FILTRATION PROCEDURE FOR ENVIRONMENTAL IMPACT ASSESSMENT OF AIR POLLUTANT

Lwun Htet Nay Aung [1], Win Zaw Myo Htet [2]

Abstract

Air quality issues are becoming of greater concern to the society because of the negative effects to human beings and the environment. This research was studied and purified the quality of pollutant air in northern Yangon District (Shwe Pyi Thar) from the aspect of physics in the area of environmental impact assessment (EIA). For the air purification process, washable or fiber pre-purifier, active carbon filter, and ultra violet lamp were used to constructed air filter. After using the filtration process, the data was analyzed by Scanning Electron Microscope (SEM). After that, the analyzed data were compared with the data of International Association for Impact Assessment's (IAIA) data. These analyzed data from the filtration process is slightly different with the International Association for Impact Assessment's (IAIA) data and the air filter can be widely used in industrial and air pollution problem. In this research presented a work effort to reduce CO_2 emissions through Carbon capture and storage mechanisms. Adsorption technique is followed to control the Carbon emissions from the burning of fossil fuels in automobiles, industries and using of fire wood.

Keywords: *washable or fiber pre-purifier, active carbon filter, and ultra violet lamp.*

Introduction

Air Quality Impact Assessment (AQIA) is a mechanism, which aids the efficient use of the air resource, where it is used, to identify, predict, and evaluate critical parameters and to identify the potential changes of air quality as a result of emissions from new proposed projects, to form a screening device for setting priorities in pollution control, to be used as a tool to test alternative project design at an early stage and aid the identification of the most suitable site in terms of benefit maximization and reduction of harmful effects. Finally, to identify the type of industry this can be accommodated in an area while maintaining good air quality.

An air filter is a device which removes solid airborne particles that are generally harmful to human health if haled in the lungs. Particles include things such as dust, powder, pollen, mold, fibers, germs etc. It is using physical and chemical processes with fibrous plated paper, foam, cotton, ionizers, activated charcoal, absorbents, chemicals, catalysts etc., and cleans the air to the designed breathable level and odor free for the intended user. Air filters are used in buildings, transportation, public areas and industries. There is air pollution due to the environmental conditions or nature of the process. Some of the popular air filers include:

- High- efficiency particulate absorption (HEPA) air filter- absorbs and clean 99.97% of airborne particles that have a size of 0.3 micrometers or larger, which are particularly sensitive for asthma patients.
- Ionizer air filter- uses ions to attract particles, dusts from a distance by magnetizing and neutralizing particles. It may not be very effective for a room with an asthma patient
- Active Charcoal air filter- filters fumes, cigarette smoke and some gaseous odors
- Germicidal ultra violet (UV) air filter-removes germs and viruses from the air by a special UV lamp.

[1] Lecturer, Department of Physics, Bago University
[2] Assistant Lecturer, Department of Physics, Bago University

Materials and Methods

Washable Fiber Pre-Filter

Washable fiber pre-filter is a semi-permeable paper barrier placed perpendicular to a liquid or air flow. It is used to separate fine substances from liquids or air. It is used in science labs to remove solids from liquids. This can be used to remove sand, dust, small particulate matter from environment. Filter paper has various properties. The important parameters are wet strength, porosity, particle retention, volumetric flow rate, compatibility, efficiency and capacity. There are two mechanisms of filtration with paper; volume and surface. By volume filtration the particles are caught in the bulk of the filter paper. By surface filtration the particles are caught on the paper surface. Filter paper is mostly used because even a small piece of filter paper will absorb a significant volume of liquid or gas.

The raw materials of fiber pre-filter are different paper pulps. The pulp may be from softwood, hardwood, fiber crops, and mineral fibers. For high quality filters, dissolving pulp and mercerized pulp are used. Most filter papers are made on small paper machines. In this research, cotton fiber was used for pre-filter. The size of the pre-filter is one square feet, width is 0.1 feet, which is located on the fourth layer of the air purification system. Therefore, the mechanisms of filtration process of the pre-filter have both volume and surface properties. The washable fiber pre-filter was shown in figure (1). After filtration process, the dust and small particulate matter was deposited in pre-filter, so the pre-filter is very dirty only in 2 weeks. This filter can wash by using the water, pressurized air, etc. And then, reuse for next filtration process until destroy.

Carbon and Sulphur Dioxide (CO_2) Scrubber or Filter

A carbon and sulphur dioxide scrubber are a type of filter that absorbs carbon and sulphur dioxide (CO_2). It is used to treat exhaust gases from industrial plants and automobile from exhaled air in life support systems. Carbon dioxide scrubbers are also used in air purification process. The Carbon dioxide scrubber or filter is very important in air purification process, because the ambient air is mostly consisting of CO_2 nearly 40% and the carbon dioxide is directly affected to environment, climate change and global warming. In this research, lime (calcium oxide) was used for carbon dioxide and sulphur dioxide, because lime is highly interaction with carbon oxide and sulphur dioxide.

Calcium oxide is a white crystalline solid with a melting point of 2572 ºC. It is manufactured by heating limestone, coral, sea shells, or chalk, which are mainly $CaCO_3$, to drive off carbon dioxide.

$$CaCO_3(s) \xrightarrow{500\text{-}600^oC} CaO(s) + CO_2(g)$$

This reaction is reversible; calcium oxide will react with carbon dioxide to form calcium carbonate. The reaction is driven to the right by flushing carbon dioxide from the mixture as it is released. At room temperature, the reaction of lime with carbon dioxide is very slow. It is speeded by mixing lime with water. When lime is mixed with water, it forms calcium hydroxide, called slaked lime.

$$CaO(s) + H_2O(I) \longrightarrow Ca(OH)_2(s)$$

The reaction of calcium hydroxide with carbon dioxide is faster, producing a mortar that hardens more quickly. This reaction is also used for lime coating on the surface of aluminum sieve. After that reaction, carbon dioxide scrubbing process become as following equation.

$$Ca(OH)_2(s) + CO_2(g) \longrightarrow CaCO_3(s) + H_2O(I)$$

Pollution control is a rapidly expanding consumer of lime. Lime is used in stack gas scrubbers to reduce sulfur dioxide emissions from power plants. Sulfur dioxide reacts with lime to form solid calcium sulfite.

$$SO_2(g) + CaO(s) \longrightarrow CaSO_3(s)$$

So lime is very useful in chemical filtration process of sulphur dioxide, carbon dioxide and other chemical compounds. In this research, carbon and sulphur dioxide scubber which is made with calicium oxide coating on the aluminum sieve. Size of the scrubber is 1 feet squared and width is 0.1 ft and which is located in second layer of the air purification system. Carbon dioxide and sulphur dioxide filter was shown in figure 2.

Active Charcoal Carbon Filter

Carbon filtering is a method of filtering that uses a bed of activated carbon to remove contaminants and impurities, using chemical absorption. Each particle of carbon provides a large surface pore structure, allowing contaminants the maximum possible exposure to the active sites within the filter media. One pound (450 g) of activated carbon contains a surface area of approximately 100 acres (40 Hectares). Activated carbon works via a process called absorption, whereby pollutant molecules in the fluid to be treated are trapped inside the pore structure of the carbon substrate. Carbon filtering is commonly used for water purification, in air purifiers and industrial gas processing, for example the removal of siloxanes and hydrogen sulfide from biogas. It is also used in a number of other applications, including respirator masks, the purification of sugarcane and in the recovery of precious metals, especially gold. It is also used in cigarette filters. Active charcoal carbon filters are most effective at removing chlorine, sediment, volatile organic compounds (VOCs), taste and odor from water. They are not effective at removing minerals, salts, and dissolved inorganic compounds. Typical particle sizes that can be removed by carbon filters range from 0.5 to 50 micrometers. These particle size will use as part of the filter description. Charcoal is carbon & Activated charcoal is charcoal that has been treated with oxygen to open up millions of tiny pores between the carbon atoms. In this research, 225 gram of active charcoal carbon was used for active carbon filter, which's volume is $(1\times1\times 01)$ ft^3 and it is located in three layer of the air purification system. The active charcoal carbon filter was shown in figure 3.

Titanium Dioxide Filtration Process

In photocatalytic air purifiers, the catalyst that cleans the air is typical titanium dioxide and it's energized by ultraviolet light. UV is the short-wavelength light just beyond the blue-violet part of the electromagnetic spectrum that our eyes can detected. The UV light is exactly the right amount of energy to get titanium dioxide. Titanium dioxide film is covering the surface of a backing material called a substrate, which is usually made from a ceramic or a piece of metal (such as aluminum). There are three steps of process in the titanium dioxide catalyst in an air purifier breaks apart molecules of air pollution.

- When UV light shines on the titanium dioxide, electrons (the tiny, negatively charged particles inside atoms) are released at its surface. It's the electron that do the useful work for purification process.
- The electron interacts with water molecules in the air, breaking them up into hydroxyl radicals ($OH^{-)}$, which are highly reactive, short-lived, uncharged forms of hydroxide ions (OH^{-}).
- These small, agile hydroxyl radicals then attack bigger organic (carbon -based) pollutant molecules, breaking apart their chemical bonds and turning them into harmless substances such as carbon dioxide and water. This is a process of oxidation and that's why air purifiers that work this away are sometimes also described as PCO (photocatalytic oxidation) air cleaners.

In this research, titanium dioxide was coating on the aluminum sieve which area of 1square feet and width is 0.2mm. Sol-gel coating method was used for the coating of titanium on the aluminum sieve.

All chemicals to prepare TiO_2 powder modified sol (PMS) were used as received, polyethylene glycol, de-ionized water, nitric acid (60%) and P-25 powder. The precursor solution consisted of 70 g TTIP, 50g IPA and 9g PEG. The solution was stirred at room temperature for approximately 1 hour. Then the pre-mixed solution containing 30g IPA, 2g nitric acid and 4 g of de-ionized water was added drop-wise under vigorous stirring. Subsequently, P-25 powder was incorporated into a precursor sol solution. The loading concentrations of P-25 powder were 0, 10, 20, 40 and 80 g·L-1. After aging the solution at room temperature for 1 day, the pre-cleaned aluminum sieve was coated with P-25 powder modified TiO_2 sol-gel solution. The dip-coated specimens were dried at 65 ºC for 1 hour and then calcined at 300 ºC for 2 hours. Finally, Titanium dioxide photocatalytic filter was used for air purification process which is located on the first layer. The titanium dioxide filter was shown in figure 4.

Figure 1 Pre-Washable Filter

Figure 2 Calcium Oxide Filter

Figure 3 Active Charcoal Carbon Filter

Figure 4 Titanium Dioxide Filter

Designing of the Air Purification Process

Four types of filters were used for air purification process, which are titanium dioxide, calcium oxide, charcoal active carbon and pre-filter. These are main components of the air purification process. The titanium oxide filter is located on the first layer which is need to react with UV and air pollutants molecules in ambient air. Calcium oxide filter is located on the second layer of the system, that it is also called carbon dioxide and sulphur dioxide trap filter. In third layer, active charcoal carbon filter is located and react with other pollutant mineral in ambient air. Finally, pre-filter is located in last layer and this layer is last stage of the air purification process. In this design, function of the fan is to support the speed of the pollutant air from ambient to air purification system. Outlet air quality can determine by using the deposited test paper. The schematic diagram of the system was shown in figure 5.

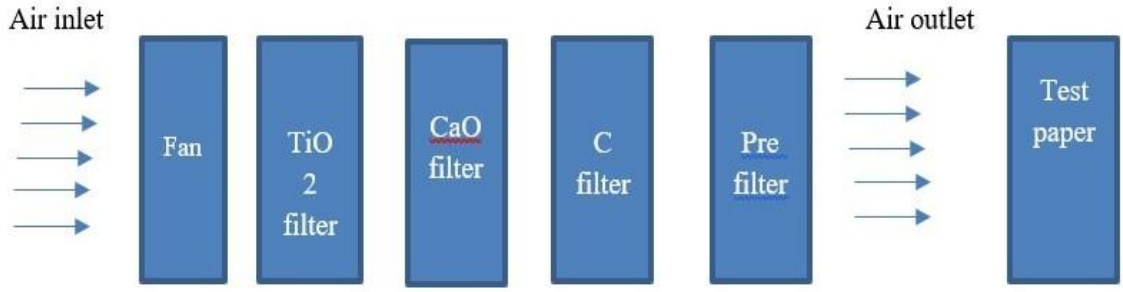

Figure 5 The Schematic Diagram of Air Purification System

Results and Discussion

Outlet air quality was determined by using two deposited test papers, these are test paper without purification process and another one is by using air purification system. These two figures were shown in figure 6(a) and 6(b). In the air purification test paper, the pollutant particles were less than the test paper without purification process. This amount of pollutant is within one month. Scanning Electron Microscope was using for particle analysing process. Figure 7(a) and 7(b) was shown the SEM image of the test papers. Image J software was used for particle counting and average size of particle analysis and those particles counting screen was shown in figure 8(a) and 8(b). Amount of the particle in air purification process test paper are 126 particles and average size of the particle is 108.230 pixels. Amount of the particle in without air purification process test paper is 274 particles and average size of the particles is 66.055 pixels. Amount of particle without air purification process test paper is larger than amount of particle in air purification process and also average size of the particle in without purification process is smaller than the size of particle in air purification process. On the other size, pixels amount of the 20 micro meter is 160 pixels, so the particle size of 108 pixels is 13.5 micro meter for filtration process and 8.25 micro meter for without filtration process. These data were analysed by using the Image J software, which is more affective of particle analysing software for scanning electron microscope image. So, air purification process is effective in this research because the purification process was reduced to particle amount of nearly 117 percent of particles and also size of the particle is increase 61.76 percent. These results are key of the air purification process.

Table 1 Comparison Results Data of Without Filtration Process and With Filtration

No.	Type of Paper	Number of Particles	Particle Size in Pixels	Particle Size in Micrometre
1	Without Filtration	274	66.055	8.25
2	With Filtration	126	108.23	13.5

Figure 6 (a) Test Paper with Air Purification Process

Figure 6 (b) Test Paper without Air Purification Process

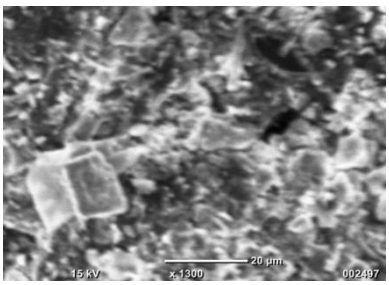

Figure 7 (a) SEM image of Air Purification Process Test Paper

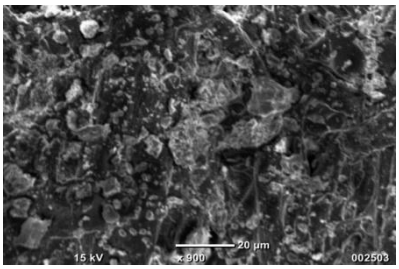

Figure 7 (b) SEM Image of without Air Purification Process Test Paper

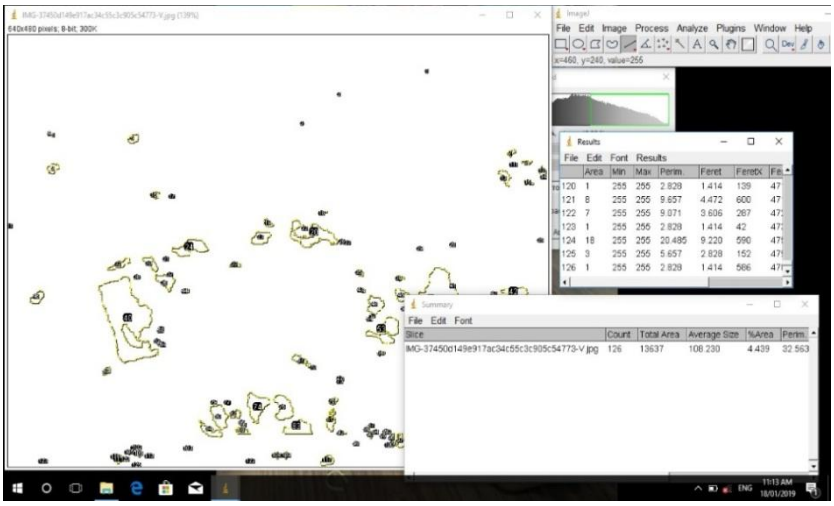

Figure 8(a) Particle Analysing of Air Purification Process Test Paper by Using Image J Software

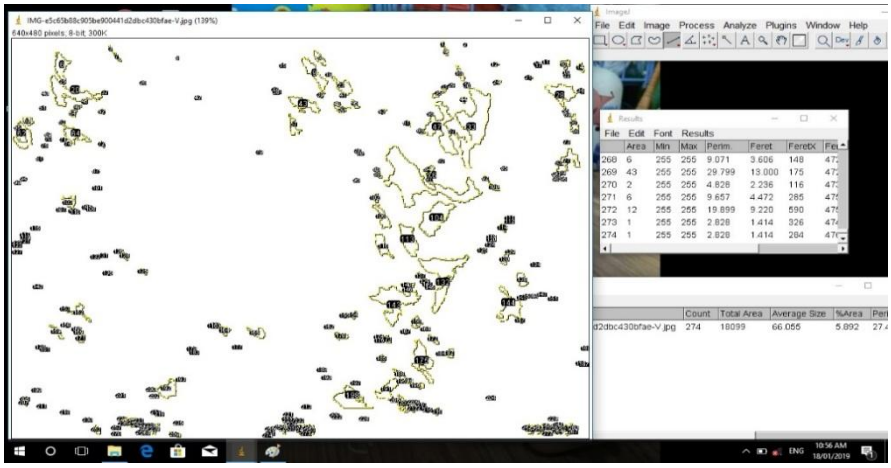

Figure 8 (a) Particle Analysing of Without Air Purification Process Test Paper by Using Image J Software

Conclusion

The National Particle Component Toxicity (NPACZT) program concluded that all particles affect to health some way. Therefore, the kinds of the particle are not important but size of the particle is important in air quality. Particles less than 10 micrometer are the worst offenders. Particles larger than 10 micrometers can still irritate eyes, nose and throat as well. So, results of this research data are compared with the PM_{10} (particulate matter). Average size of the particle in air purification process is 13.5 micrometers. Therefore, the size of the particles is larger than the PM_{10}. In addition, the air purification process was reduced the amount of particle and increased the size of the particle. In this research, the titanium dioxide filter, calcium oxide filter, active charcoal filter and pre-washable filter are affective in air purification process. So, the air purification filter design can be used in air filtration process of industry, home and public access area.

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