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A Survey of Different Types of Mask Available in Market and Development of a New Mask to Resist Particulate Pollution

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Abstract

This paper presents the comparison of developed mask with conventional mask available in the market. In Bangladesh air pollution is a great problem. Everywhere air is polluted by dust particles, exhausts of automobiles, industries etc. This polluted air is very harmful for human being as they create various respiratory diseases. Masks are capable of providing fresh air by filtration of particulate matter. The masks used in our country are mostly providing poor filtration, uncomfortable and some are costly. These masks are not properly leak proof and cannot filter less than 10µm particles. Our developed mask is better in respect of both economy and service. It can filter up to 0.3µm diameter particles. No leakage point and better air filtration are the characteristics of our improved dust mask. It is less costly, comfortable and comparatively simple and lighter structure.

Keywords: *Air pollution, particulate matter, Human respiration, Dust mask.*

1. Introduction

Air is the life sustaining precious natural resources. Fresh air is one of the most indispensable gifts of nature without which humankind will not survive all human activities can be interfered by the pollution of this vital resource. It is only in recent times that mankind has become aware of the extent to which this interference is sustainable.The atmospheric air mainly consists of nitrogen with trace of carbon dioxide, water vapor, ozone, argon, krypton, carbon monoxide, organic matter, helium, and ammonia. Air pollution is the introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms, or cause damage to the natural environment or built environment, into the atmosphere.

2. Particulate Matter and Human Health

Particulate matter (PM) is a complex mixture of solid and liquid particles that are suspended in air. These particles typically consist of a mixture of inorganic and organic chemicals, including carbon, sulfates, nitrates, metals, acids, and semi-volatile compounds. The size of PM in air ranges from approximately 0.005 to 100 micrometers (µm) in diameter.
When human inhale, human breathe in air along with any particles that are in the air. The air and the particles travel into human respiratory system (lungs and airway). Along the way the particles can stick to the sides of the airway or travel deeper into the lungs.

Particulate matter, especially fine particles (alone or in combination with other air pollutants), with a series of significant health problems, including: premature death, respiratory related hospital admissions and emergency room visits, aggravated asthma, acute respiratory symptoms, including aggravated coughing and difficult or painful breathing, chronic bronchitis, decreased lung function that can be experienced as shortness of breath, work and school absences etc [1].

3. Dust Mask

A dust mask is a simple, small mask that fits around the nose and mouth. It is designed to block particles in the air, usually particles like smoke or dust that can cause irritation when inhaled. Typical dust masks come with elastic bands or straps that fit over the user's head and keep the mask fastened on. Dust masks are made out of cotton and similar materials.
There are many filters available for dust masks. The ordinary cotton dust masks do not use filters at all and only block larger particles from nearing the nose and mouth, but more expensive versions can have several different filters. Carbon filters, for instance, neutralize active particles and odors, while HEPA filters block out almost all particles and are used in hospitals and industrial settings.

4. Description of Different Types of Masks

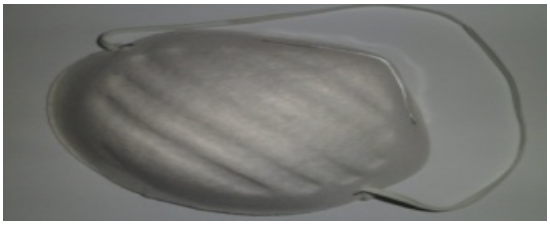

Fig. 1. Mask-1

1. Respirator style cup
2. Operation type facility safety, maintenance, repair & operations, overhaul.
3. It can filter above 5µm particulate matter.

Fig. 2. Mask-2

1. Pore size of filter paper less than 1.0µm.
2. In this mask three filter papers are used.
3. It can filter 0.3µm particulate matter.

Fig. 3. Mask-3

1. Respirator Style Cup
2. Operation Type Facility Safety, Maintenance, Repair & Operations, Overhaul
3. It cannot filter less than 0.5µm particulate matter.

Fig. 4. Mask-4

1. Respirator Style Cup
2. Costly.
3. Manufacture by 3M Company.
4. It cannot filter less than 0.5µm particulate matter.

Fig. 5. Mask-5
(Improved Mask)

Fig. 6. Mask-6

1. Pore size of filter paper 0.45 µm.
2. In this mask three filter papers are used.
3. It can filter 0.3µm particulate matter.

Fig. 7. Mask-7

1. There is used cloth as a filter paper.
2. It cannot filter less than 3µm particulate matter.

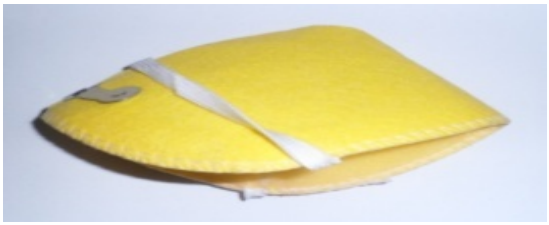

Fig. 8. Mask-8

1. There is used cloth as a filter paper.
2. It cannot filter less than 5µm particulate matter.

Fig. 9. Mask-9

1. There is used cloth and filter paper as a filter.
2. It cannot filter less than 5µm particulate matter.

Fig. 10. Mask-10

1. Respirator Style Cup
2. It cannot filter less than 3µm particulate matter.

1. There is used cloth as a filter paper
2. It cannot filter less than 10µm particulate matter.

5. Draw Backs of the Existing Mask

- The masks are not well fitted around the human face. The masks are not properly leak proof.
- The masks are not comfortable.
- The masks are not filter less than 10µm particulate matter.
- Some are costly.

6. Design and Fabrication of the Improved Mask

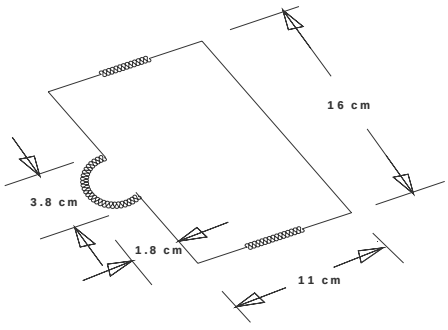

Fig. 11. Designed mask.

Fig. 12. Fabricated mask.

In design this mask our main motive was to design an improved mask of more effective whose production cost would be less and would have a light body with lees complexity and able to resist coarse particulate matter.

Mask consists of two things-

1. Frame
2. Filtering element

We selected cloth as frame materials for our mask. The pore size of the selected filter paper was 0.45µm. the filter paper are Whatman filter paper. The polluted air is allowed to pass through the filter paper. The particles of air whose diameter is above 0.3 µm cannot pass through this mask. Only sucked air can pass through these pores. The filter paper will be inactive a certain period of time. The positioning of filter paper is according to the size of the mask.
Maximum length of the mask: 16 cm
Maximum width of the mask: 11 cm
Maximum height of the mask at nose position: 1.9 cm
Maximum width of the mask at nose position: 3.7 cm

7. COST COMPARISON

Table 1: Comparison of cost of different types of mask.

Mask	Mask-1	Mask-2	Mask-3	Mask-4	Mask-5	Mask-6	Mask-7	Mask-8	Mask-9	Mask-10
Cost per piece (TK)	60	30	60	70	14.7	10	10	20	35	10

From the above table it is seen that, the highest cost is for mask-1. The cost of mask-5 is low with better quality.

8. EXPERIMENTAL SET UP

Fig. 14. Experimental set up.

1. At first the battery is charged. The charging time is approximately 260 minutes.
2. Then the battery is put into the device battery chamber.
3. The probes are connected to the terminal.
4. Then the machine is made ON.
5. Measuring mode, Particle size, Data storage, Warning beep sound, Data printing, sampling time, Frequency, Interval are set up.
6. Then a mask was set around the nose of the face of the doll.
7. Then inlet of the machine was connected to the Tracheal tube.
8. Then we gathered the data at the data book as they shown in the graphic LCD.
9. After one data was taken, then device worked again gave us data again.
10. After getting all the data we made the device set at OFF to save the battery.
11. Repeat steps 6, 7, 8, 9, 10 for different types of mask. Then data were taken for different types of masks [2].

9. Results and discussion

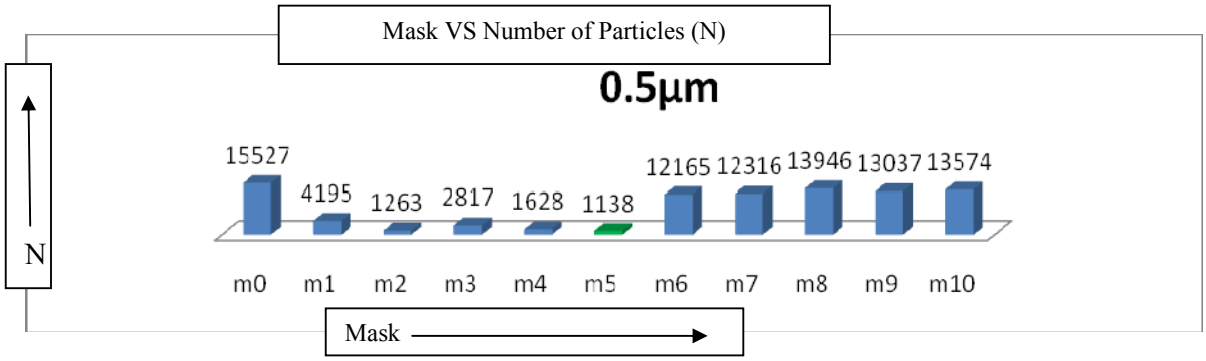

Fig. 15. Histogram of 0.5µm diameter particles passing through different types of mask tested at RUET campus.

From figure 6.1 it is shown that the filtration capacity of the developed mask (m5) is greater (92.67%) than all the masks. Lowest value is 10.18%of mask- m8.

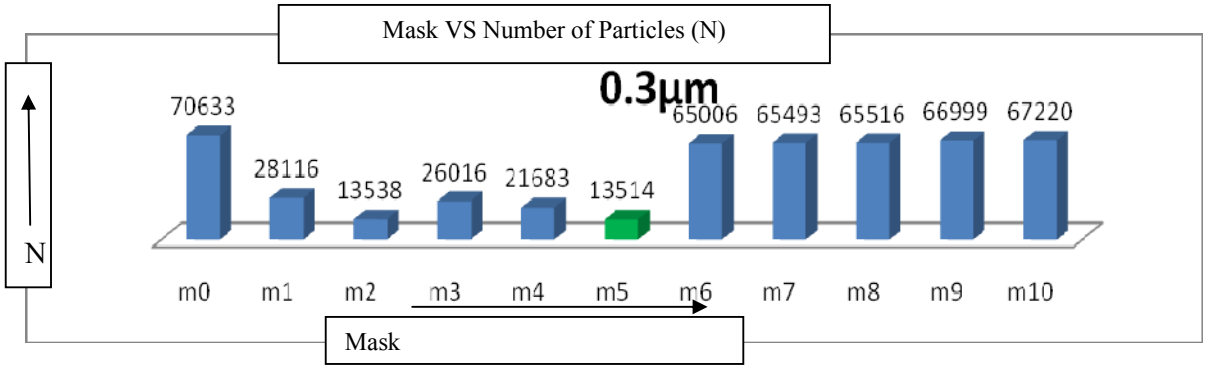

Fig. 16. Histogram of 0.3µm diameter particles passing through different types of mask tested at RUET campus.

From figure 6.1 it is shown that the filtration capacity of the developed mask (m5) is greater (80.87%) than all the masks. Lowest value is 4.83% of mask- m10.

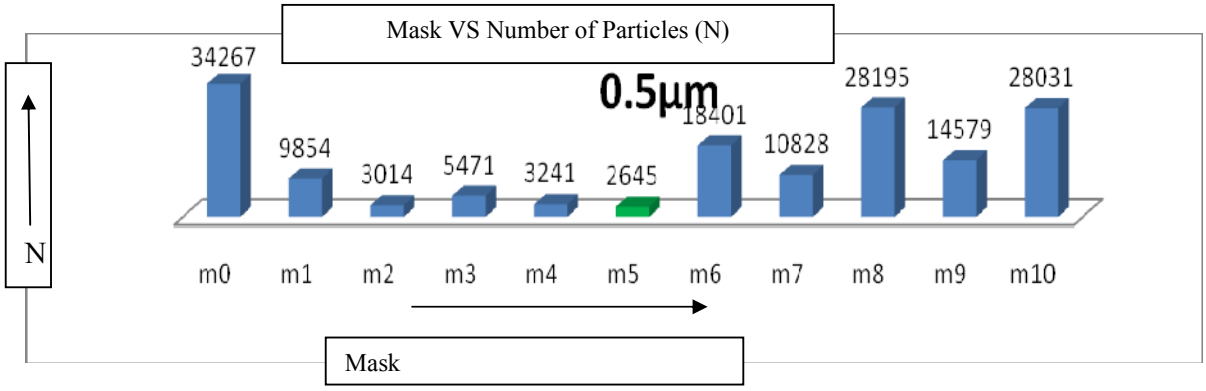

Fig. 17. Histogram of 0.5µm diameter particles passing through different types of mask tested at Rail Gate area.

From figure 6.1 it is shown that the filtration capacity of the developed mask (m5) is greater (92.28%) than all the masks. Lowest value is 17.71% of mask- m8.

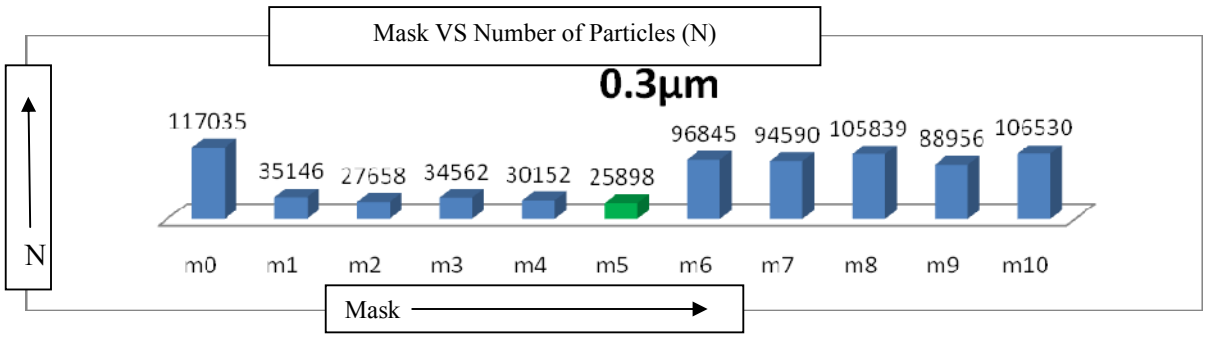

Fig. 18: Histogram of 0.3µm diameter particles passing through different types of mask tested at Rail Gate area.

From figure 6.1 it is shown that the filtration capacity of the developed mask (m5) is greater (77.87%) than all the masks. Lowest value is 8.9% of mask- m10.

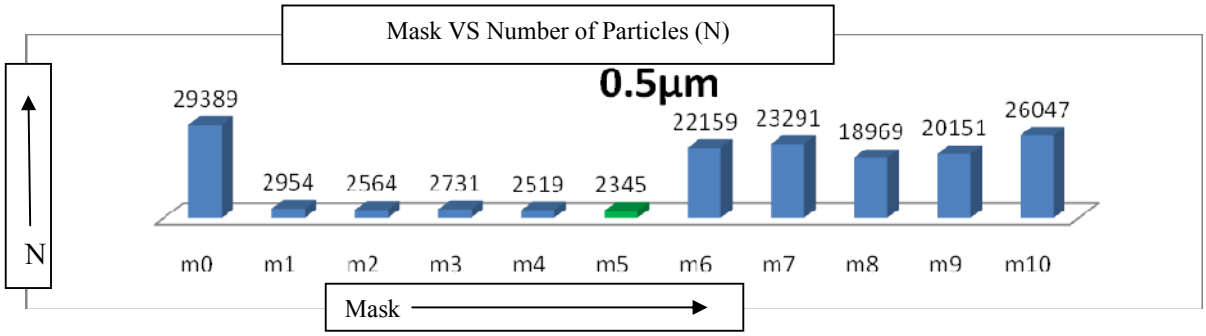

Fig. 19. Histogram of 0.5µm diameter particles passing through different types of mask tested at Saheb Bazar Zero Point.
From figure 6.1 it is shown that the filtration capacity of the developed mask (m5) is greater (92.02%) than all the masks. Lowest value is 11.37% of mask- m10.

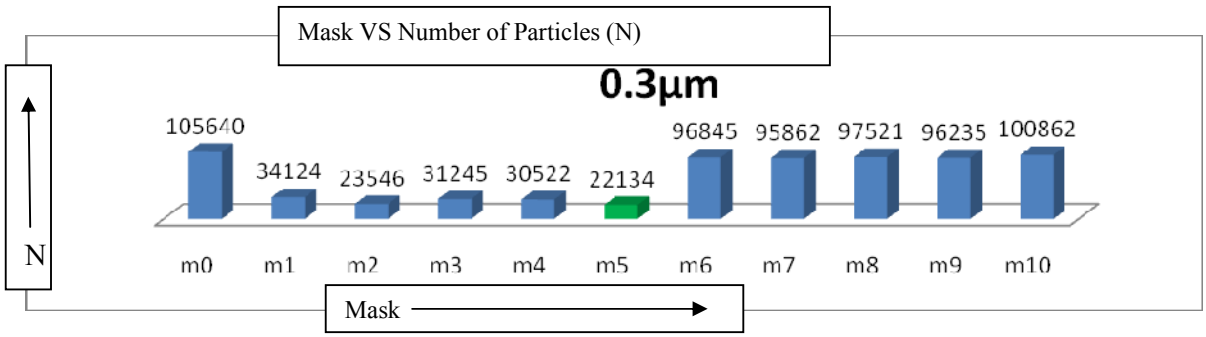

Fig. 20. Histogram of 0.3µm diameter particles passing through different types of mask tested at Saheb Bazar Zero Point.

From figure 6.1 it is shown that the filtration capacity of the developed mask (m5) is greater (79.04%) than all the masks. Lowest value is 4.5% of mask- m10.
The device used for this Experiment is very sensitive. Full charged battery was used for better performance. For better result the data was taken at very dusty area but not at high heat sunlight. Also the device was kept rest after taking a data. From above chart it is said that mask-5 resist maximum amount of particulate matter. Mask-5 is the developed mask where three whatman filter paper is used which pore size is .45µm.

10. Conclusion

From this test the following conclusion can be drawn:

- Mask-1 resists about 64% particulate pollution on the basis of particle number.
- Mask-2 resists about 88% particulate pollution on the basis of particle number.
- Mask-3 resists about 71% particulate pollution on the basis of particle number.
- Mask-4 resists about 84% particulate pollution on the basis of particle number.
- Mask-5 resists about 92% particulate pollution on the basis of particle number
- Mask-6 resists about 34% particulate pollution on the basis of particle number.
- Mask-7 resists about 42% particulate pollution on the basis of particle number.
- Mask-8 resists about 24% particulate pollution on the basis of particle number.
- Mask-9 resists about 40% particulate pollution on the basis of particle number.
- Mask-10 resists about 16% particulate pollution on the basis of particle number.

To protect from particulate pollution people use different types of mask which is found in local market. But these masks cannot resist most amount of particle. From this experiment it can be said that mask-5 resist most amount of particle. Also this mask leak proof, comfortable, low cost, simple in design, easy to manufacture and lighter structure.

11. Recommendation

If High-efficiency particulate air (HEPA) filters are used as a filter paper then it gives better result than our filter paper. Pore size of a High-efficiency particulate air (HEPA) filter is 0.3μm.So it can filter coarse and fine particles. However, HEPA filters greatly restrict air flow and require special blowers and duct design. The cost of HEPA filter is very high.
Electronic air filters and electronic air cleaners are used as filter papers then these may gives better result than our filter paper. The life time of the Electronic air filters and electronic air cleaners are greater than our filter paper. Electronic air cleaners have little air flow restriction.

12. References

[1] EPA (Environment Protection Agency) “Air Info Now What is Particulate Matter”.
[2] Operation Manual of “Handheld Laser Particle Counter” .Model 3886GEO-α. Kanomax Japan Inc.