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Pollutant Detector and Absorber

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Abstract: ***Air pollution occurs when harmful substances are released into the earth's atmosphere. It can also harm other living organisms, such as animals and food crops, and damage the natural or built environment. Both human activities and natural processes can cause air pollution. Both biological and chemical methods are used to remove pollutants from the air. Algae and sodium hydroxide (NaOH) are used to reduce carbon dioxide (CO2), nitrogen dioxide (NO2) and sulphur dioxide (SO2) in the polluted air and produce oxygen. The equipment consists of a culture fluid containing algae and NaOH solution to capture 50 - 60% of the carbon dioxide.***
Keywords: ***Air pollution, CO2, Algae, NaOH, Oxygen***

I. INTRODUCTION

Air pollution is increasing day by day and its threat is becoming a challenge that we must overcome. Every form of life is affected by this threat in one way or another. Air pollution is caused by various pollutants whether it is primary like sulphur dioxide, carbon monoxide, volatile organic compounds, chlorofluorocarbons (CFCs) etc. or secondary like ozone, peroxyacetyl nitrate (PAN). Each pollutant poses its own threats to us, some of which pose a serious threat to human life. The basic process of photosynthesis is used by plants and other organisms to convert light energy, usually from the sun, into chemical energy that can later be released to fuel the organism's activities, releasing oxygen as a by-product. Most plants, most algae and cyanobacteria are photosynthetic and such organisms are called photoautotrophs. Microalgae are sunlight-driven cell factories that convert carbon dioxide into potential biofuels, food, feed and high-value bioactive. Although we have tried to use algae to reduce air pollutants such as sulphur dioxide, nitrogen dioxide and convert carbon dioxide to oxygen through the process of photosynthesis.

Criteria air pollutants

pollutant	common sources	maximum acceptable concentration in the atmosphere	environmental risks	human health risks
carbon monoxide (CO)	automobile emissions, fires, industrial processes	35 ppm (1-hour period); 9 ppm (8-hour period)	contributes to smog formation	exacerbates symptoms of heart disease, such as chest pain; may cause vision problems and reduce physical and mental capabilities in healthy people
nitrogen oxides (NO and NO_2)	automobile emissions, electricity generation, industrial processes	0.053 ppm (1-year period)	damage to foliage; contributes to smog formation	inflammation and irritation of breathing passages
sulfur dioxide (SO_2)	electricity generation, fossil-fuel combustion, industrial processes, automobile emissions	0.03 ppm (1-year period); 0.14 ppm (24-hour period)	major cause of haze; contributes to acid rain formation, which subsequently damages foliage, buildings, and monuments; reacts to form particulate matter	breathing difficulties, particularly for people with asthma and heart disease
ozone (O_3)	nitrogen oxides (NO_x) and volatile organic compounds (VOCs) from industrial and automobile emissions, gasoline vapours, chemical solvents,	0.075 ppm (8-hour period)	interferes with the ability of certain plants to respire, leading to increased susceptibility to other environmental stressors (e.g.,	reduced lung function; irritation and inflammation of breathing passages

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Criteria air pollutants

pollutant	common sources	maximum acceptable concentration in the atmosphere	environmental risks	human health risks
	and electrical utilities		disease, harsh weather)	
particulate matter	sources of primary particles include fires, smokestacks, construction sites, and unpaved roads; sources of secondary particles include reactions between gaseous chemicals emitted by power plants and automobiles	150 $\mu g/m^3$ (24-hour period for particles <10 μm); 35 $\mu g/m^3$ (24-hour period for particles <2.5 μm)	contributes to formation of haze as well as acid rain, which changes the pH balance of waterways and damages foliage, buildings, and monuments	irritation of breathing passages, aggravation of asthma, irregular heartbeat
lead (Pb)	metal processing, waste incineration, fossil-fuel combustion	0.15 $\mu g/m^3$ (rolling three-month average); 1.5 $\mu g/m^3$ (quarterly average)	loss of biodiversity, decreased reproduction, neurological problems in vertebrates	adverse effects upon multiple bodily systems; may contribute to learning disabilities when young children are exposed; cardiovascular effects in adults

II. LITERATURE SURVEY

A. Neda Jalilian et al. (2020)

Microalgae are biological sources with an extensive range of biotechnological applications, e.g., for bioremediation of industrial and municipal wastes. Microalgae are used to monitor environmental toxicants like pesticides, heavy metals, and pharmaceuticals and in the final stage of wastewater treatment when organic pollution should be removed. CO2 capturing is also important due to the environmental issues. Macro/microalgae cultures, depending on their growth stages and life cycles, have great potential for CO_2 fixation. They are a dominant group of microorganisms for biological treatments with regards to their substantial biosorption ability to deactivate toxic heavy metals. Actual carbon bio-fixation can be employed in the direction of environmental sustainability and economic facility. Besides, algae are sustainable feedstock to produce a wide range of biofuels by applying thermochemical or biological conversion methods.

B. S. A. El-Eslamboly et al. (2019)

This study was conducted during seasons 2016 and 2017 to control the root-knot nematode Meloidogyne incognita in cucumber, cultivated in infected soil, using some algal treatments under greenhouse conditions, at Kaha Farm, Qaluobia Governorate, Egypt. Six algal treatments were tested: two foliar applications of Spirulina and Amphora, two drenched soil applications of Spirulina and Amphora, two treatments using Spirulina, as spraying and drenching, and Amphora, as spraying and drenching, in addition to the Rugby nematicide (10% Ebufos , at the rate of 5 g/m2) and control. Rugby was applied by a soil prepared in its experimental units. After 15 days from transplanting, the algal extract treatments were applied twice monthly for 3 months. The same concentration (2 g/l) of both types of algae was applied in both foliar and drench treatments. In contrast, the control plants had the lowest values in all criteria. Amphora (sprayed with soil drenched) treatment gave 2.5 and 2.69 folds the control in marketable yield in 2016 and 2017 seasons, respectively.

C. WeimingHu et al. (2015)

Polyvinylidene fluoride (PVDF) hollow fiber membranes with nano-TiO2 (5% of PVDF by mass, average size = 25 nm) additives were fabricated and applied for high-density algae (Chlorella vulgaris) cultivation. At the average light intensity of 121 μmol/m2/s, the algal membrane bioreactors (A-MBR) operated at a hydraulic retention time of 0.5 d and an average solids retention time of 25 d had an average algae biomass concentration of 2350 ± 74 mg/L (in COD units) and algal biomass production rate of 6.5 ± 0.1 g/m2/d.

D. Juliana Botelho Moreira 2015)

Biological processes are alternatives for combating pollution and generating new products. The microbial metabolism degrades and removes pollutants, which generates fewer environmentally harmful products. In this scenario, microalgae have been studied for wastewater treatment, toxic metal bioremediation, carbon dioxide (CO2), bio-fixation, biofuel, biopolymer and Nano fiber production. Semi-continuous cultivations have several advantages compared with batch and continuous processes. Semi-continuous processes involve periodically replacing part of the microalgae culture medium with fresh culture medium (dilution). Such cultivation methods can be used for larger scale biomass production while maintaining a high microorganism growth rate.

E. Gary T. Rochelle (2009)

"Amine Scrubbing for CO2 Capture "Amine scrubbing: The dominant application for CO2 scrubbing is for removal of CO2 from the exhaust of coal- and gas-fired power plants. Virtually the only technology being seriously evaluated involves the use of various amines, e.g. mono-ethanol-amine. Cold solutions of these organic compounds bind CO2, but the binding is reversed at higher temperatures:

$CO2 + 2\ HOCH2CH2NH2 \leftrightarrow HOCH2CH2NH3+ + HOCH2CH2NHCO2-$.

III. EXPERIMENTAL SETUP

A. Components Used

1) Breadboard

A breadboard is used to make up temporary circuits for testing or to try out an idea. No soldering is required so it is easy to change connections and replace components. Parts are not damaged and can be re-used afterwards.

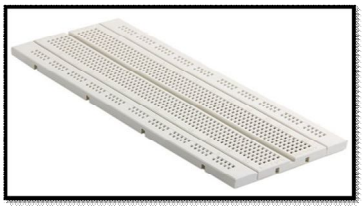


Fig 1: Breadboard

2) Jump Wires

Jump wires (also called jumper wires) for solder less bread boarding can be obtained in ready-to-use jump wire sets or can be manually manufactured. Jump wire material for ready-made or homemade wires should usually be 22 AWG (0.33 mm^2) solid copper, tin-plated wire - assuming no tiny plugs are to be attached to the wire ends.

Differently colored wires and color-coding discipline are often adhered to for consistency. Typically, a few wire colors are reserved for the supply voltages and ground (e.g., red, blue, black), some are reserved for main signals, and the rest are simply used where convenient. Some ready-to-use jump wire sets use the color to indicate the length of the wires..

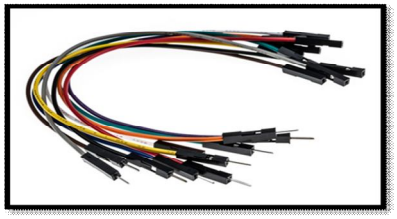


Fig 2: Jump wires

3) Arduino Nano Board

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328P released in 2008. It offers the same connectivity and specs of the Arduino Uno board in a smaller form factor. The Arduino Nano is equipped with 30 male I/O headers,in a DIP30-like configuration, which can be programmed using the Arduino Software integrated development environment (IDE), which is common to all Arduino boards and running both online and offline. The board can be powered through a type-B micro-USB cable or from a 9 V battery.

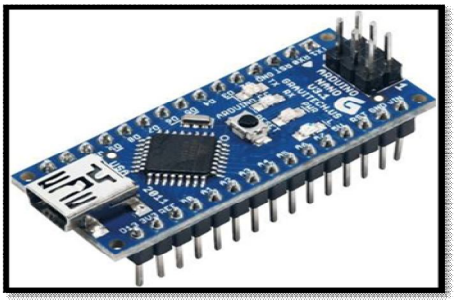


Fig3:Arduino nano board

4) USB Cable

Soldered Nano compatible, Nano Cable Mini USB to USB (cable colour might change from the one shown in picture) ATmega328 Operating Voltage (logic level): 5V Input Voltage (r1ecommended): 7V ~ 12V Input Voltage (limits): 6V ~ 20 VDigital I/O Pins: 14 (of which 6 provide PWM output) Analog Input Pins: 8 DC Current per I/O Pin: 40mAFlash Memory: 32KB (ATmega328) (of which 2 KB used by bootloader) SRAM: 2KB (ATmega328) EEPROM: 1KB (ATmega328) Clock Speed: 16MHz"



Fig 4:USB Cable

5) MQ 135 Gas Sensor

The MQ-135 Gas sensors are used in air quality control equipment's and are suitable for detecting or measuring of NH3, NOx, Alcohol, Benzene, Smoke, and CO2. The MQ-135 sensor module comes with a Digital Pin which makes this sensor to operate even without a microcontroller and that comes in handy when you are only trying to detect one particular gas. If you need to measure the gases in PPM the analog pin need to be used. The analog pin is TTL driven and works on 5V and so can be used with most common microcontrollers.

If you are looking for a sensor to detect or measure common air quality gases such as CO2, Smoke, NH3, NOx, Alcohol, Benzene then this sensor might be the right choice for you.

Features

- Sensitive for benzene, alcohol, smoke
- Output voltage boosts along with the concentration of the measured gases increases
- Fast response and recovery
- Adjustable sensitivity
- Signal output indicator

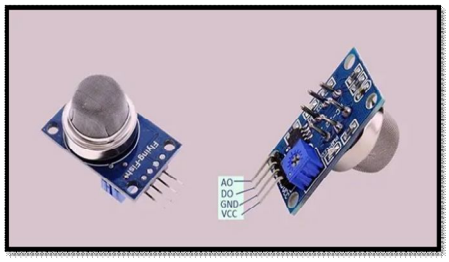


Fig 5: MQ 135 Gas sensor

6) Air Pump

The Basic function of an Air Pump is to force polluted air, through mechanical means, from the atmosphere into the solution of Algae and NaOH. By forcing air into the solution, we create rising air bubbles thus polluted air reacts with the solutions.



Fig 6: Air pump

7) Flask

An Erlenmeyer flask, also known as a conical flask or a titration flask, is a type of laboratory flask which features a flat bottom, a conical body, and a cylindrical neck. Flasks have wide bases, with sides that taper upward to a short vertical neck. They may be graduated, and often spots of ground glass or enamel are used where they can be labeled with a pencil. Depending on the application, they may be constructed from glass or plastic, in a wide range of volumes. The mouth of the flask is fixed to PVC pipe which comes out of the frame, where sensors are placed to detect the CO2 level.



Fig 7: Flask

8) Sodium Hydroxide

Sodium hydroxide, also known as caustic soda**, is** an inorganic compound with the formula NaOH. It is a white solid ionic compound consisting of sodium cat ions Na^+ and hydroxide anions OH^-.It is highly soluble in water, and readily absorbs moisture and carbon dioxide from the air. It forms a series of hydrates $NaOH+nH_2O$.The monohydrate $NaOH+H_2O$ crystallizes from water solutions between 12.3^0C and 61.8 °C. The commercially available "sodium hydroxide" is often this monohydrate, and published data may refer to it instead of the anhydrous compound.



Fig 8: Sodium hydroxide

9) IBall Valve

A ball valve is a shut off valve that controls the flow of a liquid or gas by means of a rotary ball having a bore. By rotating the ball a quarter turn (90 degrees) around its axis, the medium can flow through or is blocked. They are characterized by a long service life and provide a reliable sealing over the life span, even when the valve is not in use for a long time.

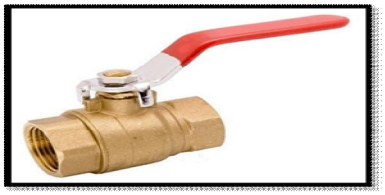


Fig 9: Ball Valve

10) Tube

The tube is used to store the atmospheric polluted air and supply that air whenever needed so that to react with NaOH and algae.



Fig 10: Tube

11) Hose Pipe

A hose is a flexible hollow tube designed to carry fluids from one location to another. Hoses are also sometimes called *pipes* (the word *pipe* usually refers to a rigid tube, whereas a hose is usually a flexible one), or more generally *tubing*. The shape of a hose is usually cylindrical (having a circular cross section).



Fig 11: Hose pipe

12) Frame

A frame is a basic structure for the model. It is made up of iron square rod; it supports all the components of the experimental process. It is enclosed by plywood which is fastened by sheeting bolts.

Dimensions:-Length x Breadth x Height = 57 x 45.5 x 36 cm



Fig 12: Frame

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IV. OPERATIONS PERFORMED

A. Marking Out

consists of transferring the dimensions from the plan to the work piece in preparation for the next step, machining or manufacture. Here a measuring tape, square and scriber is used for marking.

B. Cutting Operation

Cutting is the separation or opening of a physical object, into two or more portions, through the application of an acutely directed force. For metals many methods are used and can be grouped by the physical phenomenon used. Here a square hollow rod is cut as per the dimensions required.

C. Welding Operation

Welding is a fabrication process that joins materials, usually metals or thermoplastics, by using high heat to melt the parts together and allowing them to cool, causing fusion. Welding is distinct from lower temperature metal-joining techniques such as brazing and soldering, which do not melt the base metal. In this operation we join all the cutting parts by the help of arc welding.

D. Drilling Operation

Drilling is a cutting process that uses a drill bit to cut a hole of circular cross-section in solid materials. The drill bit is usually a rotary cutting tool, often multi-point. ... Instead, the hole is usually made by hammering a drill bit into the hole with quickly repeated short movements. Here drilling is made on the PVC pipe and also to fix the plywood to the frame using sheeting bolts.

E. Fabrication

After performing all the operations the outer frame of the setup is done. It is covered with plywood's and front portion is kept open. Flasks are placed inside the frame then it is connected to the air pump. Flasks are filled with NaOH solution & Algae. Now, the pump is made to run and polluted air flows into the flasks through the pipes and forms a bubbles in the solution, where reactions takes place. A sensor is kept at the openings of the flask.

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V. METHODOLOGY

A. Preparing NaOH Solution

CO2 trapper works on the principle of alkali bases capacity to absorb carbon dioxide and convert it into carbonate.
Take water 500 ml of water in a conical flask and add sodium hydroxide pellets 5gm, sterile it till pellets dissolve.



Fig 18: Weighing sodium hydroxide pellets



Fig 19: NaOH Solution

VI. WORKING

The Arduino board and sensor is connected through the jump wires and breadboard as shown in the circuit diagram below. It is given to the system consisting of suitable program through the USB cable. Two valve air pump is used to flow the polluted air into two flasks, containing NaOH solution and Algae. The mouth of the flask is connected to the pipe and taken out for measuring the amount of purification of air in ppm.

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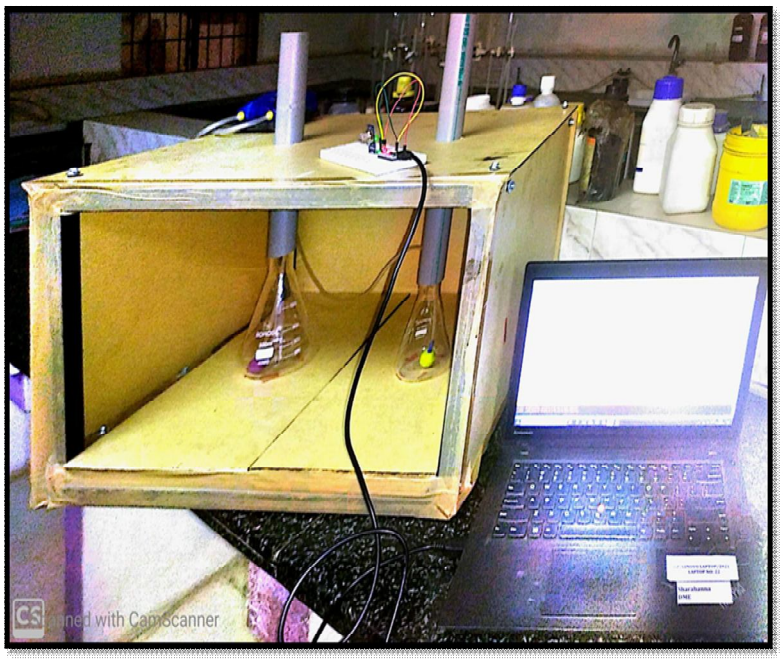


Fig 20: Working set up

After connecting the circuits as per the circuit diagram, the USB cable is connected to system, the output port is selected by clicking's tools- port- COM15, then the program is uploaded to circuit. Now the sensor senses the polluted air in the atmosphere and gives the air quality and co2 level is displayed in ppm .

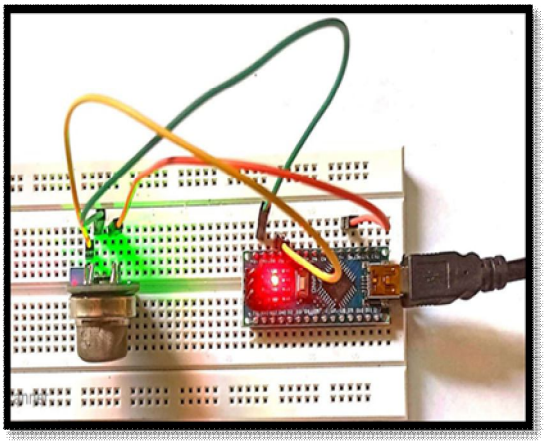


Fig 21:Circuit connection.

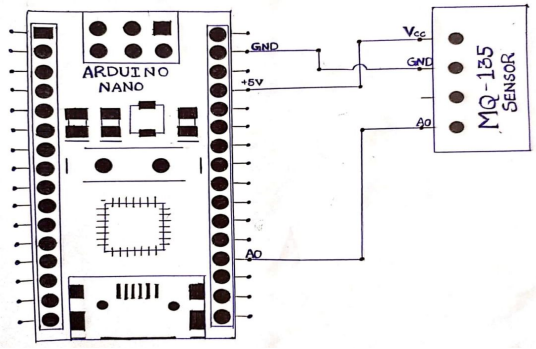


Fig 22 :Circuit daigram

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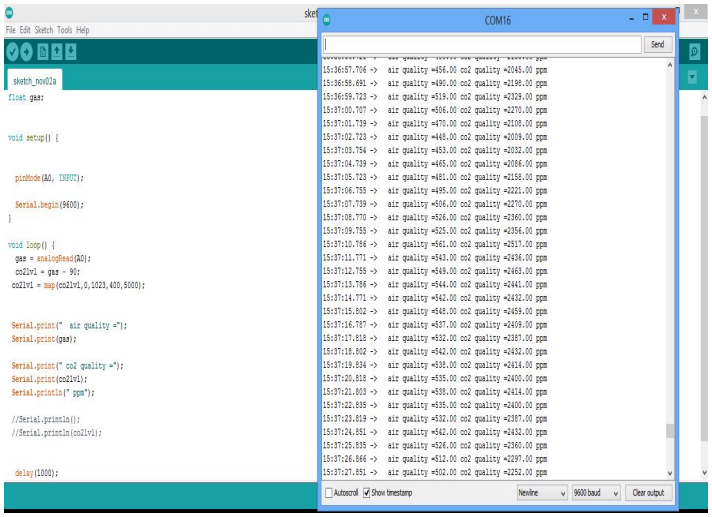


Fig 4.3: Air quality & CO2 of atmosphere.

$$NaOH + CO_2 \rightarrow NaHCO_3$$
$$NaOH + NaHCO_3 \rightarrow Na_2CO_3 + Air\uparrow$$

1) Flask containing Algae,the air is made to pass through the spirulina with culture fluid to undergo photosynthesis process, so that the cabon dioxide (CO_2) is absorbed by the algae and the filtered air made to flow into atmosphere.

$$Algae + CO_2 \rightarrow Biomass + O_2 \uparrow$$

2) Now the filtered air is sensed by the sensor at two pipe extensions, the air quality and co_2 level is displayed in ppm. Now the initial readings and the final readings are being compared, as a result we can see that co_2 level is decreased at final stage and filtered air is sent to the atmosphere.

3) The below readings shows the air quality and co_2 level of filtered air coming out after reacting with NaOH solution.

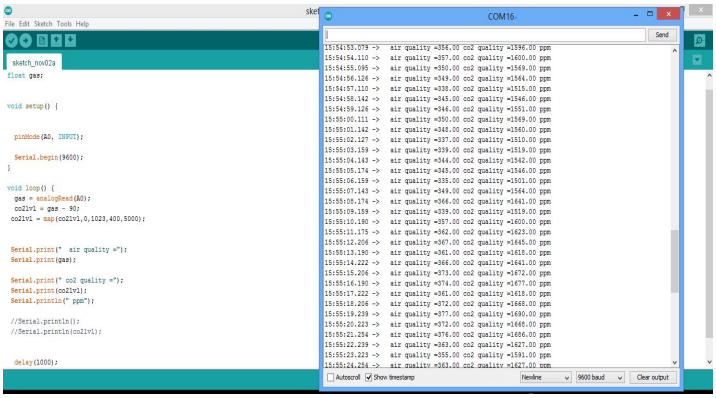


Fig 4.4:Air quality & CO_2 after reacting with NaOH.

4) The below figure shows the air quality and co2 level of air after the process of photosynthesis by algae.

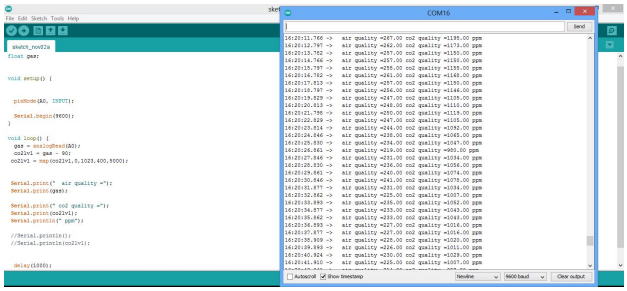


Fig 4.5: Air quality & CO_2 after photosynthesis process.

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A. Advantages

They aid in the absorption of smoke gases. They avoid air pollution and indirectly assist in improving worker's health.

1) Reduces carbon dioxide about 50-60%.
2) Various filtrations options available.
3) Helps remove harmful fumes.

B. Disadvantages

They do not have lengthy period of working efficiency.

C. Applications

1) Traffic areas
2) Chemical industries.
3) Tyre industries
4) Food industries

VII. RESULTS AND DICUSSION

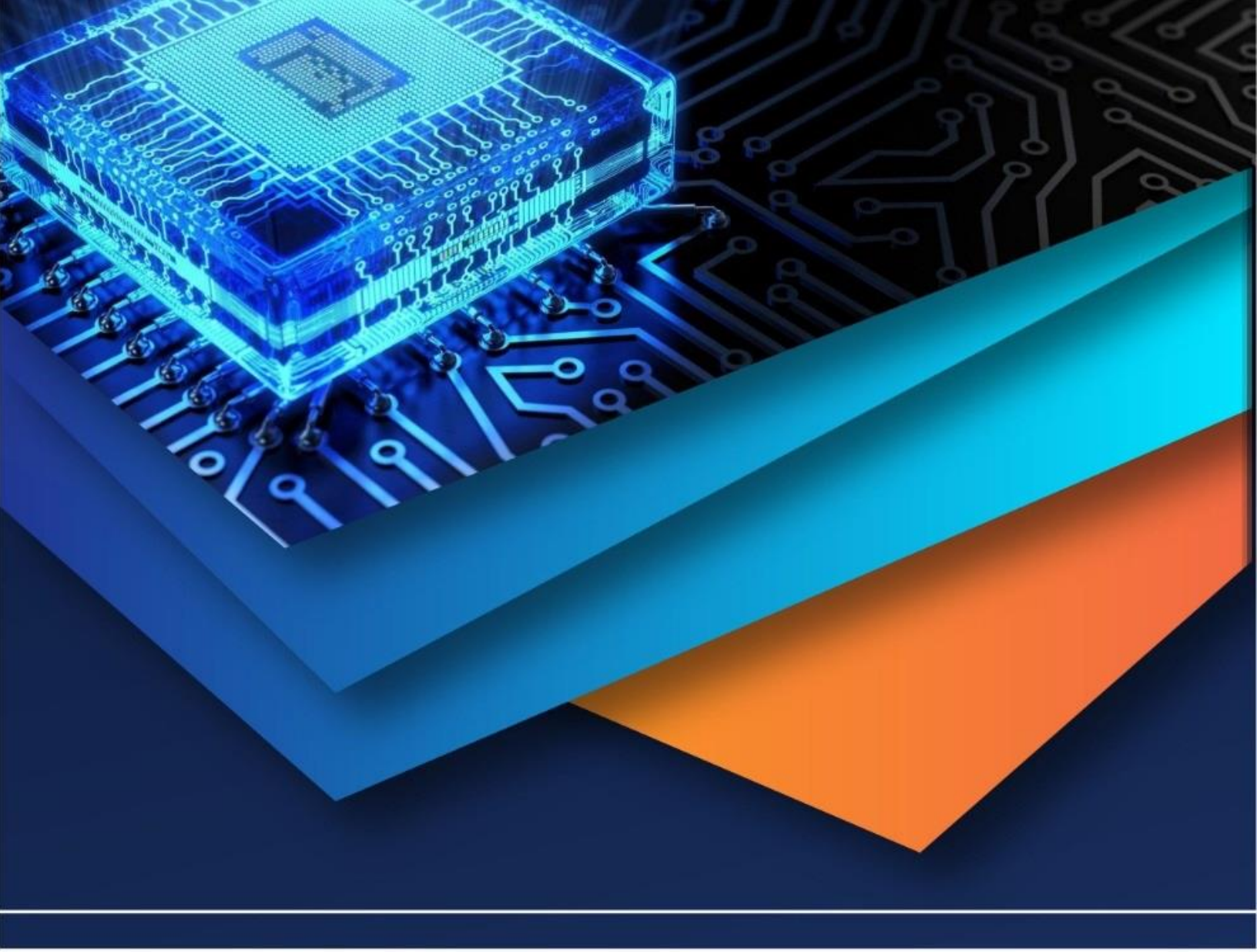
This report mainly focus on the reduction of pollutants in the atmospheric air. Here it is done by passing the pollutant gases to the equipment containing Algae and NaOH . The algae utilize the carbon dioxide, nitrogen dioxide and sulphur dioxide as the nutrients for its growth. By the process of photosynthesis where carbon dioxide is converted to oxygen. The NaOH solutions reacts with carbon dioxide and reduces it. Through series of test it is found that 40-50% of carbon dioxide has been reduced.

VIII. FUTURE SCOPE

Pollutant detector and Absorber is type of model that have own function where to save the environment by reducing the contamination in the air. We have made this project model as a prototype using NaOH & Algae but it can be further improve by using activated charcoal and other chemicals like Sodium Carbonate(Na2CO3),Ferric Oxide(Fe2O3) to reduce other air contaminations like Carbon monoxide(CO), Nitric Oxide (NOx) etc…which can be implement in large scale industries.

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