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Microcontroller based open aqua-aero purifier

Digvijay Singh[1], Diksha Singh[2], Lucy[3], Prof. M.V. Patil [4]

[1]UG Student, Electronics Department,BharatiVidyapeeth Deemed to be University, College of Engineering, Pune
[2]UG Student, Electronics Department,BharatiVidyapeeth Deemed to be University, College of Engineering, Pune
[3]UG Student, Electronics Department, BharatiVidyapeeth Deemed to be University, College of Engineering, Pune
[4]Assistant Professor, Electronics Department, BharatiVidyapeeth Deemed to be University, College of Engineering, Pune

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Abstract -Urbanization increased population density in cities and consequently leads to severe air and water pollution. As a result of these trends, the issue of sustainable and healthy environment has received increasing attention. Various air and water filtration techniques have been adopted to optimize environment quality. Air filtration technique can remove air pollutants and effectively alleviate the deterioration of air quality and same goes for water filtration. This paper aims to drive the future of air and water purification technology development in achieving sustainable and healthy ventilation. It provides a cost effective and efficient model for air and water purification simultaneously.

Key Words:Arduino UNO, Air sensors, Air Purifiers, Water sensor, Water filters

1.INTRODUCTION

Development is changing its shape drastically throughout the whole world; distinct nations have made a tremendous growth in urbanization and industrialization on a phenomenal scale. In India, one million of population had expanded in excess of 120 urban areas. This radical change of figures in small period of time has caused increased air and water contamination everywhere and many nations have dedicated sectors to resolve this issue. In concern and contribution to the environment welfare this project is proposed to overcome the harmful pollution [1].

This project is a combined air and water purification solution comprising of air and water sensors & filters boarded on a single device separated through a floating tube, which provides filtration of air and water adjacent to each other but distinctly operating as the readings meet up the separate set points respectively.

As shown in Fig.1, the structural view of aqua-aero purifier is depicted. The whole setup comprises of three major sections-

1: Open Air Purifier: This part deals with air contamination by passing the air through filters when the pollution level reaches a certain limit. It comprises of air sensors, filters and fans.

2: Floating Tube: This is a semi merged floating panel which is used to separate the other two sections which are the air purifier and water purifier. This part is crucial to make the whole setup float. It has ring structure which has air encapsulated inside making the device float and half merged inside the water simultaneously

3: Open Water Purifier: This part deals with water contamination. Pollution level more than the set limit triggers the pump to pass the water through various filters providing pollution free water from outlet.

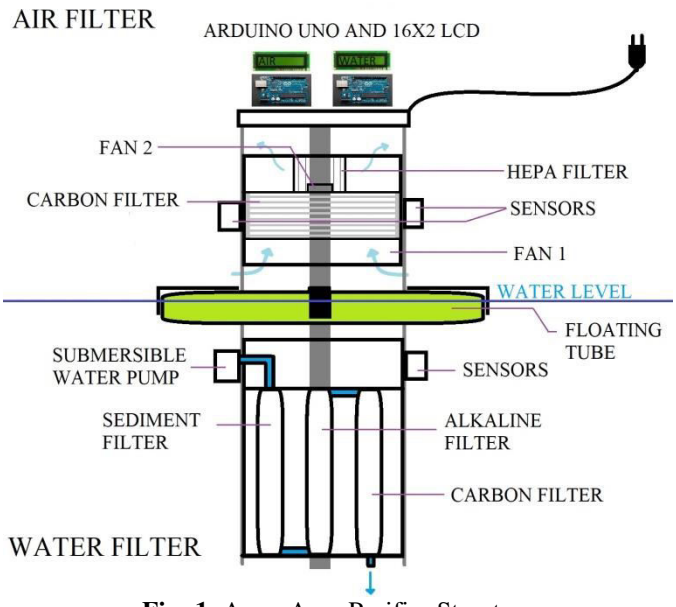

Fig -1: Aqua-Aero Purifier Structure

Combining the all three sections a single solution for air and water contamination is produced as shown in Fig.1. For a single device the purification is very small, but for a bunch of similar devices provides a large scale of purification. This paper cover ups the basic functioning of an air and water purifier which can be upgraded as per the need for example, using PLC for industrial treatment, usage of solar panels, including IOT to calibrate value as per the changes, etc.

2. Literature Survey

The proposed model suggested above is viewing the various models and papers:-

"World's Largest Air Purifier" under research at Institute of Earth Environment -

Chinese Academy of Sciences [2].This is an experimental tower that has been built in Xian in Shaanxi province, northern China that is said to be the largest air purifier in the world standing at over 100 meters (328 feet) high. Around the base of the tower is a system of greenhouses that cover an area about half the size of a soccer field. It sucks polluted air in and heats it up with solar energy. The heated air then rises up through the tower and passes through multiple layers of cleaning filters.

Dutch Group [3] has crafted and proposed an air purifier that boasts 100 percent removal of fine particles and 95 percent of ultrafine particles from the atmosphere. According to Envinity Group, the system rapidly filters these particles from the air, cleaning 80,000 m³ of air per hour within a 300-meters radius, and up to a height of 7 km.

S B Mills [4] proposed the method of a combined ionic air filter and humidifier apparatus filters; it is experimented in which ionic air filtering, humidifies at least a portion of the filtered ionized air, and directs the humidified filtered ionized air back into the environment. The apparatus generally includes an ionic air filter for ionizing and filtering air to produce filtered ionized air and a humidifier for humidifying the filtered ionized air to produce humidified filtered ionized air.

G Kuncova[5] introduces conductivity sensor and describes use of Arduino to gather data about the pollution levels. The sensor comprises of 2 copper wires which are dipped inside the water without being connected and stripped at small sections. The stripped section forms up a contact with water which provides connectivity and voltage drop across those wires, this voltage drop is calibrated into pollution level.

Mathew Rela[6] proposed water purifier using membranes, ion exchange resins and electricity to remove ionic, organic and suspended impurities from water to produce high quality, pure water. Supply water is pre-treated by directing it first into a sediment pre-filter module, a softener module and a sediment removal and dechlorination module. The pre-treated water is supplied to a reverse osmosis module which separates the water into two streams (a purified water stream and a concentrate stream) by collecting fluids from both sides of pressurized membranes. The purified water is passed to an electrodeionization module which further purifies the water and directs the water to an ultraviolet sterilization module.

3. Proposed Methodology

A. Air

The sensors provide an analog value which is sent to the microcontroller (arduino). The analogue value is then calibrated and compared with the reference value; if the sensed value lies in the range of polluted air then the controller sends the signal to the fans which are located in the middle of the device.

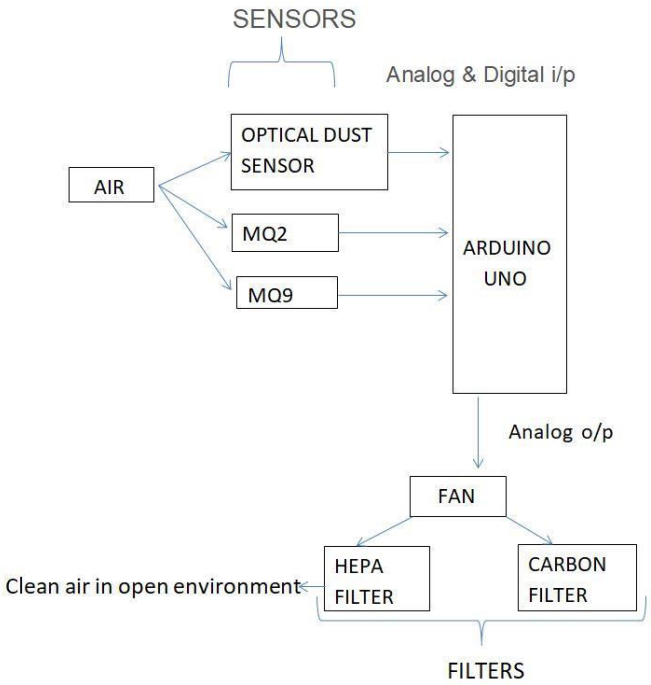

Fig -2: Air Purifier Block Diagram

The fans push the air through various filters present inside the whole architecture which provides filtration from the impure particles. The filtered air is then released in open environment resulting into purification of air. The functioning of air purifier continuous until the set point is reached. [7]. From Fig.2,

a. Sensors

1. GP2Y1010AU0f Optical Dust Sensor Module: It is used to Sense Dust Particles in air by detecting the reflected light of dust in air.[8]
Formulas used-

$$v = analogRead(A5)$$

$$voltage = 5.0 \times \frac{v}{1023}$$

$$dust\ density = 0.17 \times voltage - 0.1$$

2. MQ-2: This module uses MQ2 Smoke & Flammable gas sensor as a gas sensing element. Gases like LPG, Propane & Hydrogen.[9]
Formulas used-

$$r = analogRead(A0)$$

$$a_n = 5 \times \frac{1023 - r_n}{r_n}$$

Where n=1, 2, 3, 4 & 5

Each digit represents ms (milliseconds) passed

$$r_s = \frac{a_1 + a_2 + a_3 + a_4 + a_5}{5}$$

$$\%\ in\ ppm = 10^{\left(\frac{\log\left(\frac{r_s}{10}\right) - c[1]}{c[2]} + c[0]\right)}$$

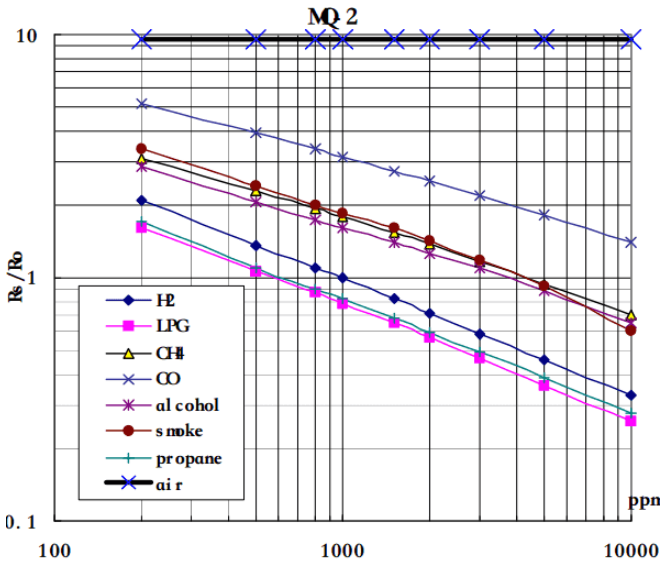

Fig -3: MQ2 Sensitivity Curve

LPG: c = [2.3, 0.21,-0.47]
CO: c = [2.3, 0.72,-0.34]
Smoke: c = [2.3, 0.53,-0.44]
Default format; c = [x , y , slope]

Two points are taken from the MQ2 sensitivity curve (Fig.3), with these points a line is formed which "approximately equivalent" to the original curve.[10]

3. MQ-9: It has high sensitivity to Carbon Monoxide, Methane and LPG. [11]
Formulas used-

$$v = analogRead(A1)$$

$$voltage = 5.0 \times \frac{v}{1023}$$

$$RS_{gas} = \frac{5.0 - v}{v}$$

$$ration = \frac{RS_{gas}}{0.91}$$

b. Filters

1. Carbon Filter: Carbon can be treated with oxygen, which opens the carbon's pores making it highly absorbent to impurities.

2. HEPA Filter: It can remove up to 99.97% of airborne particles, making them extremely effective air sanitizers. [12]

B. Water

The first step here is to determine the presence of impurity which is calibrated by a custom made water sensor which comprises of two nichrome wires dipped inside the water separated with the distance of 1 cm which provides the voltage value of the connection established due to cation and anion impurities present in the water to the microcontroller. As per the readings which are set up according to the relation between voltage drop and water impurities, the microcontroller then gives signal to the submerged water pump to circulate the water through filters. These filters separate the impurities from water and pass the clean water into the open water body. The process repeats itself until the set point is reached. [13]. From Fig.4.

a. Sensor

1. Conduction based water pollution sensor: It measures the capability of a solution such as water to pass an electric current. It detects cation and anion impurities in water. Like Chloride, Sulphate, Hydroxide, etc. [14]

$$r = analogRead(A0)$$

$$voltage = 5.0 \times \frac{r}{1023}$$

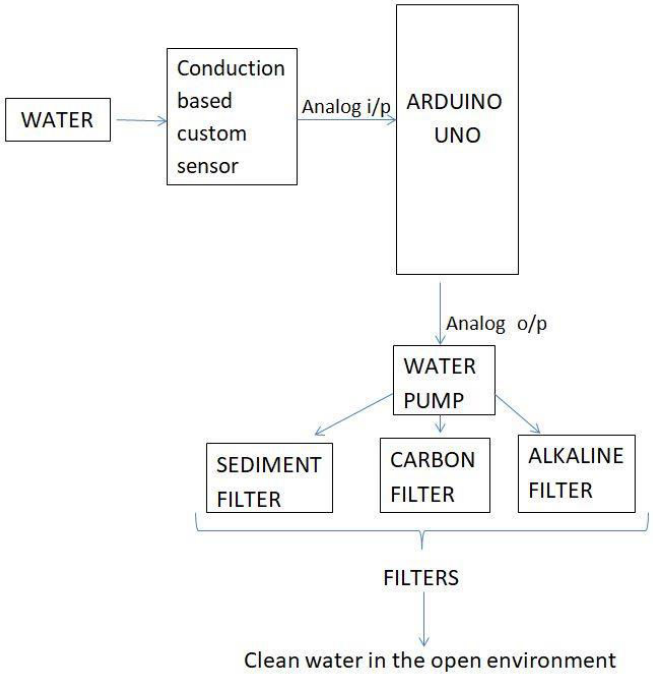

Fig -4: Water Purifier Block Diagram

b. Filters

1. Sediment Filter: The filter has a bed of natural media (sand, anthracite, etc.). As the water passes through this bed, unwanted dirt particles become trapped.

2. Alkaline Filter: It produces a chemical change in the water. The filter separates the water into two types: alkaline water and acidic water.

3. Carbon Filter: It attracts and absorbs larger particles like sediment and silt. [15].

Microcontroller

Arduino Uno (Fig.5) 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 ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. [16]

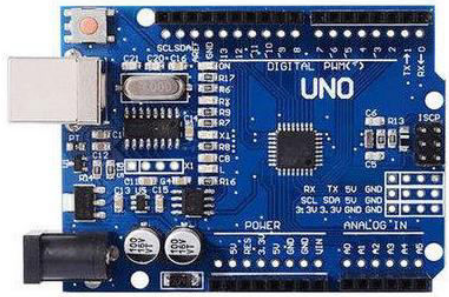

Fig -5: Arduino UNO

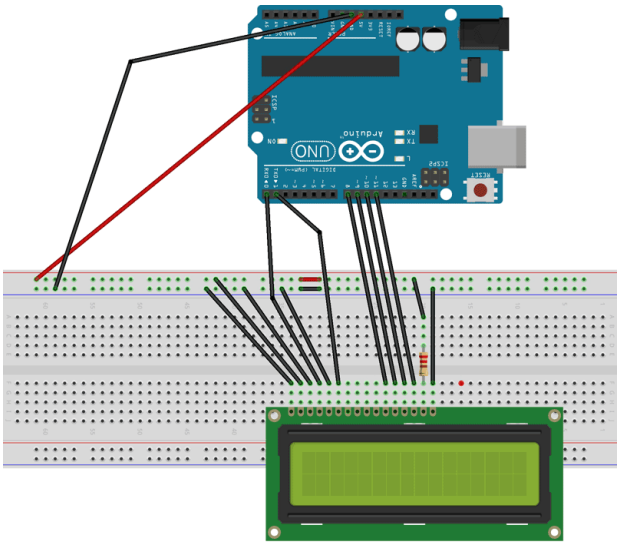

Fig -6: Arduino UNO and LCD 16X2 Connections

Table -1: LCD Interfacing with Arduino UNO

No.	16X2 LCD	Arduino Uno
1.	VSS (Ground)	GND
2.	VCC (5V)	+5V
3.	VEE (Contrast)	GND (+1.5KΩ)
4.	RS (Register Select)	11(DIGITAL)
5.	R/W (Read/Write)	GND
6.	E (Enable)	10(DIGITAL)
7.	DB0	-
8.	DB1	-
9.	DB2	-
10.	DB3	-
11.	DB4	9(DIGITAL)
12.	DB5	8(DIGITAL)
13.	DB6	7(DIGITAL)
14.	DB7	6(DIGITAL)
15.	LED +5V	+5V
16.	LED GROUND	GND

4. Experimental Results

Table -2: Set point Table

No.	Sensor	Part	Normal	Pollution	Set Point
1.	MQ 2	LPG	0-30 ppm	100-310 ppm	50 ppm
		CO	0-550 ppm	7212-13674 ppm	700 ppm
		Smoke	0-16 ppm	1200-2200 ppm	200 ppm
2.	GP2Y1010AU0f	Dust Density	0-0.10 g/cm^3	0.25-0.51 g/cm^3	0.15 g/cm^3
3.	MQ 9	R_s/R_o ration	0-1.75 ppm	11.54-11.69 ppm	4 ppm
4.	Conduction based water sensor	Voltage	0-0.2 V	1.2-4.6 V	0.5 V

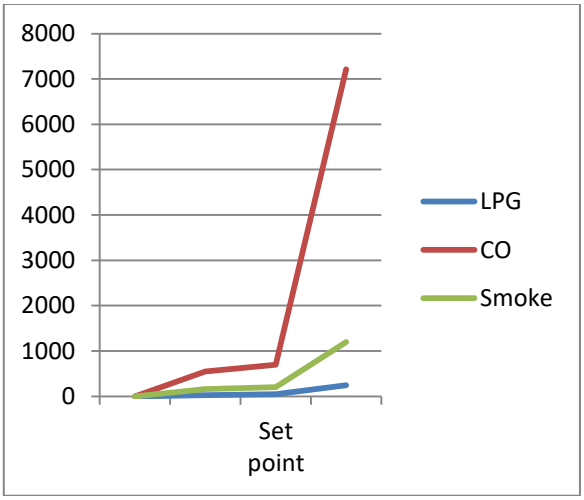

Fig -7: MQ 2(x-environment, y-ppm)

The environment is changed from clean indoor environment to open environment to the interaction of sensors to the polluted gases. For each sensor, various experiments were conducted with respective detection components. MQ 2 - LPG, Air near garbage areas and smoke. Fig.7
Dust Sensor - incense stick air and smoke. Fig.8
MQ 9 - Air near garbage areas and LPG. Fig.9
Water conduction based sensor - dilute water, salty water and chlorinated water. Fig.10.

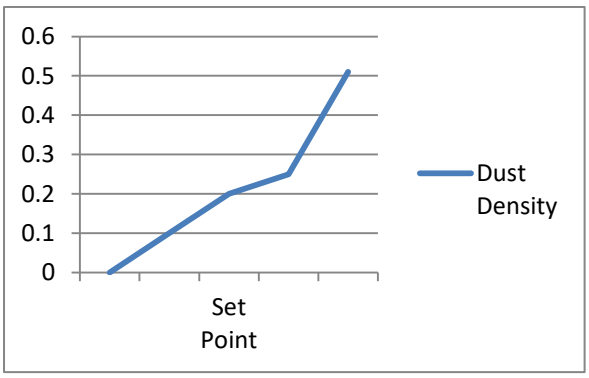

Fig -8:GP2Y1010 AU/0f Dust Sensor Module (x-environment, y-g/cm^3)

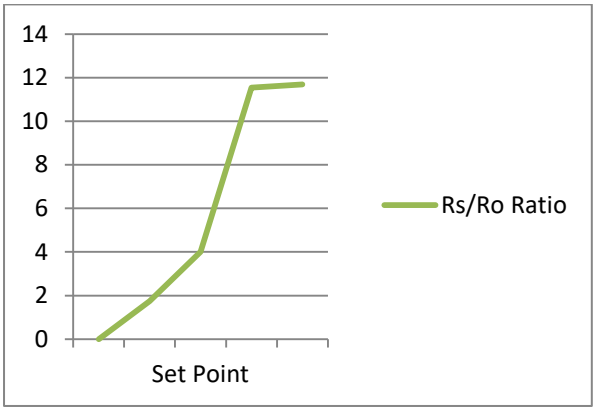

Fig -9:MQ 9(x-environment, y-ppm)

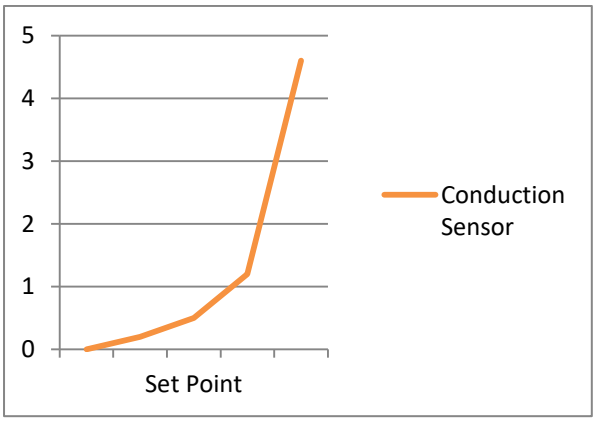

Fig 10:Water Conduction Sensor(x-environment, y-V)

5. CONCLUSION

This project includes the combination of air and water purifiers which works simultaneously. This device contributes in green environment projects and is a complete effort to reduce pollution as well as improve the air and water quality. The various sensors used in the device detect the impurities and accordingly the Arduino is functioned to perform the various filtrations in order to cope up with the quality of air and water.

This project can be used in highly polluted areas like polluted water bodies, recreational areas, residential/industrial areas, etc. Further advancements can be made in this project using advance technologies for specific applications. Like - PLC based, Ozone detection, Solar Panel, IoT connection, etc.

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