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3D Printing as an Emerging Technology in COVID -19

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ABSTRACT

3D Printing technology is a tool for many institutions to many people as it helps them build what they want with ease. May it be prototyping their projects and testing them for experiments or be gadgets for daily applications or the medical types of equipment for any hospital. During the COVID - 19 pandemic, it has also offered great help by printing face shields and various other equipment. 3D Printing is a type of additive manufacturing and is very handy and productive, which will be used for manufacturing the sanitization system primarily. It will also discuss a full sanitization model of a chamber that can be easily manufactured using 3D printing technology and can provide minimum wastage of product, space, and time. It takes a lot of effort and time to sanitize repeatedly, and there are few sanitization tunnels available in India. It also talks about how people can build this chamber by themselves under a meager budget with equipment readily available and if they own a 3D Printer, which will be found in everyone's home. 3D Printing has confirmed to an extremely useful, which is also a perfect example of Computer-Aided Manufacturing and will make manufacturing the most complex things with ease. Also, it discusses how 3D Printing has emerged in this pandemic.

Keywords: *3D Printing, COVID-19, Computer-Aided Manufacturing, Sanitization.*

1.0 Introduction

1.1 3-D Printing at home

In this modern world, with the accessibility of 3-D printers to every institute and almost every well off home, it is possible to create almost anything while sitting at home. From statues to small parts of a machine, everything can be created and assembled at home. In the earlier days, 3-D printers were limited by technology but not today.[51] Nowadays, 3-D printers can even create themselves by printing the parts, and later on, after assembling it we have another printer. There are some types of printers in the market like SLA, SLS, FDM, MJM. Each one has a quality that is not found in any other. Depending upon the usage, these printers are chosen.[6]

1.2 3-D printing as a technology

3-D Printing is a process from which 3-D solid objects of variable size and complex geometry are formed from a pre-programmed file that contains the blueprints[19] of the model to be created. It is achieved by drawing out successive layers of a specific film of a specific material until the entire model is formed. The layers are melted, shaped, and then solidified to get the desired product.[20] Every layer is shown as an exemplary sliced, flat cross-section of the final object. This is opposite to the traditional subtractive manufacturing methods that depend on the cutting and shaping of the material to form the desired model.[5]

1.3 3-D printed models advantages

- More flexibility in choosing in size and shape
- Free complexities while manufacturing
- Least assembly required
- Manufacturing skills are not required due to automated work
- Waste by-product footprint is shallow
- A more compatible & portable technology than others
- Customized as per individual's need and desire
- The material used can be remelted and reused again
- Long term cost effective[6]

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1.4 Importance of sanitization currently

Sanitization is the only way to ensure the isolation of the Sars-Cov-19. It can be done by using chemicals that can kill the virus or at least stop its spread.

1.5 Why focus on water, hygiene, or Sanitation?

As we know that about more than half of the world's population practices unsafe defecation and sanitation practices as they do not have access or the funds necessary to give them safe and clean facilities or services.[49] People in slums or poor villages don't have access to such clean facilities because they did not need them until now. Due to the pandemic, the scenery is changing and demands an order for the survival of humans.[48] Sanitizers, masks, and other medicines were facing a shortage in production.[50] For Sanitation to be adequate, all the steps must be followed and all the classes to end it ultimately. Poor Sanitation is the leading cause of spreading waterborne diseases. Therefore, the need for Sanitation and proper handling of medical waste during the pandemic is of higher priority.[46]

1.6 Ease of manufacturing by using 3-D printing

It is easy to manufacture objects using 3-D printing technology than conventional technologies due to the following reasons:

- Quick Time to Market: This technology enables people to 3-d print a concept on that day on which it was designed that reduces the number of months that might have taken to make the model properly.
- Saving Money: The conventional manufacturing of prototypes requires not only sufficient data and time but also money. But this technique does not require that much money and time as it can be made anywhere, anytime with the digital data pre-programmed.
- Personalized: This technology is customizable as per the programmer's need, which the conventional methods do not allow.
- Risking Verification: As the models made by 3-D Printing are far cheaper, prototypes from these can be tested for other errors and improvements. In conventional methods, these hit and trials methods deem to be costly.
- Fail cheap, Fail fast: Due to a much faster production rate than the conventional methods, this allows the engineer to fail at low costs and correct and try again without losing funds.[7].

2.0 Literature Review

Year	Authors	What was their finding or content or abstract or the conclusion
2020	Rami A Alfattani, et al.	This paper discusses making self sanitizing gloves to avoid spread of virus and it is made up of polymer .[33]
2020	Neelam Bharti and Shailendra Singh	It has reviewed 3D printed products like face masks, ventilators , face shield and PPE kits and talked about its safety levels.[34]
2021	Ayca Aydin & Zeynep Demirtas	Very deep review done regarding the present 3D printed equipment during COVID and talked about its challenges that it has to overcome by infusing bioprinting with it.[35]
2020	Amrita Ray Chaudhury , et al.	With the help of 3D printing technology and other sources they have come up with touch- activated, sanitizer dispensing (TSD) device,for mounting on high- touch surfaces, that minimizes nosocomial infections.[36]
2020	Claire N. Thomas, et al.	This paper shows the possibility to print the filters of face masks using in house 3D printers that are found in N95 masks and printed 50 reusable face masks.[37]
2020	Guilherme A.L, , et al.	This paper reviews the COVID-19 situation, health systems, need of 3-D Printing and its use in future.[38]
2020	Gianrico Farrugia, MD, and Roshelle W. Plutowski, BA	This paper shows us how humans reacted towards the pandemic, their innovation to crisis, cross-sector partnership, the emerging role of A.I. & ML for future solutions.[8]
2020	Alexander Brem, Eric Viardot,Petra A.N.	This paper reviews the effect of technologies and how that improves our lives worldwide. Talks about the treatment of viruses, also events in future. Challenges, innovations, social impacts are discussed.[9]
2020	Selvakumar Dharmaraj, et al.	This paper refers to managing medical waste & its consequences of its improper management. It also talks about incineration, chemical and physical processes. This study is aimed at the thermochemical process: Pyrolysis process in-depth and its use in the future. Plastic wastes are also discussed. [4][47]
2020	Chandra Wahyu Purnomo, et al.	This paper talks about the creation of CMW that mainly contains plastic, Thermochemical processes involving incineration, torrefaction, pyrolysis, and gasification. Carbonization and CO2 emissions are also reviewed.[15]

2020	Sharad Chand,et al.	In this, handling of Biomedical Waste, Poor infrastructure and its consequences are reviewed. SOPs by the government are also highlighted. [16]
2020	Bikash Chandra Behera	This paper tells us about the impacts of COVID-19 on human health and the BMW[26] left behind. It also talks about environmental effects due to wastes like PPE[30], Face shield, injections. [3]
2020	Hirak Ranjan Das, et al.	This paper discusses the need of sanitization chambers and shows the research done to build a ViroReaper (Covid De-Incubator Chamber).[17]
2020	Mohamed Bahlol, et al.	The paper reviews the readiness of the association dispensaries for the widespread. Also, the shortage of PPE kits, sanitizers, etc, and the policies are discussed.[18]
2017	Vinod G. Gokhale, et al.	This research paper reviews 3-D printing and its properties, significance, uses. It's advantages are also discussed.[7]
2014	Samer Mukhaimar Saed, et al.	This paper talks about the history, components, operations and pros & cons of additive manufacturing namely 3-D Printing.[21]
2020	Ar. Shaik Sameer	This paper reviews 3-D printing technology in the field of architecture and its advancement in the future.[22]
2020	Guilherme Arthur Longhitano, et al.	This paper talks about the lack of medical devices during the pandemic and how the 3-D printing technology can help in its production and also in the future.[23]
2019	N. Shahabudin, et al.	This reviews the Digital fabrication technology and its future in mass production for many sectors. It overviews the application and material used in it.[24]

3.0 Discussion

3.1 3-D Printing

Due to the virus's unique capability to spread through the air in the form of drops, everyone is required to wear face masks and face shields that prevent the airborne virus from entering into the host body. Due to the outbreak and surge in cases, there was a shortage in the supply of face masks and face shields globally, but demand kept increasing as more people got infected.

3D Printing, also called rapid prototyping, is an emerging technology that has captured the attention of educators, inventors, and entrepreneurs around the world and has become increasingly useful.

Production was increased in many producing countries to match the demand, but demand and supply could not meet and made people wander for other sources of production despite working overtime. Additive manufacturing or 3-D printing was seen as a solution to this problem.

3-D Printing can be used to make valves for respirators and make them in large quantities in a low time.[9] For instance, a 3D-printer company in Italy designed a prototype in less than three hours and could make 100 life-saving respirator valves in 24 hours for an Italian hospital that urgently required it.

3.2 COVID and need for sanitation

Due to the unforeseen pandemic from the Coronavirus (COVID-19), we can feel the need for the most critical resource on the planet right now, i.e., water in public health, as the world experiences a shutdown. We can see how much we need to focus on procuring clean and safe water[29] for the Sanitation needed for all those in need. As almost all the chemicals, whether it be syrups, medicines or sanitizers, all require water at some point of its creation.[1]

Sanitization is the only way to ensure the isolation of the Sars-Cov-19. It can be done by using chemicals that can kill the virus or at least stop its spread.

As we know that about more than half of the world's population practices unsafe defecation and sanitation practices as they do not have access or the funds necessary to give them safe and clean facilities or services.[25] People in slums or poor villages do not have access to such clean facilities because they did not need them until now. Due to the pandemic, the scenery is changing and demands an order for the survival of humans. For Sanitation to be adequate, all the steps must be followed and all the classes to end it ultimately, i.e., from waste's collection to its disposal. Pyrolysis is also an effective alternative in waste management and Sanitation.[12] Breaking this chain of order can trigger the surge in virus growth, and many people may be affected.

Poor Sanitation is the leading cause of spreading waterborne diseases and causes deaths at a much higher rate each year than AIDS, T.B. and Measles put together.

In covid-19, the infected people are prone to such diseases and can easily take a toll if proper care is not taken. As the patients' immune systems are down due to the virus, the body can easily be affected by other diseases, and the conditions can be critical and may lead to the death of the patients.

Also, in the unfortunate event of death of a person, his/her body is still a host to the virus and can easily infect the people who come in contact with it. Therefore, Sanitation and proper disposal of the body also play an essential role during this situation.[27]

According to the WHO & UNICEF, sanitation zones have increased by only 3% worldwide over the past 5 years.[45]

The toilets, wastewater pipes, sewers, sinks, treatment plants are not proving to be a solution for developing countries concerning Sanitation as they require large amounts of land, energy & water. The setup is costly to build and maintain, which is impossible for developing countries.[2]

Covid-19 infections are spreading and affecting the healthcare and recycling workers because of their carelessness while handling, recycling, or disposal of highly contaminated waste[13]. Ventilation is essential in treating coronavirus because it is a respiratory disease and may have severe complications for some patients. A study found that 30% Hepatitis-B, 0.35%HIV & 3% Hepatitis C has been transferred to the workers from the infected patients (2020).

Therefore, the need for Sanitation and proper medical waste management during the pandemic is of higher priority.[28] This virus spread affects humans and creates big heaps of contaminated wastes that can infect anyone who comes in contact. [3]

Figure 1: Diagramatic Representation for Safe Administration of COVID-19 Decay[3]

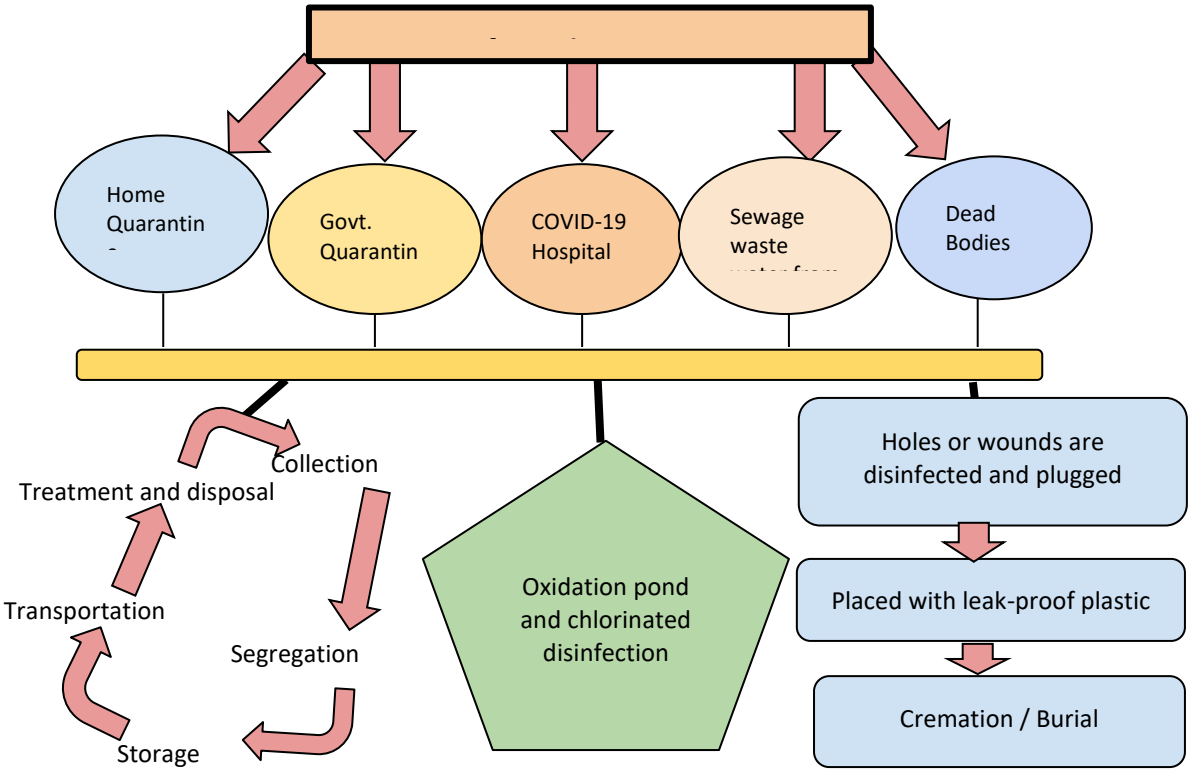


Figure 2: Variety of Decay Produced from Different Sources[14]

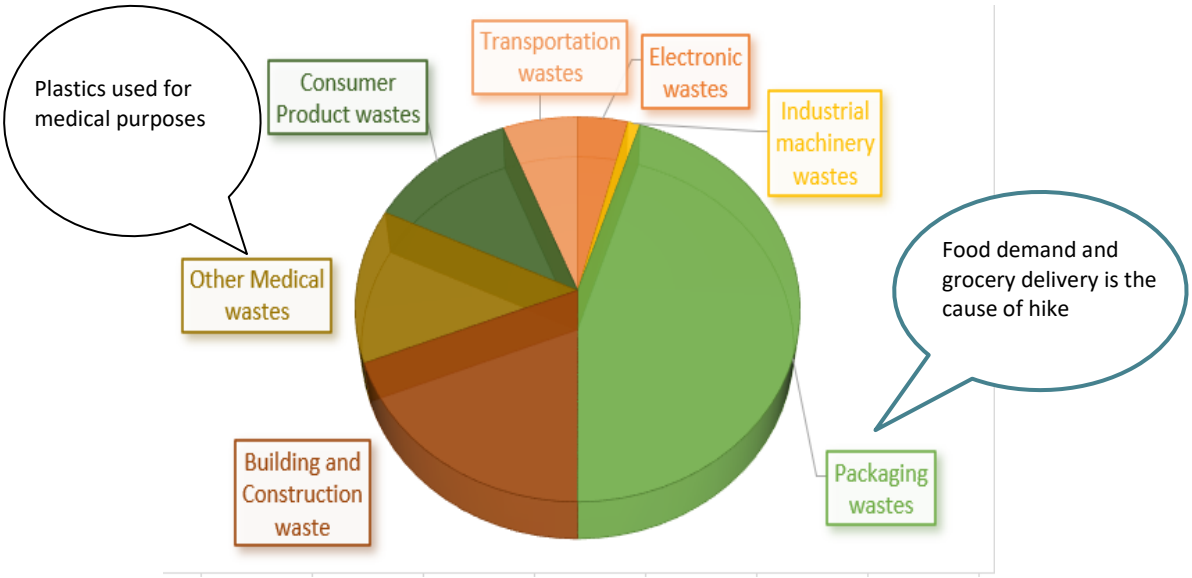
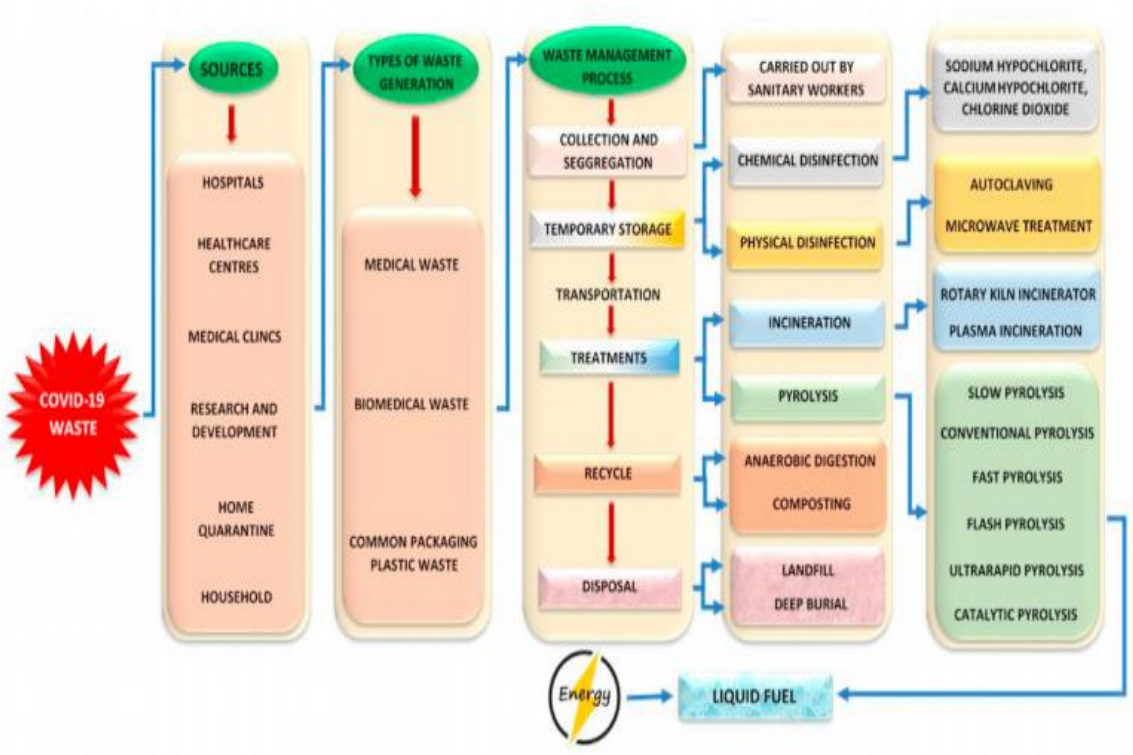


Figure 3: COVID-19 Waste Supervision Strategies and Coming Hopes[4]



The rich and the privileged enjoy the upper seat without realizing that they will be in as much danger as the poor are now. Instead of fortifying their enclosures, they should be providing Sanitation facilities and services for the poor. So together, they may tackle it.

During the pandemic, our medical sector took a huge toll all over the world and got tested. During the first few months, facilities were available for the infected people, but after six months into the pandemic, the medical facilities became overloaded [11], and faster production was required. Innovation during the crisis was looked upon by many due to the

situation. Many people worked and found many solutions to the problems faced by the people. People found alternatives to resume working from home. The Internet started being used at a higher rate during the pandemic. Cross-Sector partnerships were seen as means to solve the challenges faced in daily life. For example, the medical and production sectors collaborated to produce medical equipment at a more extraordinary rate than before to satisfy the needs. Prevention, testing, and treatment of the virus were given priority. ML and A.I. can also be used to detect diseases before the symptoms arise.[10] Also, Artificial Intelligence and Machine Learning are improving during the pandemic due to its capabilities to self-computing capabilities.[8]

Four main life-saving and health-improving technologies play a vital role during the pandemic, namely 3D printing, adaptable production systems, data analytics, and intelligent healthcare wearables (also smartphones).[9]

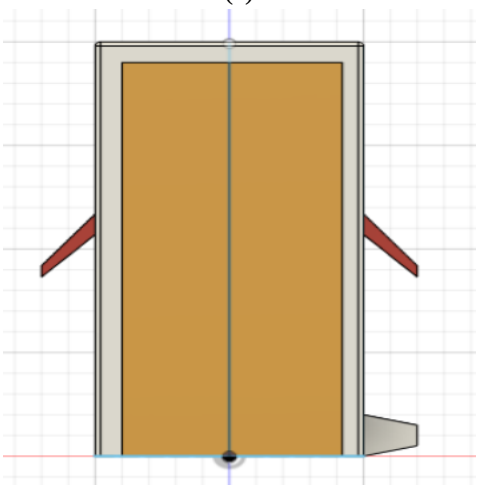
Here we talk about 3-D Printing during the pandemic in detail.

3.3 Full sanitization chamber - model design

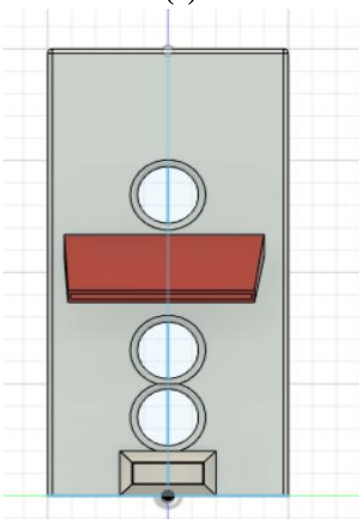
This model is made keeping in mind that sanitization is an essential part of this pandemic and a sanitization chamber where people can sanitize their whole body with the least time, effort, space, and minimum wastage of sanitizer. This chamber will be mostly 3D printed, which will open doorways to extra modification to the initial design and other challenges during manufacturing. The holes presented in the model's side view are given to insert nozzle heads into them, which will be attached to a pipe and then a pump. The pump will suck the sanitizer, and through the nozzle, the sanitizer will be sprayed in tiny droplets. A fan is attached at the top to ensure the evaporation process is geared up, and two fins of this model are vents that will have small sprayers and drying systems. This will act as a small hand sanitizing system as hands are the most exposed parts and must be thoroughly cleaned. User has to walk keeping hands in slit which will sanitize their body and hands thoroughly. Finally, a sink has been given at the bottom right to pass out the air to maintain healthy sanitization. This is an extension of the idea of a Viroreaper model.[31] This setup was created after researching ways how to kill coronavirus.[32]

Figure 4: Different Views of the Model (a) Front, (b) Side, (c) Top, (d) Isometric, (e) Rendered Image

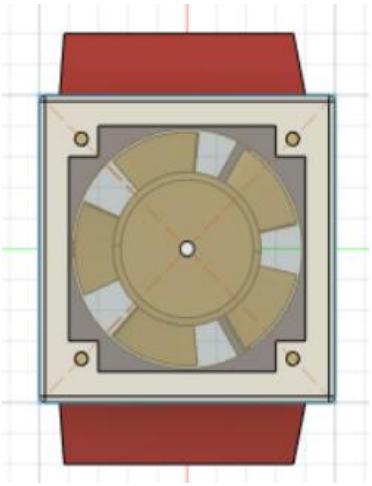
(a)



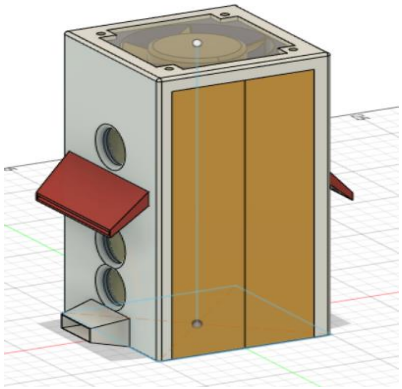
(b)



(c)



(d)



(e)

3.4 Model specifications

Part Name	Material Used	Dimensions
Plastic Chamber[40]	ABS (Plastic)	6.5 x 3.28 x 3.28 ft
Sprayer Nozzle[41]	Polypropylene	25.4mm (diameter)
Pump[42]	Cast Iron	200 x 150 mm
Fan Motor[39]	Aluminium	300mm (diameter)
Nut Bolt[43]	Stainless Steel	6mm (diameter)
Fan Fins[40]	ABS (Plastic)	150 x 30 x 2 mm
Plastic Pipes [44]	HDPE + PVC	10 x 7.5 x 6000 mm

Above mentioned dimensions are as per the model displayed and discussed in the paper, and the actual dimension may vary depending upon the requirement of the makers

3.5 Model costing

The prices shown in the table are approximate and may vary depending upon the maker's requirement and the availability & rate of the parts in the market. Also, the prices are set in Indian currency (Rupees) during 2021 and might vary in the future, thereby affecting the production cost of the desired product.

Material	Rate (Rs)	Quantity	Total Cost
Plastic Chamber + Fins	70/Kg	9Kg	630Rs
Fan Motor	500/Pc	1Pc	Rs500
Nut Bolt	60/Kg	0.1Kg (5Pc)	Rs6
Pump	1400/Pc	1Pc	Rs1400
Sprayer Nozzle	50/Pc	6Pc	Rs300
Pipes	33/m	6m	Rs200
		Total Cost	**Rs 3036**

3.6 Model manufacturing ease

Many of the components needed in the model can be printed by the 3-D printer itself, namely the Plastic Chamber, Fan Fins, Sprayer Nozzle, Hand Pieces, etc. Also, these printed parts can be customized as per the size of the chamber needed. The 3-D printing technology provides us with a cheap but durable housing for the chamber. Although the in-house 3-D printers cannot print this enormous model in a single go, the user has to program and print the whole model into small parts with fitting spaces for assembly depending upon the build volume of the 3-D printer. After printing the parts, the assembly should be done correctly to avoid damages at the joints or the weak sections of the model prone to high stress.

The parts mentioned in the model are not rigid, and modularity can be introduced according to the availability of specific products like nuts & bolts, exhaust fans, sinks, pumps, sprayer nozzles, and pipes. As there would be a further advancement in the 3-D printing technology or the additive manufacturing technology, we might print more of the necessary parts with the help of the printer itself and have some cost cuts and higher efficiency of the model as the 3-D printer would print more parts, thereby making the model more printer centric than market dependent.

The Pump, Fan Motor & Sprayer Nozzle are readily available in most markets. The pump and motor size can be varied as per the suction requirement and area of spraying. Pipes are made of many materials and, depending upon the flexibility, can be bought from the electrical/ hardware stores.

3.7 Model analysis and further recommendations

The presented model has been hypothetically built on the Fusion 360 platform. With the help of this software, a clear representation of the chamber's idea has been elaborated. This model is not fabricated at the current stage and cannot be analyzed physically by prototyping the same due to the pandemic situations. However, this will be carried out as a practical project in the future and will be tested for safety, durability, and strength.

Analytical model analysis can be done by looking into the peculiar details added to the chamber, like fillets are given at the edges to increase the design's durability and safety. Full coverage has been given, so the wear-out is slowed, and the material used will be a good quality plastic with high strength. The infill of the design can be varied in different areas to increase or decrease the material. Also, the model's quality will depend on the type of layer height and filament diameter chosen.

The costing done under model costing are not rigid and will depend on the areas. The costs can also be reduced by lowering the chamber's dimensions, reducing the thickness of the chamber, reducing the size and power of the motor, size of the fins, lowering the power and size of the pump.

4.0 Conclusion

The pandemic harms the medical industry, and because of high demands of the protective gear, the situation could have been worse but with the aid of 3D printing technology, and were also able to overcome the situation by 3D - printing needful equipment like face shields, masks, ventilators, and other necessary products in a short period as it is a technology found now commonly in most hospitals, homes, and quarantine centers. The designs required to be printed can be easily shared via the Internet to all the 3-D Printers than require to print. The products can be customized in terms of size and material used as per the person's need or the environment where the product needs to be set up.

Keeping in mind the need for Sanitation during the pandemic, we made a Sanitation Chamber model and analyzed its components and costs that can be used effectively to isolate the SARS-COV-2 and stop its spread. It is designed for everyday use. With these chambers' help, people will not need to be that careful regarding where they touch, or the virus that might have landed on their clothes or PPE kits as the full-body sanitization through the sprays and drying through the fan is going to happen while they travel through the chamber. The model displayed in this paper is an approach to use 3D Printing to enable full sanitization anywhere and make this facility accessible to everyone keeping in mind the cost and the manufacturing ease.

5.0 Future Aspect

Further, we aim to achieve the following goals using this idea as the base:

- Make the model prototype and carry on all the safety tests and equip the model with all the requirements.
- Release the model design on various platforms like Thingiverse, Reddit, and others through which anyone can easily access the design and print the model in one go.

Extend this idea into a more practical approach and review its results and provide full details about the final design's advantages and shortcomings.

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