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SOLAR AIR PURIFIER & AIR MONITORING

¹Mrs. Thanuja K, ²Mr. Swaroop N S

¹Assistant Professor, ²Assistant Professor

¹Department of Electrical & Electronics Engineering,

¹G Madegowda Institute of Technology, Bharathinagara, Maddur Taluk, Mandya, Karnataka, India

Abstract: Air pollution has become a serious problem these modern days. Poor air quality is commonly found in larger cities, and is the result of a growing industrialization that pollutes the air we breathe with contaminants like industrial dust, smog and other particles from traffic. The solution from a user perspective is to use an air purifier that cleans the air from these particles. An air purifier can also be used to ease annoyance for people suffer from allergies. However, most air purifiers on the market today are made with one-time use filters, and incur a regular cost for the consumers. Air pollution is present outside in the environment and has become difficult to provide safety inside the house. This polluted air can cause many serious health problems in cities. If someone is suffering from breathing problems like Asthma or Sinus or suffering from any lung problem then air purifier acts as a surviving tool. Air purifier reduces the chances of health issues caused by indoor pollutants, which directly trigger neurological problems, respiratory infection or symptoms in asthma suffering. Hence, the fabrication of a low-cost solar powered air purifier made using a filter, Activated Carbon Filter, Solar Panel, and some miscellaneous components that can become a low-cost but efficient alternative for surviving in such difficult times. This air purifier uses various processes like filtering large dirt particles on the first pre-filter, then capturing dust particles and smoke molecules at the filter, and uses Carbon-filter to capture micro-particles produces clean purified air.

Index Terms – Carbon filter, air purifiers, air quality

I. INTRODUCTION

AIR POLLUTION

Air pollution is a mixture of solid particles and gases in the air. Car emissions, chemicals from factories, dust, pollen and mild spores may be suspended as particles. Air pollution occurs when harmful or excessive quantities of substances including the gases, particles, and biological molecules are introduced into Earth's atmosphere. Of the most polluted cities in the world, 21 out of 30 were in India in 2019. As per a study based on 2016 data, at least 140 million people in India breathe air that is 10 times or more over the WHO safe limit and 13 of the world's 20 cities with the highest annual levels of air pollution are in India. The 51% of pollution is caused by the industrial pollution, 27% by vehicles, 17% by crop burning and 5% by diwali fireworks. Air pollution contributes to the premature deaths of 2 million Indians every year. Emissions come from vehicles and industry, whereas in rural areas, much of the pollution stems from biomass burning for cooking and keeping warm. In autumn and winter months, large scale crop residue burning in agriculture fields – a cheaper alternative to mechanical tilling – is a major source of smoke, smog and particulate pollution. India has low per capita emissions of greenhouse gases but the country as a whole is the third largest greenhouse gas producer after China and the United States. A 2013 study on non-smokers has found that have 30% weaker lung function than Europeans.



Fig. 1.1: Gases from Chimneys

RAPID URBANIZATION

Rapid urbanization is the main cause for all means of pollution and air pollution is also in an alarming condition, the increase in population density in city leads to rapid deforestation and also maximum use of automobiles which produce harmful gases into the atmosphere. The death rates have increased drastically due to these harmful gases causing air pollution which leads to unconditional and unseasonal rain eventually leads to shifting in monsoon and disturbs the ecological cycle. About 34% of India's population lives in urban areas. Automobile exhaust produces elevated lead levels in urban air.

EFFECTS OF AIR POLLUTION ON HUMAN HEALTH

- Respiratory problems
- Ischemic heart disease
- Stroke
- Chronic obstructive pulmonary disease
- Lung cancer

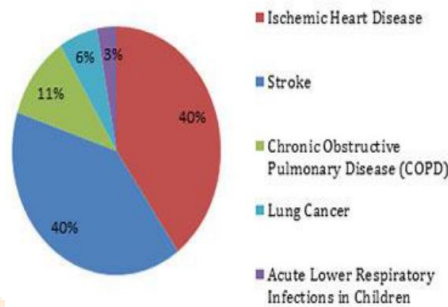


Fig. 1.2: Ambient Air Pollution

AIR POLLUTANTS

1. PM2.5 & PM10

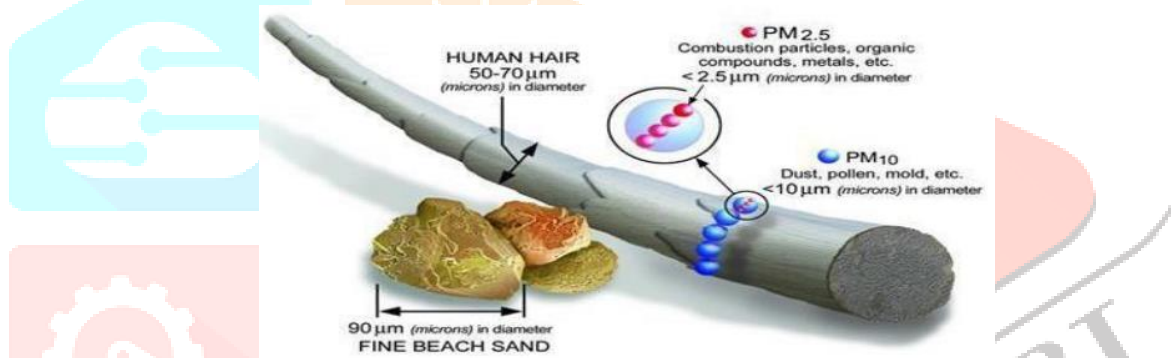


Fig. 1.3: Particulate Matter

Particulate matter mainly includes Carbon monoxide. PM2.5 and PM10 refers to the atmospheric particulate matter that have diameter of less than 2.5 micro meters, the particles in this category are so small that they can only be detected with an electron microscope, the particulate matter arises from power plants, motor vehicles, airplanes, residential wood burning, forest fires, agricultural burning, volcanic eruptions and dust storms etc. As shown in the fig above the human hair diameter is 50-70 microns and PM2.5 particles are so small that it varies from 10 microns to 2.5 microns or even less, since they are so small and light, fine particles tend to stay longer in the air than heavier particles, this increases the chances of humans and animals inhaling them into the bodies. Owing to their minute size, particles smaller than 2.5 micro meters are able to bypass the nose and throat and penetrate deep into the lungs and some may even enter the circulatory system, these particulate matter cause asthma, cardiovascular diseases, lung cancer and so on.

2. SMOG

Smog is a type of intense air pollution. This kind of visible air pollution is composed of nitrogen oxides, sulphur oxides, ozone, smoke and other particulates. Man-made smog is derived from coal combustion emissions, vehicular emissions, industrial emissions, forest and agricultural fires and photochemical reactions of these emissions. A type of air pollution derived from vehicular emission from internal combustion engines and industrial fumes.



Fig. 1.4: SMOG

3. BACTERIA, VIRUS AND ODOUR

Airborne diseases are illnesses spread by tiny pathogens in the air. These can be bacteria, fungi, or viruses, but they are all transmitted through airborne contact. It causes Anthrax, Diphtheria and other diseases.

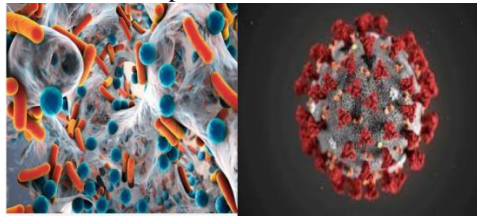


Fig. 1.5: Bacteria & Virus

II. BLOCK DIAGRAM

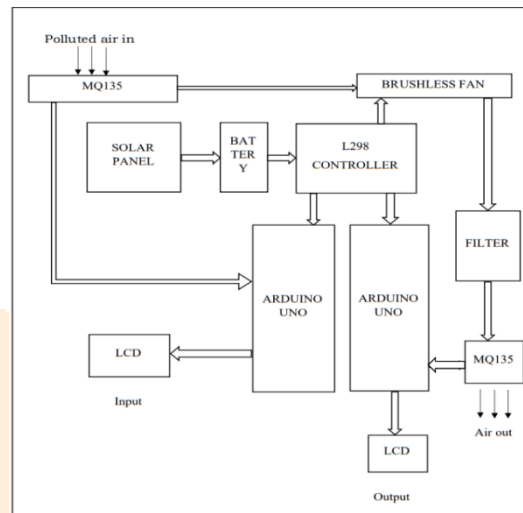


Fig. 2.1: Block diagram of Solar Air Purifier

The above figure shows the block diagram of the solar air purifier that we are implemented in our paper.

- The solar panel of the range 10 watt is used which captures the sun light, which is then given to the battery to store the converted solar energy into electrical energy.
- The rating of the battery used is 12v and 1.3 amps. Here another end of battery is connected to L298 controller. It converts 12 V supply into 5v for Arduino uno board.
- From the controller two connections are given to two Arduino boards and another connection is given to brushless fan.
- To the brushless fan one MQ135 sensor is connected also from the fan a connection is given to filter. MQ135 measure the air in the range of 10 meters.
- Brushless fan is used to suck the air and push the air towards the filter.
- From the filter connection is given to another MQ135 sensor. Filter adsorbs the polluted air and makes the bonding.
- Now both the sensors given to two Arduino boards to measure the air quantity, also two LCDs are given to the two Arduino boards to display input and output from the module.

III. SYSTEM REQUIREMENTS

Hardware Requirements

Solar panel

Solar panels are those devices which are used to absorb the sun's rays and convert them into electricity or heat. A solar panel is actually a collection of solar (or photovoltaic) cells, which can be used to generate electricity through photovoltaic effect. These cells are arranged in a grid-like pattern on the surface of solar panels. Thus, it may also be described as a set of photovoltaic modules, mounted on a structure supporting it. A photovoltaic (PV) module is a packaged and connected assembly of 6×10 solar cells. Most solar panels are made up using crystalline silicon solar cells. Here we are using 10-watt capacity solar panel.

Battery (12v)

A battery can be defined as an electrochemical device (consisting of one or more electrochemical cells) which can be charged with an electric current and discharged whenever required. Batteries are usually devices that are made up of multiple electrochemical cells that are connected to external inputs and outputs. Batteries are widely employed in order to power small electric devices such as mobile phones, remotes, and flashlights. Historically, the term battery has always been used in order to refer to the combination of two or more electrochemical cells.

Arduino UNO

The Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

LCD

A liquid-crystal display (LCD) is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals combined with polarizer's. Liquid crystals do not emit light directly, instead using a backlight or reflector to produce images in color or monochrome. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images with low information content, which can be displayed or hidden. For instance: pre-set words, digits, and seven-segment displays, as in a digital clock, are all good examples of devices with these displays.

MQ135 sensor

The MQ-135 Gas sensor can detect gases like Carbon monoxide (CO), Ammonia (NH₃), sulfur (S), Benzene (C₆H₆), CO₂, LPG and other harmful gases and smoke. Similar to other MQ series gas sensor, this sensor also has a digital and analog output pin. When the level of these gases goes beyond a threshold limit in the air the digital pin goes high. This threshold value can be set by using the on-board potentiometer. The analog output pin, outputs an analog voltage which can be used to approximate the level of these gases in the atmosphere.

Technical Specifications of MQ135 Gas Sensor

- Operating Voltage: 2.5V to 5.0V
- Power consumption: 150mA
- Detect/Measure: CO, NH₃, NO_x, CO₂, Alcohol, Benzene, Smoke, LPG
- Typical operating Voltage: 5V
- Digital Output: 0V to 5V (TTL Logic) @ 5V Vcc
- Analog Output: 0-5V @ 5V Vcc

PCB

A printed circuit board (PCB) mechanically supports and electrically connects electrical or electronic components using conductive tracks, pads and other features etched from one or more sheet layers of copper laminated onto and/or between sheet layers of a non-conductive substrate. Components are generally soldered onto the PCB to both electrically connect and mechanically fasten them to it.

I2C module

I2C Module has an inbuilt PCF8574 I2C chip that converts I2C serial data to parallel data for the LCD display. These modules are currently supplied with a default I2C address of either 0x27 or 0x3F. To determine which version, you have checked the black I2C adaptor board on the underside of the module. If there 3 sets of pads labeled A0, A1, & A2 then the default address will be 0x3F. If there are no pads the default address will be 0x27. The module has a contrast adjustment pot on the underside of the display. This may require adjusting for the screen to display text correctly.

DHT 11 sensor

The DHT11 is a commonly used Temperature and humidity sensor that comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data.

L298 controller

The module has two screw terminal blocks for the motor A and B, and another screw terminal block for the Ground pin, the VCC for motor and a 5V pin which can either be an input or output. It converts 12 v supply into 5v for Arduino UNO board.

Brushless fan

A brushless DC fan uses brushless DC motors (BLDC motor) that have a cross pattern arrangement of four permanent magnets mounted on the sides of the rotors. Unlike brushed DC motors, BLDC motors do not require any commutator or brushes to operate. The brushless DC fan is a combination of a powerful BLDC motor, shaft, and fan blades. These fans are durable, reliable, and highly energy efficient. They do not produce sparks in the circuit and operate noiselessly.

Carbon filter

Carbon air filters are the filters most commonly used to remove gases. They are designed to filter gases through a bed of activated carbon (also called activated charcoal) and are usually used to combat volatile organic compounds (VOCs) released from common household products. They are also often used to remove odours from the air, such as the smell of tobacco smoke. Carbon air filters are the filters most commonly used to remove gases. They are designed to filter gases through a bed of activated carbon (also called activated charcoal) and are usually used to combat volatile organic compounds (VOCs) released from common household products. They are also often used to remove odours from the air, such as the smell of tobacco smoke.

IV. WORKING PRINCIPLE

Fig. 4.1: Purification Process

The solar panel captures sunlight and it converts solar energy into electrical energy. Then it sends 12 v supply to the battery. The battery stores the current according to its respective capacity and these batteries can serve as low cost power solution for all terral robots or combat robots and other electronic projects. If you looking for high performance high current discharge batteries try titanium battery. From battery to it's connected to L298 electronic drive controller. This drive controller is used for controlling a DC motor and 5v supply for Arduino uno board and it is commonly used in autonomous robots. A drive controller takes the low voltage input from a controller like Arduino and it can control the DC motor by giving appropriate logic to the motor drive module. From the controller one end is connected to brushless DC fan and the brushless DC fan is required 12v supply. The controller is connected to two Arduino uno boards. The Arduino uno board is a microcontroller board based on the Atmega328P it has 14 digital input and output pins, 6 analog inputs. The first Arduino uno board shows the input of the polluted air by using MQ135 sensor and LCD display. Here for both the Arduino uno boards separate LCD and MQ135 sensor is connected to read the analog values and display them. The Arduino uno get the input analog signal from the MQ135 gas sensor and it send the signal to LCD display the amount of polluted air in ppm (parts per million). The MQ135 is one of the commonly used gas sensors in MQ sensor series it is a metal oxide semiconductor type gas sensor.

Liquid crystal display is a type of flat panel display which uses liquid crystal in its primary form of operation and the fan is pushes polluted air through the filters. The filters are the elements filtering air or gases, fluids, where the filters provide filtration and gets the output as cleaned air and the other Arduino is used to show the output of the air quality and the second MQ135 gas sensor gives the analog signal to the second Arduino board. The Arduino send the signal to the output LCD display is shows the amount of filtered air signal. Then as the result the amount of air pollution is reduced and it shows the output on the LCD display.

Air environmental parameters

With rapid industrialization and urbanization over the past decades, the world has experienced widespread air pollution and increased awareness of the importance of environmental air monitoring. Air pollution can be defined as an atmospheric condition in which various substances are present at concentrations high enough, above their normal ambient levels to produce a measurable effect on people, animals, vegetation or materials. Air pollutants are dangerous to human health as well as environment.

In scientific research concerning air quality studies, scientists are able to determine the significant short and long-term impacts that come from industrial activities and the areas that may experience these effects. In people's daily lives, environmental monitors can indicate the safety of people's in-door and out-door activities. For example, people can stay informed of local real-time air pollution to decide if they can exercise outside, if they need a breathing mask to be safe, or if staying indoors is their best option. In extreme conditions, schools will be closed for the safety of the children, and it is best for anyone who is sensitive to reduce their exposure to hazardous air pollution levels.

Deciding the air quality on any given day requires environmental analysis and monitoring, which is a very challenging and dynamic field. In this part, we discussed the several major air parameters that are related to the safety of people during their day-to-day lives. There has been an increasing awareness of the air quality issue all over the world, with a special focus on PM 2.5. This parameter refers to microscopic solid or liquid matter suspended in the air that has a diameter of 2.5µm or less. Particle pollution comes from many different types of sources, including power plants, industrial processes, vehicle tailpipes, woodstoves, wildfires, and some agricultural operations. PM2.5 is able to penetrate deep into our lung tissues and can cause various health problems. The table 5.2 shows the impacts of different level of PM2.5 pollutant.

Table 4.1: PM2.5 Pollutant Level

PM2.5 (µg/m ³)	PM2.5 Health Effects Statement	PM2.5 Cautionary Statement
Good (0-35)	PM2.5 air pollution poses little or no risk.	None
Moderate (36-75)	Unusually sensitive individuals may experience respiratory symptoms.	Unusually sensitive people should consider limiting prolonged outdoor exertion.
Unhealthy for Sensitive Groups (75-115)	Increasing likelihood of respiratory symptoms in sensitive individuals, aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly.	Active children and adults, and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion.
Unhealthy (116-150)	Increased aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; increased respiratory effects in general population.	Active children and adults, and people with respiratory disease, such as asthma, should avoid prolonged outdoor exertion; everyone else, especially children, should limit prolonged outdoor exertion.
Very Unhealthy (151-250)	Significant aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; significant increase in respiratory effects in general population.	Active children and adults, and people with respiratory disease, such as asthma, should avoid all outdoor exertion; everyone else, especially children, should limit outdoor exertion.
Hazardous (251-500)	Serious aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; serious risk of respiratory effects in general population.	Everyone should avoid all outdoor exertion.

Oxygen is another important air parameter, as it's essential to life. The oxygen level in the atmosphere varies from place to place. For instance, areas near a large number of factories and big cities have lower Oxygen levels due to pollution. Other places such as rural areas and forests have higher oxygen levels that promote good health because there is less pollution and more plants to make oxygen. The normal atmosphere contains between 20.8 to 21 percent oxygen. According to OSHA (Occupational Safety and Health Administration), air oxygen concentration below 19.5 percent is considered to be oxygen deficient; and above 22 percent is oxygen 8 enriched.

CO is a colourless, odourless gas and non-combustible gas. Moreover, it is considered under the category of asphyxiate gases that have capability of interfering the availability of oxygen for tissues. The global average concentration of CO now in Earth's atmosphere is about 400 ppm (parts per million by volume). Prior to the Industrial Revolution, CO levels were at 280 ppm. The planet didn't reach the 400 ppm mark by itself. There is abundant evidence showing that the atmospheric CO increase is caused by humans. CO makes up less than 1 percent of our atmosphere. But this small amount of CO has a big impact on the planet. Plants use CO for photosynthesis and earth's temperature is controlled by CO. For these reasons and more, CO is an important parameter in measuring air quality.

The unit of parts per million (ppm) is numerically equivalent to micromoles of CO per mole of air. Outdoor CO levels are usually 350-450 ppm whereas the maximum indoor CO level considered acceptable is 1000 ppm. When the concentration goes above 1000ppm, the air becomes stagnant and people begin to feel sleepy. Once the CO reaches 5000ppm, a person should be limited to 8 hours of exposure according to OSHA (The Occupational Safety and Health Administration).

Rain can help to remove pollutant particles from the air, and it is a very efficient way to decrease the PM_{2.5} level quickly. It is also linked to temperature and humidity levels thus is an important factor in weather condition. Temperature and humidity also affect the presence of pollutants in the air. For instance, haze often occurs when dust, smoke and other pollutant particles accumulate in relatively dry air. Winter is the most polluted time of year in China, as cold and dry air prevents smoke and other pollutants from dispersing. This is because warm air sits near the ground and the air can rise easily and carry away pollutants, but cold air is trapped near the ground by a layer of warm air. Temperature and humidity can also affect human comfort and many manufacturing processes in industries. OSHA recommends temperature control in the range of 20- 25°C and humidity control in the range of 20%-60%.

In addition to above parameters there are some other factors that determine the air quality. These factors include toxic gases (NO_x, O₃, CO₂, SO₂, NH₃, H₂S), volatile organic compounds (benzene, toluene, xylene), polycyclic aromatic hydrocarbons (PAH), greenhouse gases (CO₂, CH₄, N₂O), particulate matter PM_{2.5}, PM₁₀ (PM₁₀ are particles less than 10 micro meters in diameter), aerosol and dust, heavy metals, pollens in the environment. Humans inhaling pollutants for an extended period of time will cause irreversible damage to their health.

Hardware Implementation



Fig. 4.2: Model Implementation

4.1 Conclusion

This paper was a valuable experience in the design, implementation, and testing of environmental air parameters. The design process also helped raise awareness of the quality of air that one breathes daily. In general, the design fulfills its intended objective, which is a user friendly, low cost, portable, environmental monitoring device. The measurement results were satisfactory in some aspects. The CO sensor would work better after calibration; lacking a professional calibration equipment and condition, the measured value only reflects the approximated trend of gas concentration, it does not represent the exact gas concentration. Overall, this portable system can give a real time measurement of air parameters and record the results for future long term air quality studies. Furthermore, its dual power supply design and low consumption components make it more affordable for home based users. The device is also designed in such a manner that it can have extended uses in the future, by adding an extra sensor such as sensors for the measurement of the SO₂ parameter or NO parameter.

This work contributes with a methodology to improve the quality of the air, which helps to balance the healthy lifestyle and to protect humans from suffering breathing problems. It also very economical and do not have to replace any component quickly. It reduces particulate level to satisfactory position where a person does not need to worry about pollution related problems. A pure and clean air is right of a human being and all other living creatures

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