Title: Development of a Low-Cost Vaporized Hydrogen Peroxide-Based Disinfection Method for PPE

Background of the Study: The COVID-19 pandemic has placed a tremendous amount of strain on resources in the health care setting around the world. Many countries are experiencing or imminently expecting shortages for a variety of equipment and disposable supplies. One of the most pressing issues is the rapid depletion of PPE (especially N95 and surgical masks recommended by CDC) used in the care of patients. Without an adequate supply of N95 masks, health care providers are at extreme risk of acquisition of COVID19 disease. The occurrence of patient to health care workers spread of SARS-CoV-2 at sufficiently high rates would lead to demoralization of the workforce, depletion of health care workers for quarantine and turn hospitals into extreme hotspots for infection transmission.
Disinfection and sterilization of PPE for corona viruses and reuse them can potentially solve this crisis. Multiple potential methods for disinfection and sterilization have begun to be studied. Some based on chemical methods, such as the use of hydrogen peroxide (H_2O_2), chlorine dioxide, bleach, alcohol, soap solutions, ethylene oxide, ozone decontamination, etc., and physical methods, such as the use of heat with steam or with dry air, UV rays, gamma irradiation, microwave, etc. (Mohapatra, 2017), although strict follow-up of procedures is undoubtedly of vital importance. (Bessesen et al., 2015).
Hydrogen peroxide is an oxidizing agent that works by producing highly reactive hydroxyl radicals that attack nucleic acids and proteins causing viral disintegration. Gas-based decontamination methods are advantageous because of their ability to cover large surface areas and ease of diffusion to reach areas. The vaporized form of hydrogen peroxide is much more effective at denaturing proteins as compared to the liquid form. HPV has long been used as an industrial decontaminant and recent studies performed by the Dutch national institute of health have shown that this method is effective at inactivating similar viruses and does not damage N95 masks (J.C. Rubio-Romero, et al., 2020). Similar approaches and technology have been validated by Duke University. They specifically designed a room to use hydrogen peroxide vapor to decontaminate laboratory equipment and has been operational for over a decade.

Problem Statement: This study will highlight the utility of HPV-based strategy to ensure a safe and effective disinfection of PPEs for reuse. Using this method, we shall establish and operationalize a research facility to disinfect PPE used in managing COVID-19 at our institute.

Objectives of the Study:

1. To establish a small scale low-cost disinfection chamber run with HPV for the disinfection of reusable metal and nonmetal devices used in health care facilities.
2. To identify necessary conditions for HPV to kill organisms without degrading the function of filters.
3. To determine the tolerance of repeated cycles of decontamination while maintaining structural integrity.

Research Outcome:

1. Innovation of a low-cost disinfection chamber, where the disinfectant is hydrogen peroxide vapor (HPV)

2. Development of disinfection protocol for masks, laboratory equipment, PPE etc to make them reusable.

Research Methodology:

The research will consist of the following steps:

i) Manufacturing and Installation of Decontamination Chamber: An airtight and leakproof chamber will be manufactured using locally available materials like steel frame, glass etc. The chamber will be installed with vacuum pump and H_2O_2 vapor generation assembly (Schwartz et al., 2020)

ii) Generation of Hydrogen Peroxide Vapor (HPV): A hydrogen peroxide disinfection process involves H_2O_2 vapor filling the disinfection chamber, contacting and disinfecting exposed device surfaces.

iii) Disinfection by H_2O_2 vapor: The disinfection process is composed of the following main stages:

a. Disinfection chamber pressure is reduced to a very high vacuum
b. Liquid H_2O_2 is converted into vapor
c. Under high vacuum, vapors fill the chamber, contacting all surfaces
d. After disinfection, H_2O_2 vapor is withdrawn from the chamber and converted into water and oxygen

The process will be carried out at a constant temperature of 55°C.

iv) Microbiological testing: Microorganisms (bacteria) will be cultured on the masks (PPE) and then disinfected in the disinfection chamber (Saini et al. 2020). After the disinfection process, the masks will be tested for presence of bacteria.

v) Fit Test: After disinfection process, the masks (PPE) will be undergone for fit test to find out whether the disinfected PPE can be reused.



Fig: Experimental Setup

Tentative Time Frame:

Phase	1st Month	2nd Month	3rd Month	4th Month	5th Month	6th Month	7th Month
Manufacturing and Installation							
H_2O_2 Vapor generation and disinfection trials							
Microbiological testing							
Fit Test							
Report preparation and submission							

Resources Required:

Installation of the disinfection chamber, trial run, microbiological testing will be conducted in the Environmental Engineering Lab, EWCE Dept, MIST.

Estimated Cost: Approximate costing will be as follows:

SL No	Item Name	Unit (no, L)	Unit Price (BDT)	Total Price (BDT)	Remarks
Decontamination Chamber					
1.	Vacuum pump (1 HP)	2	35,000.00	70,000.00	
2.	Acrylic Chamber Unit	1	15,000.00	15,000.00	
3.	Vapor Producing setup	1	15,000.00	15,000.00	
4.	Digital Thermometer	1	8,000.00	8,000.00	
5.	Pressure gauge	1	5,000.00	5,000.00	
6.	Small parts & accessories	-	5,000.00	5,000.00	
7.	Hot Water bath	1	1,00,000	1,00,000	
Reagents/ Chemicals					
8.	H_2O_2 Solution	5	3,500.00	17,500.00	
9.	Endo Agar Solution	1	10,000.00	10,000.00	
10.	Endo Broth Solution	1	10,000.00	10,000.00	
11.	Misc.	-	5,000.00	5,000.00	
	Total =			**2,60,500.00**	

Team Members:

1. Team Leader – Col Monzurul Islam
2. Members – Prof. Tauhid Ur Rahman (CE), Col Foyezur Rahman (EWCE), Maj Shafiul Azam (EWCE), Maj Kazi Shamima Akter (EWCE), Maj Polash Chandra Sarkar (Sc and Hum), Maj Maruf Hasan (BME).
3. Lab Testing – SAE Abul Kalam Azad, Lab Asst Kamrul

Outline Structure for Report to be Submitted:

The research outcome will be presented as a report containing the followings:

1. Title Page – containing research title, conducting department, team members
2. Executive Summary
3. Table of Content
4. Chapter One: Background of the Research, Statement of Problem, Research Objectives, Scope of the Research
5. Chapter Two: Research Methodology
6. Chapter Three: Research Outcome
7. Chapter Four: Conclusion

References:

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