A Low Cost Homemade Air purifier

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Abstract -- **An air purifier is provided having a purifier housing and an air way housing mounted therein. A fan having a cylindrical whirlpool leaf construction is mounted within the air way housing and air is directed in a predetermined direction through an air exit opening formed in a wall of the purifier housing. An extended and tapered discharging copper needle is electrically coupled to a high voltage generator contained within the purifier housing and produces negative ions. The discharging needle is pointed in contour and has an apex end located adjacent the air exit opening. The discharging needle extends in the direction of the passage of high pressure air from the purifier housing which allows the discharging needle to vibrate responsive to the high pressure air flow and increases the amount of negative ions mixed with the air passing from the purifier housing.**

Keywords: Air Purifier, UV, HEPA, Air polution, Air ionizer

I. INTRODUCTION

AIR PURIFIER is a device which removes contaminants from the air in a room. These devices are commonly marketed as being beneficial to allergy sufferers and asthmatics, and at reducing or eliminating second-hand tobacco smoke. The commercially graded air purifiers are manufactured as either small stand-alone units or larger units that can be affixed to an air handler unit (AHU) or to an HVAC unit found in the medical, industrial, and commercial industries. Air purifiers may also be used in industry to remove impurities such as CO_2 from air before processing. Pressure swing absorbers or other adsorption techniques are typically used for this.

Dust, pollen, pet dander, mold spores, and mite feces can act as allergens, triggering allergies in sensitive people. Smoke particles and volatile organic compounds (vocs) can pose a risk to health. Exposure to various components such as vocs increases the likelihood of experiencing symptoms of sick building syndrome. Additionally, with the advancement in air purification technology, air purifiers are becoming increasingly capable of capturing a greater number of bacterial, virus, and DNA damaging particulates. Air purifiers are used to reduce the concentration of these airborne contaminants and can be useful and wholesome for people who suffer from allergies and asthma.

II. SOURCES OF AIR POLLUTION AND EFFECTS

1. Carbon Monoxide (CO):-Source: Fuel combustion from vehicles and engines.
   Effect: Reduces the amount of oxygen reaching the body's organs and tissues; aggravates heart disease, resulting in chest pain and other symptoms.
2. Ground-level Ozone (O_3):- Source: Secondary pollutant formed by chemical reaction of volatile organic compounds (vocs) and NO_x in the presence of sunlight.
   Effect: Decreases lung function and causes respiratory symptoms, such as coughing and shortness of breath, and also makes asthma and other lung diseases get worse.
3. Lead (Pb):- Source: Smelters (metal refineries) and other metal industries; combustion of leaded gasoline in piston engine aircraft; waste incinerators (waste burners), and battery manufacturing.
   Effect: Damages the developing nervous system, resulting in IQ loss and impacts on learning, memory, and behavior in children. Cardiovascular and renal effects in adults and early effects related to anemia.
4. Nitrogen Dioxide (NO_2):- Source: Fuel combustion (electric utilities, big industrial boilers, vehicles) and wood burning.
   Effect: Worsens lung diseases leading to respiratory symptoms, increased susceptibility to respiratory infection.
5. Particulate Matter (PM):- Source: This is formed through chemical reactions, fuel combustion (*e.g.*, burning coal, wood, diesel), industrial processes, farming (plowing, field burning), and unpaved roads or during road constructions.
   Effect: Short-term exposures can worsen heart or lung diseases and cause respiratory problems. Long-term exposures can cause heart or lung disease and sometimes premature deaths.
6. Sulfur Dioxide (SO_2) :- Source: SO_2 comes from fuel combustion (especially high-sulfur coal); electric utilities and industrial processes as well as natural occurrences like volcanoes.
   Effect: Aggravates asthma and makes breathing difficult. It also contributes to particle formation with associated health effect.

III. METHODS OF PURIFICATION

Several different processes of varying effectiveness can be used to purify air.

Ultraviolet germicidal irradiation - UVGI can be used to sterilize air that passes UV lamps via forced air. Air purification UVGI systems can be freestanding units with

shielded UV lamps that use a fan to force air past the UV light. Other systems are installed in forced air systems so that the circulation for the premises moves micro-organisms past the lamps. Key to this form of sterilization is placement of the UV lamps and a good filtration system to remove the dead micro-organisms. For example, forced air systems by design impede line-of-sight, thus creating areas of the environment that will be shaded from the UV light. However, a UV lamp placed at the coils and drain pan of cooling system will keep micro-organisms from forming in these naturally damp places. The most effective method for treating the air rather than the coils is in-line duct systems, these systems are placed in the center of the duct and parallel to the air flow.

Filter-based purification traps airborne particles by size exclusion. Air is forced through a filter and particles are physically captured by the filter.

HEPA filters remove at most 99.97% of 0.3-micrometer particles, and are usually more effective for particles which are larger. HEPA purifiers which filter all the air going into a clean room must be arranged so that no air bypasses the HEPA filter. In dusty environments, a HEPA filter may follow an easily cleaned conventional filter (prefilter) which removes coarser impurities so that the HEPA filter needs cleaning or replacing less frequently. HEPA filters do not generate ozone or harmful byproducts in course of operation.

Activated carbon is a porous material that can absorb volatile chemicals on a molecular basis, but does not remove larger particles. The absorption process when using activated carbon must reach equilibrium thus it may be difficult to completely remove contaminants. Activated carbon is merely a process of changing contaminants from a gaseous phase to a solid phase, when aggravated or disturbed contaminants can be regenerated in indoor air sources. Activated carbon can be used at room temperature and has a long history of commercial use. It is normally used in conjunction with other filter technology, especially with HEPA. Other materials can also absorb chemicals, but at higher cost.

Ionizer purifiers use charged electrical surfaces or needles to generate electrically charged air or gas ions. These ions attach to airborne particles which are then electrostatically attracted to a charged collector plate. This mechanism produces trace amounts of ozone and other oxidants as by-products. Most ionizers produce less than 0.05 ppm of ozone, an industrial safety standard. There are two major subdivisions: the fan less ionizer and fan-based ionizer. Fanless ionizers are noiseless and use little power, but are less efficient at air purification. Fan-based ionizers clean and distribute air much faster. Permanently mounted home and industrial ionizer purifiers are called electrostatic precipitators.

Ozone generators are designed to produce ozone, and are sometimes sold as whole house air cleaners. Unlike ionizers, ozone generators are intended to produce significant amounts of ozone, a strong oxidant gas which can oxidize many other chemicals. The only safe use of ozone generators is in unoccupied rooms, utilizing “shock treatment” commercial ozone generators that produce over 3000 mg of ozone per hour.

Restoration contractors use these types of ozone generators to remove smoke odors after fire damage, musty smells after flooding, mold (including toxic molds), and the stench caused by decaying flesh which cannot be removed by bleach or anything else except for ozone. However, it is not healthy to breathe ozone gas, and one should use extreme caution when buying a room air purifier that also produces ozone.

IV. IMPLEMENTATION

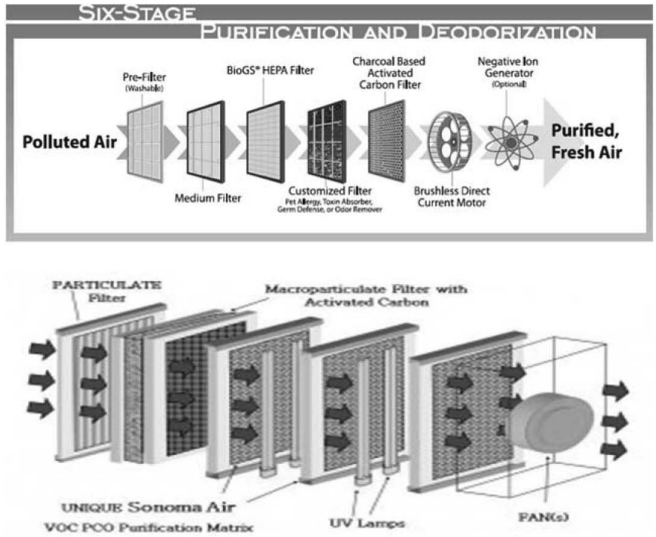

Figure 1. Stages of Airpurification.

Electrostatic Air Filtration:-
Electrostatic filters or electrostatic precipitators are based on a two-stage filtration principle, and they consist of two sections: the charging section and the collection section. The first stage begins when the electrostatic filter employs ionized wires in order to infuse the contaminant particles, such as dust, pollen, smoke and fumes with small positive charges.

The charged particles are attracted to the negatively charged electrical field in the collection section which contains a row of metal plates. The particles are then collected on the plates, and thus trapped whilst clean air is released into the room. Electrostatic filters are very effective, and can collect particles as small as 0.01 microns in diameter which even beats HEPA filters! They have an open cell design which is there to maintain a low pressure drop which in turn, means less power is required.

This means savings in terms of energy and quieter operation. Adding to the cost cutting pattern is the fact that this type of filter can be cleaned, or even washed in a dishwasher. In the long run, it will save you money and the hassle of having to buy a new filter every year.

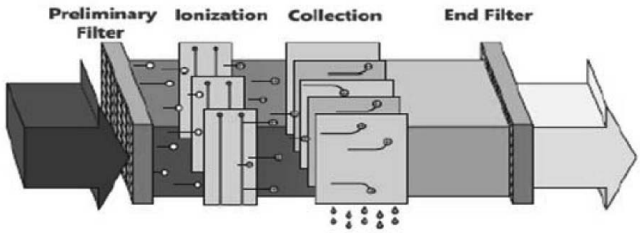

Figure 2. Typical HEPA filter.

Ionic Air Filtration: Ionizers can often be found in air purifiers in combination with HEPA filters. They use a negative ion generator which introduces negatively charged ions that in turn, attract positively charged air pollutants. As the particles group together they become too heavy and fall from the air. Although do bear in mind you will be able to see the evidence!

One great thing about ionizers is that they are extremely effective at removing smoke particles from air. On the other hand, if your problem is dust, pollen, dust mites or some other common allergen an ionizer won't do you much good because the particles will not be removed completely. The biggest concern regarding ionizers is the fact they create ozone which can be harmful in large concentrations. However, many manufacturers have addressed this issue. Just make sure you check the safety certifications included.

An air ionizer or as some may refer it as a room ionizer is basically a device or electronic circuit which is designed for generating voltage at the level of kilo-volts for implementing the said ionizing effects. So what's ionizing after all? The high voltage that's generated from an ionizer is actually tuned for generating a negative voltage, at around minus 4 kV. This high negative voltage is allowed to get terminated over an open ended sharp conductor tip or point that's sharply carved. When the voltage reaches at this sharp point, it tends to continue its forward motion and gets shot or released into the air in the form of negatively charged ions. Once in the air, these ions become free to move around and start getting dispersed across the room or the premise, as more and more ions are released from the air ionizer device. Now as these ions roam freely in the air it comes across and starts colliding with the already present pollutants like dust particles, smoke/gas particles etc in the air. As per the rules all particles and all materials present around should be positively charged, so what happens, the oppositely charged ions starts collecting these pollutants from the air by attracting them toward them (opposites attract), just as a magnet bar would do to iron pins.

The pollutants in the air slowly find themselves pulled and firmly stuck over these ions until each of the ions become so much pollutant laden and heavy that they start crashing on the ground or if they find a wall nearby they start gathering on it. In this way, the air in the course of time becomes absolutely clean and free from all impurities.

The circuit is quite simple The circuit is fundamentally based on Cockcroft-Walton Ladder Network, The concept makes use of a network of many diodes and capacitors arranged in such a way that the applied voltage to it gradually becomes stepped up to very high levels, in the order of around 10kV.

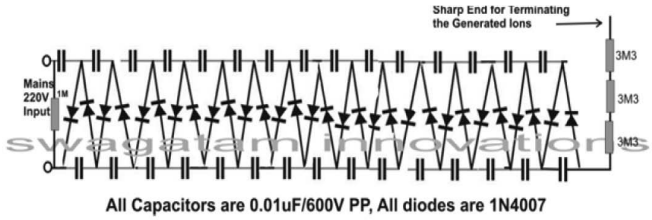

Figure 3. Cockcroft-Walton Ladder Network.

However a 10kV range is not suitable for the discussed ionizing effects, in fact at this level the effect might produce opposite results.

If we go by calculations, the present design would also generate around -10kV, spoiling the intended cause, however practically it is found to be dropping to about -4kV. This reduction happens due to radiation losses, because in the course of its stepping up, the voltage tends to spark through emissions across the PCB until finally the resultant voltage at the output tip of the device reaches only up to around -4kV which is the exact level for achieving the ionizing effect. The entire circuit may be built over a general purpose board, by soldering the shown number of capacitors and diodes exactly in the way they are arranged in the diagram. Following the diagram pattern would make it easier to assemble and produce guaranteed results without faults.

After the circuit is assembled, check the entire board for any wiring connections, this is important because the circuit is very critical with its polarities, a single wrongly connected diode would make the results zero.

Figure 4. Cockcroft-Walton Ladder Network (implemented).

After proper confirmation, the soldered side should be thoroughly cleaned with thinner so that no residual flux stays deposited causing loss of voltage and reduction in the desire defects. The end which is terminated for releasing the ions must be needle shaped; preferably a small pin or needle can be used there for enabling perfect prorogation of the ions. After all the above precautions are complete, it's time to power the unit. Be extremely careful, as the entire circuit is connected directly with mains AC and can be life-threatening if touched in the powered position. Once the circuit and if hopefully everything is rightly done with the assembly, you would hear a "hissing" noise near the tip of the releasing pin point. The area near the tip of the pin would give you a cooler sensation like a cool breeze flowing out. The point would also produce a fish like smell.

All the above indications would confirm that the unit is working right and you are already breathing fresh air around your nose and heading toward a healthy life.

UV Air Filtration:- In the case of UV filtration, a UV light is employed to treat airborne contaminants. By using UV light of a certain wavelength, air purifiers are able to break down the DNA of living organisms such as bacteria, mold and yeast sport, fungus, mildew and even molecular bonds inside the RNA of a virus. This is why they're often used in institutions such as hospitals, schools and laboratories.

As ideal as UV filters sound, they have their flaws. They are not effective when it comes to removing non-living contaminants such as dust, allergens, fumes, odors, and gases which is why you will often find them paired up with some other type of filter functions. UVGI is used in a variety of applications, such as food, air, and water purification. In recent years, UVGI has found renewed application in air purifiers.

Figure 5. UV Air Filteration.

Ultraviolet germicidal irradiation: Ultraviolet germicidal irradiation (UVGI) is a sterilization method that uses ultraviolet (UV) light at sufficiently short wavelength to break down micro-organisms. It is used in a variety of applications, such as food, air and water purification. UV has been a known mutagen at the cellular level for more than 100 years. The 1903 Nobel Prize for Medicine was awarded to Niels Finsen for his use of UV against tuberculosis.

UVGI utilises the short wavelength of UV that is harmful to forms of life at the micro-organic level. It is effective in destroying the nucleic acids in these organisms so that their DNA is disrupted by the UV radiation. This removes their reproductive capabilities and kills them. The wavelength of UV that causes this effect is rare on Earth as its atmosphere blocks it. Using a UVGI device in certain environments like circulating air or water systems creates a deadly effect on micro-organisms such as pathogens, viruses and moulds that are in these environments. Coupled with a filtration system, UVGI can remove harmful micro-organisms from these environments.

The application of UVGI to sterilization has been an accepted practice since the mid-20th century. It has been used primarily in medical sanitation and sterile work facilities. Increasingly it was employed to sterilize drinking and wastewater, as the holding facilities were enclosed and could be circulated to ensure a higher exposure to the UV. In recent years UVGI has found renewed application in air sanitization.

How UVGI Works

Ultraviolet light is electromagnetic radiation with wavelengths shorter than visible light. UV can be separated into various ranges, with short range UV (UVC) considered "germicidal UV." At certain wavelengths UV is mutagenic to bacteria, viruses and other micro-organisms. At a wavelength of 2,537 Angstroms (254 nm) UV will break the molecular bonds within micro-organism DNA, producing thymine dimmers in their DNA thereby destroying them, rendering them harmless or prohibiting growth and reproduction. It is a process similar to the UV effect of longer wavelengths (UVB) on humans, such as sunburn or sun glare. Micro-organisms have less protection from UV and cannot survive prolonged exposure to it.

A UVGI system is designed to expose environments such as water tanks, sealed rooms and forced air systems to germicidal UV. Exposure comes from germicidal lamps that emit germicidal UV electromagnetic radiation at the correct wavelength, thus irradiating the environment. The forced flow of air or water through this environment ensures the exposure.

V. EFFECTIVENESS

UVGI is a highly effective method of destroying microorganisms. Since the Earth's atmosphere absorbs most of the UV from the sun, germicidal UV is very rare in all circumstances. When concentrated in a closed environment such as a water holding tank or duct system it is lethal over time to all micro-organisms.

The effectiveness of germicidal UV in such an environment depends on a number of factors: the length of time a micro-organism is exposed to UV, power fluctuations of the UV source that impact the EM wavelength, the presence of particles that can protect the micro-organisms from UV, and a micro-organisms ability to withstand UV during its exposure. In many systems redundancy in exposing micro-organisms to

UV is achieved by circulating the air or water repeatedly. This ensures multiple passes so that the UV is effective against the highest number of micro-organisms and will irradiate resistant micro-organisms more than once to break them down.

The effectiveness of this form of sterilization is also dependent on line of sight exposure of the micro-organisms to the UV light. Environments where design creates obstacles that block the UV light are not as effective. In such an environment the effectiveness is then reliant on the placement of the UVGI system so that line of sight is optimum for sterilization.

A separate problem that will affect UVGI is dust or other film coating the bulb, which can lower UV output. Therefore bulbs require annual replacement and scheduled cleaning to ensure effectiveness. The lifetime of germicidal UV bulbs varies depending on design. Also the material that the bulb is made of can absorb some of the germicidal rays.

Creating UVGI: Germicidal UV is delivered by a mercury-vapor lamp that emits UV at the germicidal wavelength. Mercury vapor emits at 254nm. Many germicidal UV bulbs use special transformers to ensure even electrical flow to the bulbs so the correct wavelength is maintained. Since germicidal UV has a narrow bandwidth, power fluctuations will render intended irradiating environments ineffective. In some cases, UVGI electrode less lamps can be energized with microwaves, giving very long stable life and other advantages. This is known as 'Microwave UV.'

There are several different types of germicidal lamps: - Low-pressure UV lamps offer high efficiencies (approx 35% UVC) but lower power, typically 1 W/cm³ power density. - Amalgam UV lamps are a high-power version of low-pressure lamps. They operate at higher temperatures and have a lifetime of up to 16,000 hours. Their efficiency is slightly lower than that of traditional low-pressure lamps (approx 33% UVC output) and power density is approx 2-3 W/cm³. - Medium-pressure UV lamps have a broad and pronounced peak-line spectrum and a high radiation output but lower UVC efficiency of 10% or less. Typical power density is 30 W/cm³ or greater.

Depending on the quartz glass used for the lamp body, low-pressure and amalgam UV lamps emit light at 254 nm and 185 nm (for oxidation). 185 nm light is used to generate ozone.

Potential dangers: A 9 W germicidal lamp in a modern compact fluorescent lamp form factor at certain wavelengths (including UVC) UV is harmful to humans and other forms of life. In most UVGI systems, the lamps are shielded or are in environments that limit exposure, such as a closed water tank or closed air circulation system, often with interlocks that automatically shut off the UV lamps if the system is opened for access by human beings. Limited exposure mitigates the risk of danger. In human beings, skin exposure to germicidal wavelengths of UV light can produce sunburn and (in some cases) skin cancer. Exposure of the eyes to this UV radiation can produce extremely painful inflammation of the cornea and temporary or permanent vision impairment, up to and including blindness in some cases. UV can damage the retina of the eye.

Another potential danger is the UV production of ozone. UVC light from the sun is partly responsible for the earth's ozone layer in the stratosphere, but ozone at the atmospheric level can be harmful to a person's health. The United States Environmental Protection Agency designated .05 parts per million (ppm) of ozone to be a safe level.

UV-C radiation is able to break-down chemical bonds. This leads to rapid ageing of plastics (insulations, gasket) and other materials. Note that plastics sold to be "UV-resistant" are tested only for UV-B, as UV-C doesn't normally reach the surface of the Earth.

Uses for UVGI, Air purification: UVGI can be used to sterilize air that passes UV lamps via forced air. Air purification UVGI systems can be freestanding units with shielded UV lamps that use a fan to force air past the UV light. Other systems are installed in forced air systems so that the circulation for the premises moves micro-organisms past the lamps.

Key to this form of sterilization is placement of the UV lamps and a good filtration system to remove the dead micro-organisms. For example, forced air systems by design impede line of sight, thus creating areas of the environment that will be shaded from the UV light. However, a UV lamp placed at the coils and drain pan of cooling system will keep micro-organisms from forming in these naturally damp places. The most effective method for treating the air rather than the coils is in-line duct systems, these systems are placed in the center of the duct and parallel to the air flow.

Water purification: Water purification via UVGI is used in most water sterilization processes, such as purification, detoxification and disinfection. Its use in wastewater treatment is replacing chlorination due to that chemical's toxic by-products. A disadvantage is that water treated by chlorination is resistant to re-infection, where UVGI water must be transported and delivered in such a way as to avoid contamination. Individual waste streams to be treated by UVGI must be tested to ensure that the method will be effective due to potential interferences such as suspended solids, dyes or other substances that may block or absorb the UV radiation.

"UV units to treat small batches (1 to several liters) or low flows (1 to several liters per minute) of water at the community level are estimated to have costs of 0.02 US$ per 1000 liters of water, including the cost of electricity and consumables and

the annualized capital cost of the unit." (WHO).

Laboratory hygiene: UVGI is often used to sterilize equipment such as safety goggles, instruments, pipettors, and other devices. Lab personnel also sterilize glassware and plasticware this way. Microbiology laboratories use UVGI to sterilize surfaces inside biological safety cabinets ("hoods") between uses.

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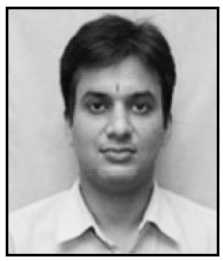

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