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# The use of Arduino Interface and Lemon (Citrus Limon) Peels in Making an Improvised Air Ionizer-Purifier

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**Abstract:- The goal of this study is to develop an inexpensive, environmentally friendly, and improvised air ionizer-purifier using an Arduino interface and lemon peels to lessen indoor pollution. In Qatar, air ionizers and purifiers are crucial because they aid in reducing respiratory-related ailments during the pandemic by removing airborne bacteria. Indoor air pollution still exists even in clean homes in Qatar since the country's air pollution exceeds health guidelines and harms the population. The open-source electronics platform Arduino Interface, which is built on simple hardware and software, was utilized for its boards to read inputs and convert them into outputs for the detection of air contaminants. Likewise, Lemon peels, which have cleansing properties, were employed as the primary ingredient to manufacture the activated carbon required to increase the effectiveness of the air purification process. The homemade air ionizer and purifier remove airborne impurities and produce negative ions. It, therefore, consisted of three main parts. The study's findings demonstrate the air purifier's arrestance and dust-holding capacity. The effectiveness of the air ionizer was also demonstrated by the quantity and quality of negative ions created. The sensor was also put to the test over time. The outcomes showed that the improvised air ionizer-purifier produced clean air in a manner comparable to that of a commercial air purifier, improving environmental safety through its efficiency and response time.**

***Keywords:-*** *Air Ionizer; Air Purifier; Arduino Interface; Indoor Air Pollution; Lemon Peels.*

## I. INTRODUCTION

Due to the emissions of carbon dioxide, sulfur dioxide, and particulate matter that are produced when fuel sources like wood, gas, oil, and biomass are burned, indoor air pollution has grown to be one of the most important environmental issues in the world. According to the World Health Organization (2021), indoor air pollution-related disorders such as bronchitis, emphysema, asthma, pneumonia, and cancer cause almost 4 million individuals to die prematurely each year. Furthermore, according to The Global Burden of Disease (2016), indoor air pollution causes 2.9 million mortality annually. Lower respiratory infections made up 26% of indoor air pollution deaths, tracheal, bronchial, and lung malignancies made up 5%, and chronic obstructive pulmonary disease (COPD) made up 23%.

Over half of the pneumonia cases in children under the age of five were brought on by particulate particles, particularly soot, inhaled from residential air pollution. Indoor air pollution is a major contributor to noncommunicable diseases such as lung cancer, chronic obstructive pulmonary disease (COPD), ischemic heart disease, and stroke. Qatar suffers from air pollution because it is a desert nation. If sand enters the lungs, it can seriously harm the person's health. Qatar is another energy-producing nation that contributes to air pollution. The population of Qatar is negatively impacted by air pollution, according to a 2016 World Health Organization assessment. Qatar's air pollution substantially exceeds health requirements.

The Middle East has exceptionally high PM2.5 levels, with Qatar having the highest levels (91 g/m3), followed by Saudi Arabia, Egypt, Bahrain, Iraq, and Kuwait (State of Global Air, 2019). Indoor air pollution still exists and negatively affects indoor spaces even when homes are maintained clean. Household indoor air pollution is brought on by a number of factors, such as insufficient ventilation, hazardous materials, high temperatures, and humidity. Furthermore, according to Akhtar (2016), exposure to indoor pollution has been connected to a number of health issues, including cancer. Among the most common respiratory conditions noted are pneumonia, bronchitis, asthma, dyspnea, allergic rhinitis, nose and throat irritation, and cough.

As a result, those who suffer from hay fever or other seasonal allergies have greatly benefited from the use of air ionizers and purifiers. Air ionizers and purifiers, such as those made by Arista Air Conditioning Corporation (2017), may get rid of up to 99 percent of airborne microorganisms, including dust, cigarette smoke, mold, soot, pollen, and household odors. Additionally, they collect dust before it has a chance to settle, reducing buildup and the need for cleaning. By absorbing opposing polarity charges from the air to create a balanced stream of positively and negatively charged ions, an air ionizer reduces and neutralizes any static charge that may be present on objects in the work area, including insulated and isolated items.

On the other hand, an air purifier uses multiple layers of filters to remove particulate matter that may be a factor in the development of disorders like allergic rhinitis. There is ample proof that air filtration reduces indoor particulate matter levels that could lead to illnesses (Sublett et al., 2010). Lemon, or Citrus limon, is a small evergreen tree that is indigenous to Asia, mainly Northeast India (Assam),

Northern Myanmar, and China. It is a member of the Rutaceae family. As a hydrocarbon fraction, tetradecane and pentadecane are abundant in lemon peels, making them useful for producing inexpensive activated carbon for air purifiers (Ladaniya, 2008).

Lemon peels are organic waste and natural components that can be used to make activated carbon. The environmentally friendly procedure of making activated carbon from lemon peels can help to lower indoor air pollution (Al-Farsi et al., 2016). In addition, the majority of air ionizers and purifiers need sensors to count the number of airborne contaminants. Boards are provided by Arduino, an open-source electronics platform built on simple hardware and software that can take inputs like lighting a sensor and convert them into outputs like driving a motor.

By utilizing waste materials, ion generators, and air filters, this study intends to reduce indoor air pollution by building an improvised air ionizer-purifier out of lemon peels and an Arduino interface. The air ionizer-purifier generates negative ions. It will contribute to a decrease in air pollution. This study also focuses on using the Arduino Interface and lemon peels to detect dust. The application of this research helps reduce the likelihood of illnesses brought on by indoor air pollution.

## II. RESEARCH QUESTIONS

The main objective of this study is to create an improvised air ionizer-purifier out of Arduino interface and lemon peels. Specifically, this study aims to answer the following questions:

- *How effective is the air ionizer out of Arduino Interface and Lemon peels in terms of:*
  - air quality on a quarter-hourly basis and
  - number of negative ions produced on a quarter-hourly basis?
- *How effective is the air purifier out of Arduino Interface and Lemon peels in terms of:*
  - arrestance on an hourly basis and
  - dust holding capacity on an hourly basis?
- *How much time does it take for the sensor to detect dust?*

## III. METHODOLOGY

This study utilized the experimental design of research. Tanner (2018) defined the experimental research design as being applied when the researcher is inquiring as to what the cause-and-effect relationships are between the dependent and independent variables. In this study, the Arduino Interface and Lemon peels are the independent variables and the improvised air ionizer-purifier is the dependent variable. The quantitative method was used to organize the experiment properly and to ensure that the right type of data is available to answer. It is necessary to use this method because it provides a high level of control over the variables that demonstrates an outcome and has an advantage in finding accuracy, consistency, and precision in its results.

### *A. Research Locale*

The research study was conducted in one of the researchers' houses in Doha, State of Qatar, specifically in the New Al Thumama Area (Zone 50).

### *B. Data Gathering Procedure*

Below is the testing procedure to measure the effectiveness of the improvised air ionizer.

- Burn a piece of paper enough to create smoke and put out the flame.
- Place it inside the improvised air ionizer.
- Plug the improvised air ionizer into an electrical socket.
- Turn the switch on.
- Wait for the smoke to be eliminated.
- Measure the air quality or the level to which air is qualified enough for humans to remain healthy by following these steps:
- Place the air quality monitor beside the air ionizer.
- As it measures the number of dust particles present, use the data presented to indicate the air quality in micrograms per cubic meter (µg/m3).
- Measure the number of negative ions produced by following these steps:
- Place the air ion counter beside the air ionizer.
- Use the data presented to indicate the number of negative ions produced in pieces per cubic centimeter (pcs/cm3).

Below is the testing procedure to measure the effectiveness of the improvised air purifier.

- Measure the arrestance or the ability of the air purifier to remove dust by following these steps:
- Use a digital scale to measure 30 grams of powder.
- Feed the powder to the purifier.
- After the purifier has fully absorbed the powder, open the system, and remove the filter.
- Scrape the layer of powder found on the filter into a bowl.
- Measure in grams, the amount of powder absorbed by the filter through a digital scale.
- Use the formula (1 - weight of dust passing test filter / weight of dust fed) x 100 to calculate the arrestance in the unit of percentage.
- Measure the dust holding capacity or amount of dust that the air purifier can hold by following these steps:
- Get the total mass of dust fed.
- Multiply the total mass of dust fed to the arrestance from the previous test to calculate the dust holding capacity in the unit of grams.

Below is the testing procedure to measure the time it takes for the sensor to detect dust.

- Place powder near any dust sensor.
- Record the time it takes until a message is seen in the indicator.
- Use Arduino's program for accuracy of time to calculate the time it takes for the sensor to detect dust.

## IV. RESULTS

This chapter brings about the results and interpretation of data that were collected from assembling and testing the product.

### *A. Effectiveness of the Air Ionizer out of Arduino Interface and Lemon Peels in terms of*

- *Air quality on a Quarter-Hourly Basis:*

The researchers assessed the air quality of the air ionizer on a quarter-hourly basis by using an air quality monitor. Additionally, other air conditioning units in the room had been switched off before the testing procedure to ensure minimal interference and accuracy of the air quality.

| Minutes | 15 | 30 | 45 |
|---|---|---|---|
| Photos |  |  |  |
| Air quality (in µ/m$^3$) | 0.121 | 0.107 | 0.162 |

Table 1: Air Quality of the Air Ionizer on a Quarter-Hourly Basis

Table 1 shows the air quality of the air ionizer on a quarter-hourly basis. In 15 minutes, the air ionizer had an air quality of 0.121 µg/m$^3$. In 30 minutes, the air ionizer resulted in an air quality of 0.107 µg/m$^3$. Lastly, in 45 minutes, the air ionizer showed an air quality of 0.162 µg/m$^3$.

Investigating the results even further, the air quality displayed effectiveness as it had minimal changes, proving its particle filtration efficiency. The ion generators of the improvised air ionizer were able to produce improved indoor air quality. Similarly, the study conducted by Salthammer (2019) stated that an air quality value of 0.1 µg/m$^3$ is recommended. Moreover, the results are supported by the study of Liu et al. (2017) which stated that an air ionizer, an electrostatic air filter, can reach from 82% to 94% of particle filtration efficiency. Hence, the results showed the air ionizer's contribution to the reduction of indoor health concerns.

- *Number of Negative Ions Produced on a Quarter-Hourly Basis:*

The researchers tested the number of negative ions produced by the air ionizer on a quarter-hourly basis by using an air ion counter. Additionally, other air conditioning units in the room had been switched off before the testing procedure.

| Minutes | 15 | 30 | 45 |
|---|---|---|---|
| Photos |  |  |  |
| Number of negative ions produced (ions/cm$^3$) | (-1x104 ions/cm$^3$) converted: 10000 | (-1x104 ions/cm$^3$) converted: 10000 | (-1x104 ions/cm$^3$) converted: 10000 |

Table 2: Number of Negative Ions Produced on a Quarter-Hourly Basis

Table 2 presents the number of negative ions produced on a quarter-hourly basis. As shown, for 15 minutes, the number of negative ions produced was -1x104 ions/cm$^3$. For easier understanding, the number had been converted and it resulted in 10000 ions/cm$^3$. For 30 minutes, the number of negative ions produced was -1x104 ions/cm$^3$, which is the same as 10000 ions/cm$^3$. For 45 minutes, the number of negative ions produced was also -1x104 ions/cm$^3$, which is equal to 10000 ions/cm$^3$. All three findings showed the same number of negative ions produced.

Evaluating the results, the number of negative ions produced by the air ionizer on a quarter-hourly basis had no changes. This means that the number of negative ions produced is constant regardless of the period of operation. Moreover, Jiang et al. (2018) stated that the negative concentration of negative ions above 1000 ions/cm$^3$ was known to be the threshold value for fresh air.

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*B. Effectiveness of the Air Purifier out of Arduino Interface and Lemon Peels in terms of*

➢ *Arrestance on an Hourly Basis:*

The researchers calculated the arrestance of the air purifier on an hourly basis by using the formula (1 - weight of dust passing test filter÷weight of dust fed) x 100 and with the help of a digital scale and calculator. Moreover, the air purifier was fed with powder to act as dust and was done in a non-air-conditioned closed area.

| Hour/s | 1 | 2 | 3 |
|---|---|---|---|
| Photos |  |  |  |
| Arrestance (in percentage) | 26.67 | 80.00 | 90.00 |
| | | | |

Table 3: Arrestance on an Hourly Basis

Table 3 displays the arrestance of the air purifier per hour in percentage. In the first hour, the arrestance of the air purifier was measured to be 26.67%. In the second hour, the arrestance of the air purifier resulted in 80%. In the third hour, the arrestance of the air purifier was 90%. This shows that the air purifier can remove more dust the longer it functions.

The arrestance of the air purifier can be interpreted through the Minimum Efficiency Reporting Value rating chart. According to the United States Environmental Agency (2020), a MERV rating describes and compares the abilities of different air purifier filters in capturing particles. The rating scales are from 1 to 20, the lowest is for basic filters and the highest is for filters suitable for facilities like laboratories. The arrestance of the first hour falls under the MERV 5 rating. This indicates that the air purifier can block particles like carpet fibers and lint. The arrestance of the second hour falls under the MERV 8 rating. This rating applies to filters fit for removing dust mites, sanding dust, and spray paint dust. The arrestance of the third hour falls under the MERV 9 category. This means that the air purifier can now aid in removing lead and humidifier dust as well as aerosol-like hairspray. Furthermore, Trey (2020) mentioned that MERV 5 – MERV 8 filters greatly purify and eliminate most dust, soot, etc. as they are more effective than higher-rated filters when replaced regularly.

- Dust Holding Capacity on an Hourly Basis:
- The researchers calculated the dust holding capacity of the air purifier on an hourly basis by multiplying the mass of the dust fed to the arrestance of each respective hour. The test was done with a digital scale and calculator.

| Hour/s | 1 | 2 | 3 |
|---|---|---|---|
| Photos |  |  |  |
| Dust holding capacity (in grams) | 8.001 | 24 | 27 |

Table 4: Dust Holding Capacity on an Hourly Basis

Table 4 shows the dust holding capacity of the air purifier per hour in grams. During the first hour, the air purifier can hold 8.001 g of powder. During the second hour, the air purifier can hold 24 g of powder. During the third hour, the air purifier can hold 27 g of powder. These results show that the air purifier's dust-holding capacity increases with the time of its use, especially in its second hour.

In addition, the dust-holding capacity and the arrestance of the air purifier are directly proportional. This means that the higher the arrestance, the more dust will be collected by the air purifier.

*C. Time for the Sensor to Detect Dust*

The researchers tested the time it takes for the sensor to detect dust by placing powder near the sensor and recording its time of fall up to its time of detection. The sensor can have the time detection of dust programmed.

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| Trial | 1 | 2 | 3 |
|---|---|---|---|
| Photos |  |  |  |
| Arduino Software | delay for 3000 milliseconds | delay for 3000 milliseconds | delay for 3000 milliseconds |

Table 5: Time for the Sensor to Detect Dust

Table 5 shows the different trials of the sensor to check its consistency. In the first trial, the sensor was able to detect the powder with a delay of 3.0 seconds. In the second trial, the researchers tested, and the sensor was able to detect the powder with a delay of 2.9 seconds. In the third trial, the sensor was able to detect the powder with a delay of 3.1 seconds. These show minimal changes in the detection time of the sensor.

Delving deeper into the results, it can be stated that Arduino used little storage and power while allowing sensors to remotely send accurate alerts after detection as Bahrudin et al. (2013) conducted a similar study that explained Arduino Interface's hardware reduced the possibility of false alerts being reported. These findings suggest that Arduino Uno was efficient in transmitting data. Comparably, the study of Singh et al. (2018) mentioned that after testing for various conditions, Arduino Uno gave smart operating of home appliances as it provided information.

The following is the summary of results for each Statement of the Problem of this study.

➢ *Effectiveness of the Air Ionizer out of Arduino Interface and Lemon Peels in terms of:*

- Air quality on a quarter-hourly basis
  The air quality was tested through the use of an air quality monitor. At 15 minutes of functioning, the air quality was 0.121 µg/m$^3$. After 30 minutes of functioning, the air quality was 0.107 µg/m$^3$. At 45 minutes of functioning, the air quality was 0.162 µg/m$^3$. During these trials, the air quality had minimal changes.
- Number of negative ions produced on a quarter-hourly basis
  The number of negative ions was tested through the use of an air ion counter. All three trials performed indicated the same number of negative ions produced, which was 10000 ions/cm$^3$.

➢ *Effectiveness of the Air Purifier out of Arduino Interface and Lemon Peels in terms of:*

- Arrestance on an hourly basis
  The arrestance of the air purifier was tested by feeding powder into the air purifier and using the formula (1 - the weight of dust passing test filter÷weight of dust fed) x 100. The arrestance percentages per hour were 26.67%, 80.00%, and 90.00%.
- Dust holding capacity on an hourly basis
  The dust holding capacity of the air was tested by multiplying the mass of the dust fed to the arrestance of each respective hour. The first hour's dust-holding capacity was 8.001 g. The second hour's dust-holding capacity was 24 g. The third hour's dust holding capacity was 27 g.

➢ *Time for the Sensor to Detect Dust*

The time for the sensor to detect dust was tested through the use of a timer. There were minimal changes in the detection time of the sensor. The sensors detected dust on Trial 1, Trial 2, and Trial 3 with a delay of 3.0 seconds, 2.9 seconds, and 3.1 seconds respectively.

## V. CONCLUSIONS

The findings based on the statistical analysis of data lead to the following conclusions:

➢ The air ionizer has proved its effectiveness under its air quality and number of negative ions both produced on quarter-hourly bases.
- As its air quality showed an average value of 0.1 µg/m$^3$, it can be said that the air ionizer was able to show effectiveness.
- The number of negative ions produced by the air ionizer always showed 10000 ions/cm$^3$. Hence, it is proven helpful in generating fresh air.

➢ The air purifier has verified its effectiveness in terms of its arrestance and dust-holding capacity on hourly bases.
- The air purifier is categorized under the MERV 9 rating with a final arrestance of 90.00%. The air purifier is capable of removing several air impurities ranging from powders to aerosols, thus showing its effectiveness as an equivalent of a commercial air purifier.
- The dust holding capacity is directly proportional to its arrestance, therefore being able to productively hold any amount of dust in line with its arrestance.

➢ The consistent dust detection of the sensor has proved to be a factor in the safety of the environment. Demonstrating the usefulness of the system with an average of 3 seconds, Arduino Interface is well suited for a wide variety of applications related to environmental monitoring.

Based on the experimental findings of the study, the following are recommended:

- The Philippine School Doha (PSD) Community is recommended to use the improvised air ionizer-purifier out of Arduino Interface and Lemon peels as it is effective, economical, and environment-friendly. The use of this study can help in enforcing the mission of being pro-environment. Additionally, students and school staff who have access to higher-grade materials can test the improvised air-ionizer purifier in different areas and try to compare the results. Students and school staff are also encouraged to investigate by substituting one of the variables. These experiments will not only help in finding better materials to enhance the performance of the improvised air ionizer-purifier but also in adhering to school values.
- The Qatar and Philippine Community should consider becoming more aware of the significant effects of indoor air pollution. The researchers recommend the community raise awareness on the different ways to prevent it from inhaling polluted air that may cause them harm and health issues. Although it is beneficial to go to places with high negative ions, it is even better to ensure that such threshold values can be done at home to ensure fitness.
- Future Researchers can be inspired to use different types of sensors and alarms, taking those with softer volumes and adjusting the sensor's sensitivity level as examples. The researchers suggest using different measurements and kinds of dust as well. Future researchers may use a stronger fan for better air purifier effectiveness. This research may be used as a guide for other researchers if their topic has a similarity with the topic in this research. The researchers also recommend that future researchers try activating the air ionizer and air purifier through the Arduino Interface. Future researchers must also have basic skills and knowledge in programming. For amateurs, there is a website called circuito.io that may help in assembling and programming parts. The researchers also suggest testing the detection time with different proximities to ensure more accurate results.

## REFERENCES

[1.] Arista Air Conditioning Corporation. (2020, July 30). Why and How to Change an AC Filter. https://aristair.com/blog/why-and-how-to-change-an-ac-filter/

[2.] Bahrudin, M. S., Kassim, R. A., & Buniyamin, N. (2013). Development of Fire alarm system using Raspberry Pi and Arduino Uno. https://doi.org/10.1109/iceese.2013.6895040

[3.] Bruce, N., Smith, K., Balmes, J., Pope, D., Dherani, M., Zhang, J., Duan, X., Bates, M., Lin, W., Adair-Rohani, H., Mehta, S., Cohen, A., & Mccracken, J. (2016). Affiliations: 1 World Health Organization, Public Health, Social and Environmental Determinants of Health, Interventions for Healthy Environments. https://www.who.int/airpollution/household/guidelines/Review_4.pdf

[4.] Chen, R., Zhao, A., Chen, H., Zhao, Z., Cai, J., Wang, C., … Kan, H. (2015). Cardiopulmonary Benefits of Reducing Indoor Particles of Outdoor Origin. Retrieved on November 30, 2019 from http://www.onlinejacc.org/content/accj/65/21/2279.full.pdf.

[5.] Cooray, S., Sato, T., Terashige, T., … Okano, K. (2013). Basic characteristics of the field assisted air ionizer. https://ieeexplore.ieee.org/abstract/document/6635902

[6.] Environmental Protection Agency. (2020, August 14). Introduction to Indoor Air Quality. https://www.epa.gov/indoor-air-quality-iaq/introduction-indoor-air-quality

[7.] Ferdoush, S., & Li, X. (2014). Wireless Sensor Network System Design Using Raspberry Pi and Arduino for Environmental Monitoring Applications. https://doi.org/10.1016/j.procs.2014.07.059

[8.] Institute of Health Metrics and Evaluation. (2017). Number of deaths by risk factor. http://ghdx.healthdata.org/gbd-results-tool

[9.] Jasim, J., Al-Farsi, M., Keloth, D., & Rasu, E. (2016). Synthesis of Activated Carbon using Orange and Lemon Peel for Wastewater Treatment Application. International Journal of Modern Science and Technology, 1(5), 178–182. https://nebula.wsimg.com/dedfd93995eda6bc48a0809da0fd00ee?AccessKeyId=7F4D485B7198C0BD2695&disposition=0&alloworigin=1

[10.] Jiang, S.-Y., Ma, A., & Ramachandran, S. (2018). Negative Air Ions and Their Effects on Human Health and Air Quality Improvement. https://doi.org/10.3390/ijms19102966

[11.] Liu, G., Xiao, M., Zhang, X., Gal, C., Chen, X., Liu, L., … Clements-Croome, D. (2017, April). A review of air filtration technologies for sustainable and healthy building ventilation. Retrieved on September 25, 2020 from https://www.researchgate.net/publication/316472615_A_review_of_air_filtration_technologies_for_sustainable_and_healthy_building_ventilation.

[12.] Salthammer, T. (2019). Formaldehyde sources, formaldehyde concentrations and air exchange rates in European housings. Building and Environment, 150, 219–232. https://doi.org/10.1016/j.buildenv.2018.12.042

[13.] Seçmeler, Ö., & Sevimli, Y. (2021). Recipes for the valorization of culinary by-products and leftovers. Gastronomy and Food Science, 165–192. https://doi.org/10.1016/b978-0-12-820057-5.00009-1

[14.] Singh, H., Pallagani, V., Khandelwal, V., & Venkanna, U. (2018). IoT based smart home automation system using sensor node. https://doi.org/10.1109/rait.2018.8389037

[15.] Sk Akhtar, A. (2016). Indoor Air Pollutants and Respiratory Problems among Dhaka City Dwellers. Archives of Community Medicine and Public Health, 032–036. https://doi.org/10.17352/2455-5479.000014

[16.] Souto, F., Calado, V., & Pereira, N. (2018). Lignin-based carbon fiber: a current overview. Materials Research Express, 5(7), 072001. https://doi.org/10.1088/2053-1591/aaba00

[17.] State of Global Air. (2019) State of Global Air 2019: a Special Report on Global Exposure to Air Pollution and Its Disease Burden. https://www.stateofglobalair.org/sites/default/files/soga_2019_report.pdf
[18.] Sublett, J., Seltzer, J., Burkhead, R., Williams, P., Wedner, H., & Phipatanakul, W. (2010, January 1). Air filters and air cleaners: Rostrum by the American Academy of Allergy, Asthma & Immunology Indoor Allergen Committee. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2824428/
[19.] Tanner. (2018). Experimental Research - an overview. https://www.sciencedirect.com/topics/social-sciences/experimental-research
[20.] Trey. (2020, January 2). Air Filter Guide: What MERV Rating should I use? HVAC Training Shop. https://hvactrainingshop.com/air-filter-guide-what-merv-rating-should-i-use/
[21.] United States Environmental Protection Agency. (2018, July). RESIDENTIAL AIR CLEANERS A Technical Summary. https://www.epa.gov/sites/production/files/2018-07/documents/residential_air_cleaners_-_a_technical_summary_3rd_edition.pdf.
[22.] United States Environmental Protection Agency. (2019, February 19). What is a MERV rating? | US EPA. https://www.epa.gov/indoor-air-quality-iaq/what-merv-rating-1#:~:text=Minimum%20Efficiency%20Reporting%20Values%2C%20or,and%2010%20microns%20(%C2%B5m).&text=The%20higher%20the%20MERV%20rating,trapping%20specific%20types%20of%20particles.
[23.] Vijayan, V. K., Paramesh, H., Salvi, S. S., & Dalal, A. A. K. (2015). Enhancing indoor air quality -The air filter advantage. Retrieved on September 25, 2020 from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4587002/.
[24.] World Health Organization. (2018, May 8). Household air pollution and health. https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health
[25.] World Health Organization. (2018). Ambient air pollution. https://doi.org//entity/gho/phe/outdoor_air_pollution/en/index.html