ongoing pandemic increases environmental pollution and harms human and animal health. Therefore, some sustainable solutions need to reduce the environmental impacts.

2. MATERIALS AND METHODS

2.1 Data collection

i. Literature review

The data collection approach of this study was focused on the review of the most relevant journal articles related to rapidly growing COVID-19. The data and knowledge on this particular topic are collected not only from scientific literature, but also from numerous reliable online resources, journals, and policy and media reports as they provide high coverage of similar papers to the subject of this review and minimize the risk of missing any important document. The literature was gathered from 17th July 2020 (at the peak of the first wave of COVID-19 pandemic) until the completion of this review. The data collection process concentrated on a following categories of: (a) precautionary measures that we used to monitor the forms of COVID-19; (b) the components of the cotton and surgical mask; (c) problems relating to the disposal of these masks; (d) and sustainable solutions to address the effect of waste mask.

ii. Online survey

The data is collected confidentially by conducting an online survey among different families in various districts in Kerala. This survey was performed on a total of 138 families for a period of one month (12 April 2021 – 12th May 2021) at COVID-19 pandemic. In this survey, the questions were focusing following parameters: the types of masks; the number of masks used per week; and methods of mask disposal. The aim of survey is to identify the mask waste generation and provide the fundamental information and awareness about the effect of the mask waste to the environment. However, finding of this study help to develop the waste management policies as well as choosing proper impact categories involved during LCA analysis using software.

iii. Survey results

The data obtained from the online survey were clearly analysed. Highest population (i.e., 73.2%) of people are used cloth mask for their personal safety. While, the surgical mask is the second highest for use (37%) as it's cheaper than N95 mask and also be self-made. The results from this survey illustrates that the fundamental quantification value of mask waste. The survey results shows that more than 25% of people out of 100% generates 5 masks waste per week. Consequently, at least one surgical or cotton mask waste was created by an individual per day. This survey results indicates that this COVID-19 pandemic will impact not only the health and economy, but it will also affect the sustainability of environment.

In order to identify the mask disposal method, the survey question was generated with six general disposal methods: 1) incineration/open burning 2) thrown away 3) Flush in toilet 4) others. Results shows that most of individuals dispose the mask by open burning/incineration. This has the potential to create harmful effects and the environmental issues to the nature. Consequently, it has high chances of creating a future global warming issue. About 26% of people simply dump the masks and are responsible for the contamination of the air, ground water etc. The mask production will be a significant or important process and increase the mask waste in upcoming years. The mask is made of variety types of plastic, which is not decomposable, and it induce the negative impacts on the environments. Essential steps should be taken to replace some decomposable raw material in production of the surgical and cotton face masks. And to recycle the used waste mask by different methodologies and it can be used as a supplementary material in any innovative products such as construction materials.

2.2 Methodology

We conducted LCA method as defined in ISO standards in four distinct phases using Open-LCA 1.10.3 software. Open-LCA is an open source and free software for Sustainability and Life Cycle Assessment, with the following features: Fast and reliable calculation of sustainability Assessment and Life Cycle Assessment.

The four steps of the LCA are:

- ISO 14040 Environmental management, LCA, Principles and framework.
- ISO 14041 Environmental management, LCA, Goal definition and inventory analysis.
- ISO 14042 Environmental management, LCA, Life-cycle impact assessment.
- ISO 14043 Environmental management, LCA, Life-cycle interpretation.

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 220km- Trivandrum to Kochi. Since Trivandrum is capital city of Kerala & Kochi is trade centre.
4.Weight of components for one mask is considered for input
5.Incineration is taken as end of life based on survey results

Four steps of LCA in detail:

Goal and Scope Definition: Aims to describe intentional aim of the study and explain the reason for executing the study: what is the intended application, how to use results and to whom results to be reported. The scope of the study will be defined to ensure details of the study are compatible and sufficient to address the stated goal. The functional unit is a measure of the function of the system being studied, and it act as a reference for relating the inputs and outputs. This enables comparison of two different systems under consideration.

Life Cycle Inventory (LCI): In this phase we examined the sequence of steps in the life cycle boundaries of the product system, beginning with raw material extraction to final disposition. Developed a flow diagram which is aimed to give a clear picture of the essential inputs and outputs to the process or system. ELCD 3.2 greendelta-18 database is used to cover the unavailable processes and materials. The ELCD provides core Life Cycle Inventory (LCI) data.
The inventory analysis involves data collection and calculations to quantify material and energy inputs and outputs of the facemask cases. Identification and quantification of material and energy flows (inputs and

outputs) of the facemasks are completed using ELCD 3.2 greendelta-18. A complete list of materials is compiled based on the outcome from the modelling program. Life cycle phases considered are material production, transportation and end of life.

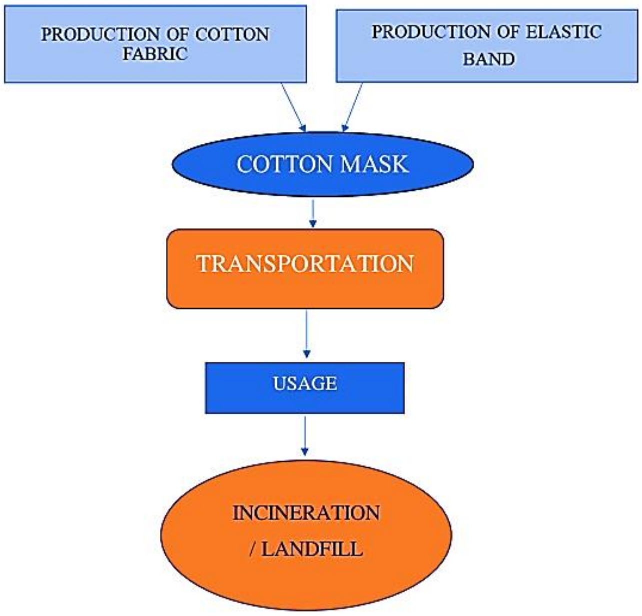


Fig 1. System boundaries – Cotton mask

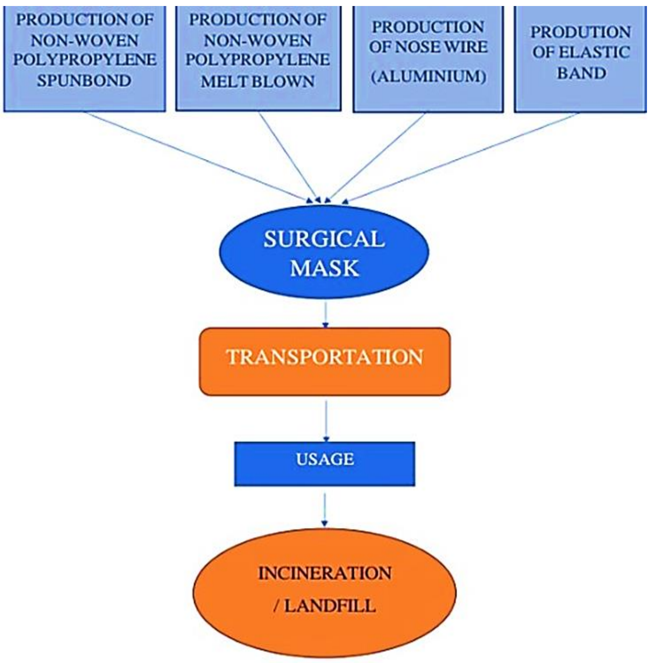


Fig 2. System boundaries – Surgical mask

Fig 1 and Fig 2 indicates system boundaries of cotton and surgical mask set during the entire life cycle assessment procedure. Fig 3 and Fig 4 refers system flow diagrams which indicate the input values taken in the software phase. However, the input values are taken by considering raw material for the production of only a single face mask.

COTTON MASK GRANULATE PRODUCTION

INPUT	OUTPUT
Cotton (11.5g), Polyurethane(0.25g)	Granulates(Cotton (11.5g), Polyurethane(0.25g))

COTTON MASK TRANSPORT A

INPUT	OUTPUT
Granulates(Cotton (11.5g), Polyurethane(0.25g))	Granulates(Cotton (11.5g), Polyurethane(0.25g)),transported
Transport in t*KM	

COTTON MASK -END OF LIFE

INPUT	OUTPUT
Granulates(Cotton (11.5g), Polyurethane(0.25g)),transported	Landfill/ Incineration
Landfill/ Incineration	

Fig 3. System flow diagram – Cotton mask

SURGICAL MASK GRANULATE PRODUCTION

INPUT	OUTPUT
PP Spunbond(1.63g), PP Meltblown(0.82g), Polyurethane(0.25g), Aluminium(0.18g)	Granulates(PP Spunbond(1.63g), PP Meltblown(0.82g), Polyurethane(0.25g), Aluminium(0.18g))

SURGICAL MASK TRANSPORT A

INPUT	OUTPUT
Granulates(PP Spunbond(1.63g), PP Meltblown(0.82g), Polyurethane(0.25g), Aluminium(0.18g))	Granulates(PP Spunbond(1.63g), PP Meltblown(0.82g), Polyurethane(0.25g), Aluminium(0.18g)),transported
Transport in t*KM	

SURGICAL MASK -END OF LIFE

INPUT	OUTPUT
Granulates(PP Spunbond(1.63g), PP Meltblown(0.82g), Polyurethane(0.25g), Aluminium(0.18g)),transported	Landfill/ Incineration
Landfill/ Incineration	

Fig 4. System flow diagram – Surgical mask

Life Cycle Impact Assessment (LCIA): The impact categories considered are Acidification, Global warming potential, Ozone layer depletion, Carbon monoxide, Heat waste, Climate change, Human toxicity, cancer effect, and Particulate matter as major disposal method obtained from survey results is by open burning and incineration. The chosen data base is ELCD 3.2 in Open-LCA which combine databases from open-LCA Nexus in more consistent way and comprises, materials, energy carriers, transport, and waste management. The chosen life cycle impact assessment methods are; CML IA baseline, Selected LCI results, additional and ILCD 2011 Midpoint+.

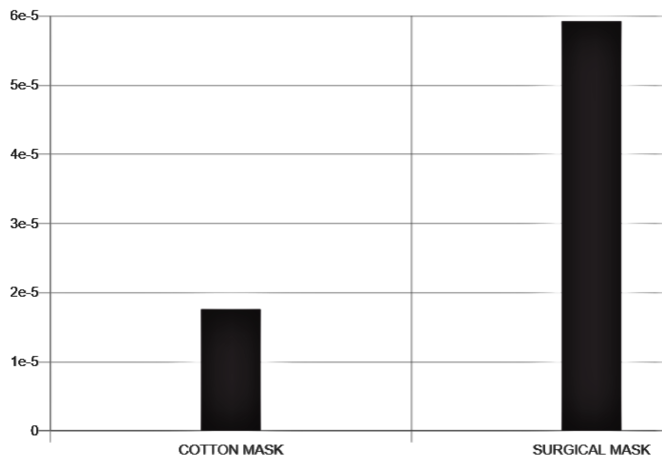
Interpretation: Involves Identification of the significant issues based on results of the LCI and LCIA phases. The choice is based on the consideration of the most broadly accepted environmental problems such as acidification, carbon monoxide, global warming potential and some other impact categories that may be potential in close relation with the production, transport, energy generation and waste management.

Table -1 Open lca Final results

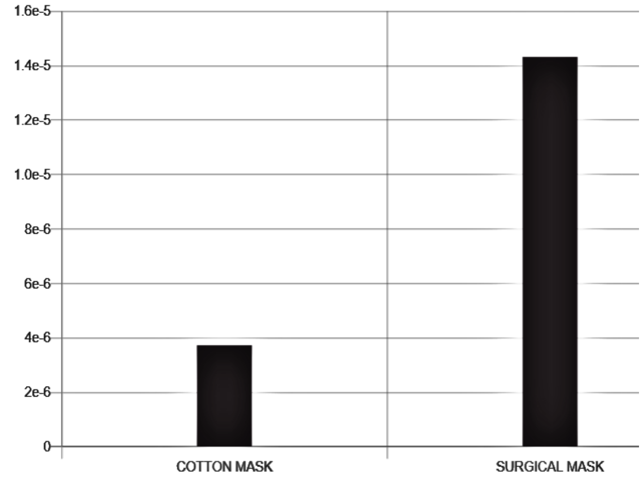
INDICATOR	COTTON MASK	SURGICAL MASK	UNIT
Acidification	1.75937e-5	5.92338e-5	kgSO_2 eq
Carbon Monoxide	3.72098e-6	1.43173e-5	Kg
Climate change	1.92100e-2	4.89612e-2	Kg CO_2 eq
Global warming	6.72443e-3	4.90880e-2	Kg CO_2 eq
Heat, Waste	8.76128e-2	2.69170e-1	MJ
Human toxicity, Cancer effects	3.17968e-11	3.11726e-10	CTU h
Ozone layer depletion	3.92303e-11	8.03727e-10	Kg CFC-11 eq
Particulate matter	6.11188e-7	2.95794e-6	Kg PM2.5 eq

3. RESULTS AND RECOMMENDATIONS

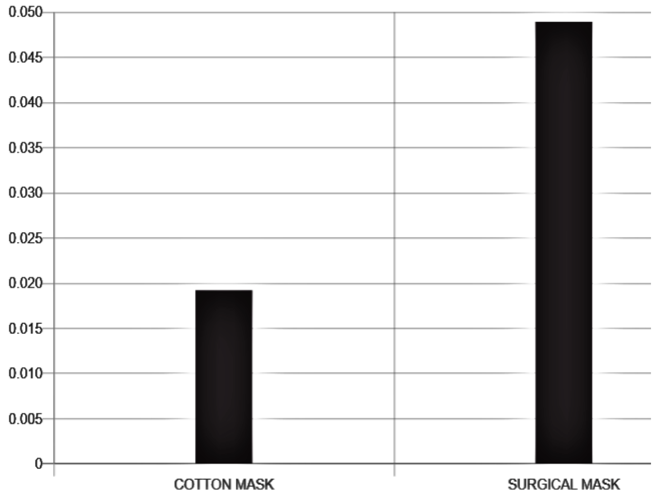
Open LCA 1.10.3 software is used to perform experiment. The PC for experiment is equipped with ELCD 3.2 database.



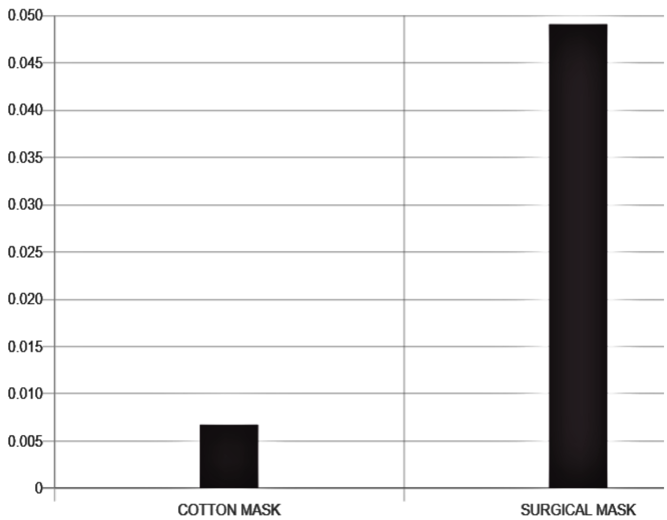
(a) Acidification



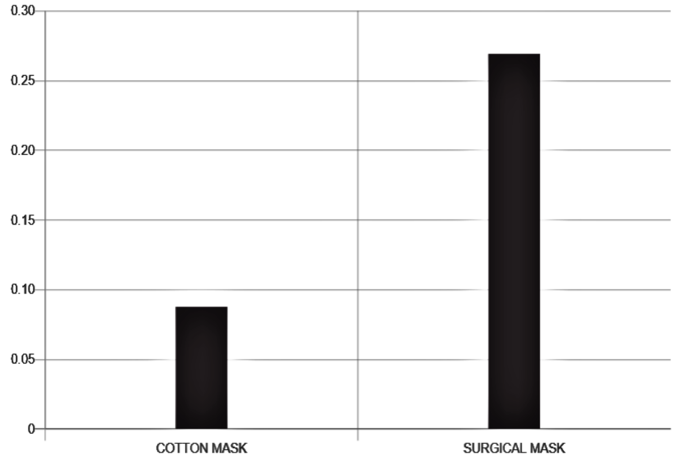
(b) Carbon monoxide



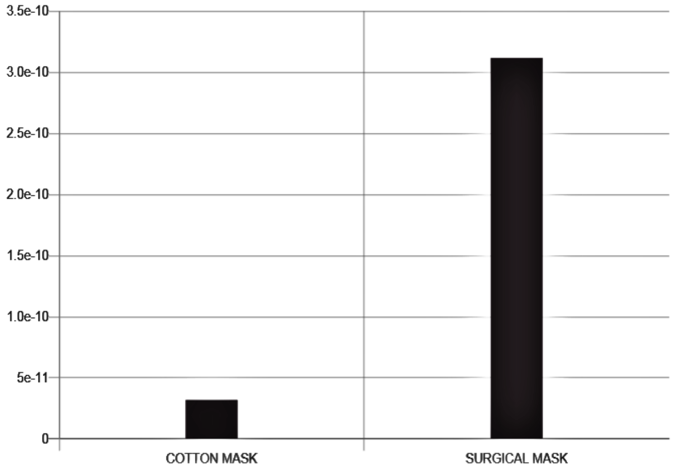
(c) Climate change



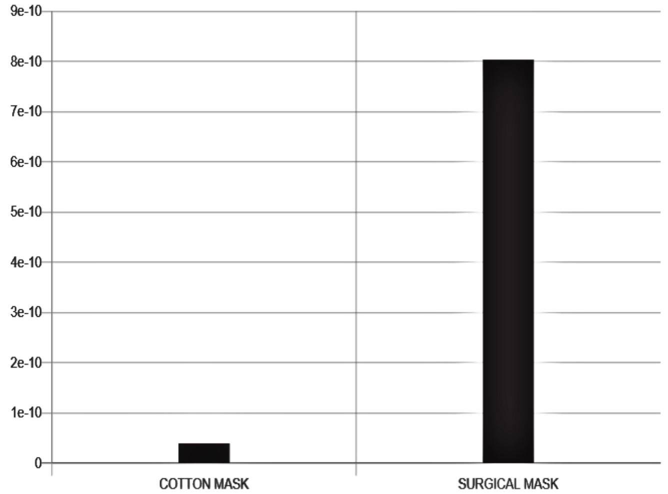
(d) Global warming potential



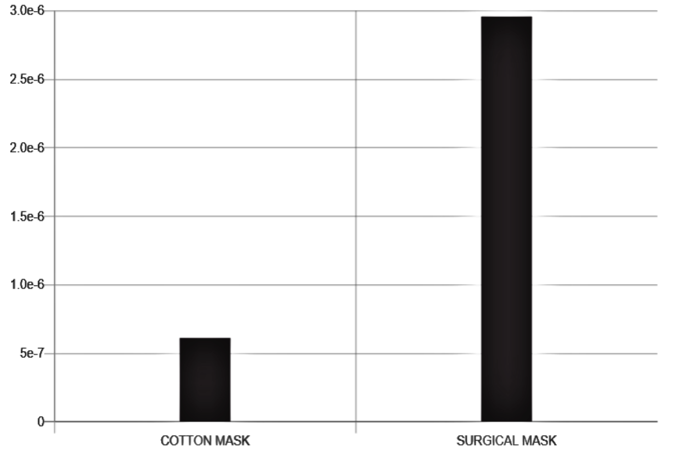
(e) Heat waste



(f) Human toxicity, cancer effects



(g) Ozone layer depletion



(h) Particulate matter

Fig 5. Software results of cotton and sirgical mask (a) Acidification, (b) Carbon monoxide, (c) Climate change, (d) Global warming potential, (e) Heat waste, (f) Human toxicity, cancer effects, (g) Ozone layer depletion, (h) Particulate matter.

The further analyses were performed in order to understand which processes of the lifecycle had the most influence on those impacts. In the case of cotton mask, waste incineration of textile fraction process contributing most of the environmental impact and in the case of surgical mask, waste incineration of plastic process contributing high impact on the environment.

Recommendations to reduce the mask wastes:

1) To lessen the risk of coronavirus transmission, keeps the masks in storage for at least four days. After removing elastic bands and wires, we will use them as seedling bags. The elastic bands and wires can be turn into twist-ties. They are stronger and longer than the average twisted ties, they have utility on plant stakes, to close chip bags, and to keep longer cables organized.

2) Clean the surgical masks properly. Remove the metal strips and elastic band (ear loop). Then shredded to the size of 0.5 cm width and 2 cm length. The commercial recycled concrete aggregate (RCA) and shredded face masks are mixed with different proportions can be used as the aggregate for pavement base/subbase applications and it will satisfy the stiffness and strength requirements of pavement base.

3) Collect all the used mask and disinfect it properly. Remove the ear loops and the nose wire. Glue each mask accordingly to get as the size of a towel. Fold it and cut as a circular shape. Mix cement and water in the form of a paste and dip the circular shaped mask set into it. Then place a bottle upside down and cover circular shaped mask over the bottle. Let keep it for 24 hours. After it get dried remove the bottle

slowly. Finally, it becomes a flower pot. Color it to get an aesthetic look.

4) Wash the cotton mask and dry it under the sun or in a hot dryer, if possible. Remove the elastic bands and stitch cloth of mask one by one, in length-wise. Then cut it into strips. Take 3 strips and tie them together at one end. Tightly braid three strips of cloth starting from tie end. Using a needle and thread, stitch the end of all three strips in the braid together. Starting from one end roll the braided coil to form the mat.

4. CONCLUSIONS

After carrying out an assessment of environmental impacts, very interesting outcomes have been observed. We can conclude that: Since most single- use masks are made from plastics like polypropylene, polyethylene and vinyl – material that takes 450 years to degrade, surgical mask might be contributing most to environmental impact compared to recyclable cotton masks.

All the concerning aspects have to be taken into account in order to better understand how environmental and human health issues are correlated so that to produce safe and sustainable textile masks. However, the masks should be designed for their intended purpose of decreasing the transfection rate of diseases. In order for masks to be sustainable, they should be efficient, safe, and breathable as well as environmentally performant.

As a conclusion, we identified that, the surgical mask contributes high impact on the environment than cotton mask. And, in the case of cotton mask, waste incineration of textile fraction process contributing most of the environmental impact and in the case of surgical mask, waste incineration of plastic process contributing high impact on the environment. Also, some recommendations are highlighted in order to reduce the mask waste.
This paper highlighted the sustainable approach by integrating the use of natural plant fibre in the woven face mask technology to reduce the plastic waste induced by face masks. Further, recycling this mask wastes and producing construction materials such as artificial aggregates, seedling bags, crafts would be viable solutions in the near future to reduce the plastic waste and environmental and health impact.

In nutshell, it has been noticed that the textile industry does not have any major impacts which can lead to serious issues of environmental pollution or any other hazards. It has been noticed that the textile industry is significantly helping in improving the social status of the region.

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