INOFAIR 2020

Greening solution for environmental pollution: converting waste clothes into smart car exhaust filters

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1. ABSTRACT

Car exhausts emit a wide range of gases and solid matter, causing global warming, acid rain, and harming the environment and human health. Also, burning clothes is a big problem of a modern age. Many high fashion brands burn their unsold clothes in order not to lose their prestige and high prices. These facts are the reasons why the purpose of this project is "Converting waste clothes into smart car exhaust filters". With a big research of the properties of the materials, the hypothesis of this scientific research is that: ***If we use waste cotton and other waste clothes materials as well as tea bags and inedible biomass, we will be able to reduce the amount of CO, CO_2, HC and increase the amount of Oxygen in the exhaust fumes from cars.***

In order to prove our hypothesis, we performed 24 experiments. On 3 different types of cars (one that uses gasoline, one that uses LPG and one that uses diesel oil), we tested out the 7 filters. The filters consist of a tube filled with waste materials (5 filters with different types of waste clothes, 1 with used tea bags and 1 with waste biomass). We measured the emission of toxic gases and then we compared it with the results obtained when the filters were used.

Waste clothes filters showed an absorption of CO with efficiency up to 100%, CO_2 with efficiency up to approximately 79% and HC with efficiency up to 96%.
For a car that uses gasoline, I strongly recommend the 3rd filter (filled with georgette) as well as the 1st (cotton), 4th ("Porhet"-type of cotton), 5th (cord), 6th (inedible biomass) and 7th (used tea bags) considering the fact that they all have showed amazing results in absorbing different types of gases (the percentage of absorption is shown in details further in the project) .
For a car that uses LPG, I strongly recommend the 4th filter (filled with "Porhet"-type of cotton) as well as the 1st (filled with cotton), 3rd (filled with georgette) and the 7th (filled with used tea bags) filter which showed great results(the percentage of absorption is shown in details further in the project).
For car that uses diesel oil, I strongly recommend the 1st filter (cotton), 2nd (synthetic material), 3rd (georgette), 4th ("Porhet" –cotton) and the 5th filter (filled with cord).
This project solves two big and world-wide important problems with a very greening-ecologically friendly, efficient and low-cost method.

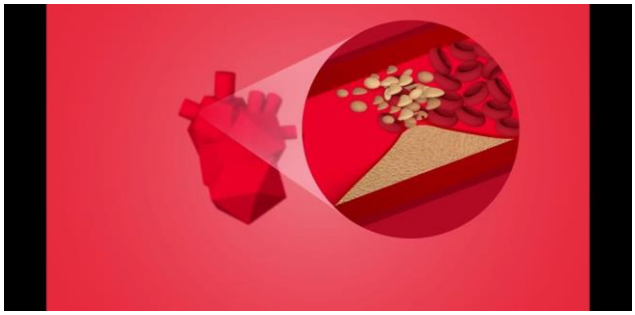
Based on this in future we plan to implement these filters in our every- day life and to develop them to a professional level in a collaboration with engineers and scientists.

2.INTRODUCTION

As the world gets hotter and more crowded, our engines continue to pump out dirty emissions, and half the world has no access to clean fuels or technologies (e.g. stoves, lamps), the very air we breathe is growing dangerously polluted: nine out of ten people now breathe polluted air, which kills 7 million people every year.
The health effects of air pollution are serious – one third of deaths from stroke, lung cancer and heart disease are due to air pollution. This is having an equivalent effect to that of smoking tobacco, and much higher than, say, the effects of eating too much salt. Poor air quality increases respiratory ailments like asthma and bronchitis, heightens the risk of life-threatening conditions like cancer, and burdens our health care system with substantial medical costs. Particulate matter is singlehandedly responsible for up to 30,000 premature deaths each year. Air pollution is hard to escape, no matter how rich an area you live in is. It is all around us. Microscopic pollutants in the air can slip past our body's defences, penetrating deep into our respiratory and circulatory system, damaging our lungs, heart and brain.
Air pollution is closely linked to climate change - the main driver of climate change is fossil fuel combustion which is also a major contributor to air pollution - and efforts to mitigate one can improve the other.

The video in the following link shows the causes and effects of air pollution on human's body:

https://www.youtube.com/watch?v=GVBeY1jSG9Y



1. Effects on the blood cells

2.1. Car pollution effects

Car pollutants cause immediate and long-term effects on the environment. Car exhausts emit a wide range of gases and solid matter, causing global warming, acid rain, and harming the environment and human health. Engine noise and fuel spills also cause pollution. Cars, trucks and other forms of transportation are the single largest contributor to air pollution in the United States, but car owners can reduce their vehicle's effects on the environment.

Global Warming

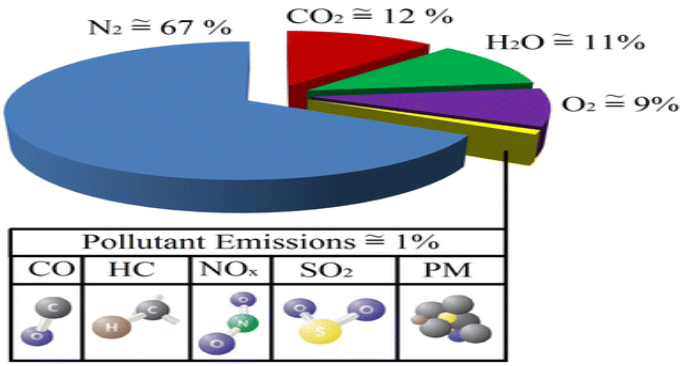
Car pollution is one of the major causes of global warming. Cars and trucks emit carbon dioxide and other greenhouse gases, which contribute one-fifth of the United States' total global warming pollution. Greenhouse gases trap heat in the atmosphere, which causes worldwide temperatures to rise. Without greenhouse gases, the Earth would be covered in ice, but burning excessive amounts of fossil fuels, such as gasoline and diesel, has caused an increase of 0.6 degrees Celsius, or 1 degree F, in global temperatures since pre-industrial times, and this will continue to rise over the coming decades. Warmer global temperatures affect farming, wildlife, sea levels and natural landscapes.

Air, Soil and Water

The effects of car pollution are widespread, affecting air, soil and water quality. Nitrous oxide contributes to the depletion of the ozone layer, which shields the Earth from harmful ultraviolet radiation from the sun. Sulfur dioxide and nitrogen dioxide mix with rainwater to create acid rain, which damages crops, forests and other vegetation and buildings. Oil and fuel spills from cars and trucks seep into the soil near highways, and discarded fuel and particulates from vehicle emissions contaminate lakes, rivers and wetlands.

Human Health

Particulate matter, hydrocarbons, carbon monoxide and other car pollutants harm human health. Diesel engines emit high levels of particulate matter, which is airborne particles of soot and metal. These cause skin and eye irritation and allergies, and very fine particles lodge deep in lungs, where they cause respiratory problems. Hydrocarbons react with nitrogen dioxide and sunlight and form ozone, which is beneficial in the upper atmosphere but harmful at ground level. Ozone inflames lungs, causing chest pains and coughing and making it difficult to breathe. Carbon monoxide, another exhaust gas, is particularly dangerous to infants and people suffering from heart disease because it interferes with the blood's ability to transport oxygen. Other car pollutants that harm human health include sulfur dioxide, benzene and formaldehyde.



2. The compositions of diesel exhaust gas

2.2. Burning waste clothes

Burning clothes is a big problem of a modern age. Many high fashion brands burn their unsold clothes in order not to lose their prestige and high prices.

High-end clothing manufacturers burned $37.8 million of unwanted products last year, sparking environmental concerns from its shareholders and a debate over the wastage by luxury brands.

Designer brands often destroy unwanted stock to stop it from being sold at discounted prices and maintain the exclusivity of their products so they are not sold to the "wrong people," *The Times* reported.
In its annual report, the luxury clothes maker, renowned for its checked designs, $1,800 trench coats and $250 polo shirts, said it destroyed $13.76 million in beauty products and $24 million in ready-to-wear products and accessories.

This was three times more than in 2014. More than $116 million worth products have been destroyed over the past five years, *The Times* said.
Shareholders at the company had complained about the destruction, with one investor asking at the annual general meeting why the products were not made available, *Retail Gazette* reported. Retailers say the practice helps stop counterfeiting and protects intellectual property.

Why do brands burn? Well, there's the fact that hefty markdowns can hurt a company's image of being exclusive and always in-demand; a row of messy sale rails in a luxury boutique selling handbags that cost more than the average person makes in two months doesn't exactly scream, 'THIS IS A WORTHWHILE INVESTMENT'. If the market becomes oversaturated with cut-price products, it can negatively impact a label's prestige – brands need their high prices to seem justifiable, and exclusivity is a key part of that. While many high-end companies operate their own outlets, they are perhaps less willing to palm off unsold stock to chains – after all, who is going to shell out for a cashmere coat if it might end up in TK Maxx in a few weeks?

Then there's the argument that destroying clothing is protection against counterfeiting – if enough stock is sold cheaply enough to end up in the wrong hands to be copied, a brand's intellectual property is at risk. Counterfeiting is a huge, and illegal, industry reportedly worth $450bn – where vulnerable people like undocumented immigrants are regularly exploited for low-cost labor, including in the UK. According to the UK's Anti-Counterfeiting Group, intellectual property crime helps to fund other kinds of illegal behavior, including the smuggling of drugs, guns and people.

3.Clothes that can be found in landfills

This big problem has a serious effect on people's health and their well-being. I wanted to connect these problems and find a solution that will decrease the damage they make to the environment. After a long research we concluded that burning big amounts of waste clothes is a big pollutant to the air. We wanted to create a solution by which we can decrease the air pollution by using these clothes waste so we can solve two problems at once. By Living in a small town like Tetovo, I am aware that the exhaust fumes from cars are one of the leading polluters of the air.

3.THEORETICAL PART

We decided that the purpose of the project will be to decrease the amount of toxic gases in the exhaust fumes of cars by using fashion waste which otherwise would have ended in a landfill, polluting the air additionally. Also, we will try to use other eco-friendly products in order to decrease the amount of toxic gases.

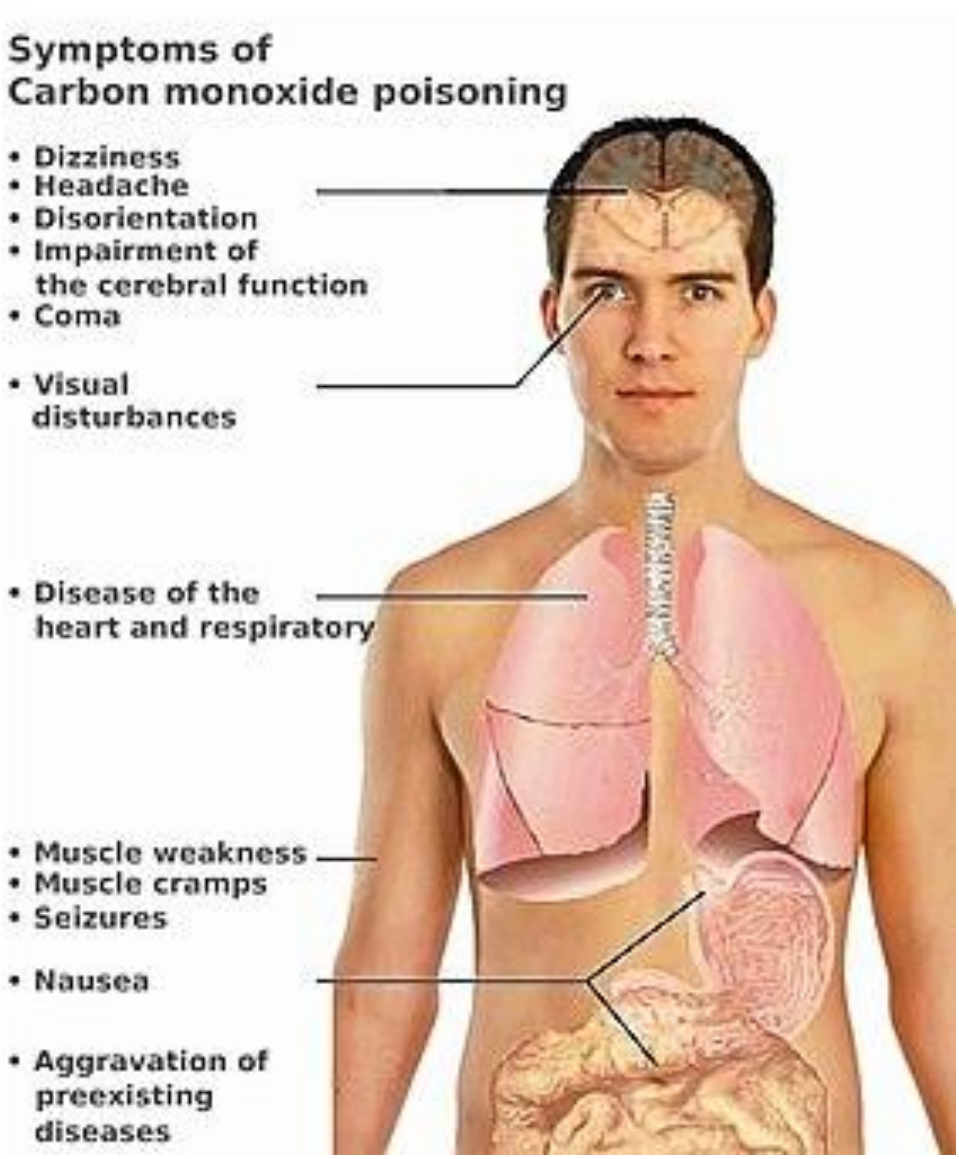
By reading lots of articles about this topic, we concluded that some of the most important and toxic gases that can be found in the exhaust fumes are:

- Carbon monoxide
- Carbon dioxide
- Hydrocarbon
- Nitrogen oxides
- Sulphur dioxide
- Soot (Not exactly a gas)

  - Also, we want to see if our filters will be able to increase the percentage of oxygen released which will help to reduce the big difference between oxygen and carbon dioxide in the air and return it to its normal and healthy borders.

3.1. Carbon monoxide (CO)

No discussion pertaining to car fumes and its dangers can be complete without mentioning this hazardous gas. Carbon monoxide is a colorless, tasteless and odorless gas in itself, and is one of the chief culprits that make exhaust fumes hazardous to human health, as it binds to the hemoglobin in our blood, which results in suffocation. If exposed to even a minuscule amount (0.0035%) of carbon monoxide constantly for 6-8 hours, one will start experiencing the initial symptoms of carbon monoxide poisoning, which include lightheadedness, confusion, dizziness, and headache. It increasingly becomes worse as the concentration of the gas in the air rises.

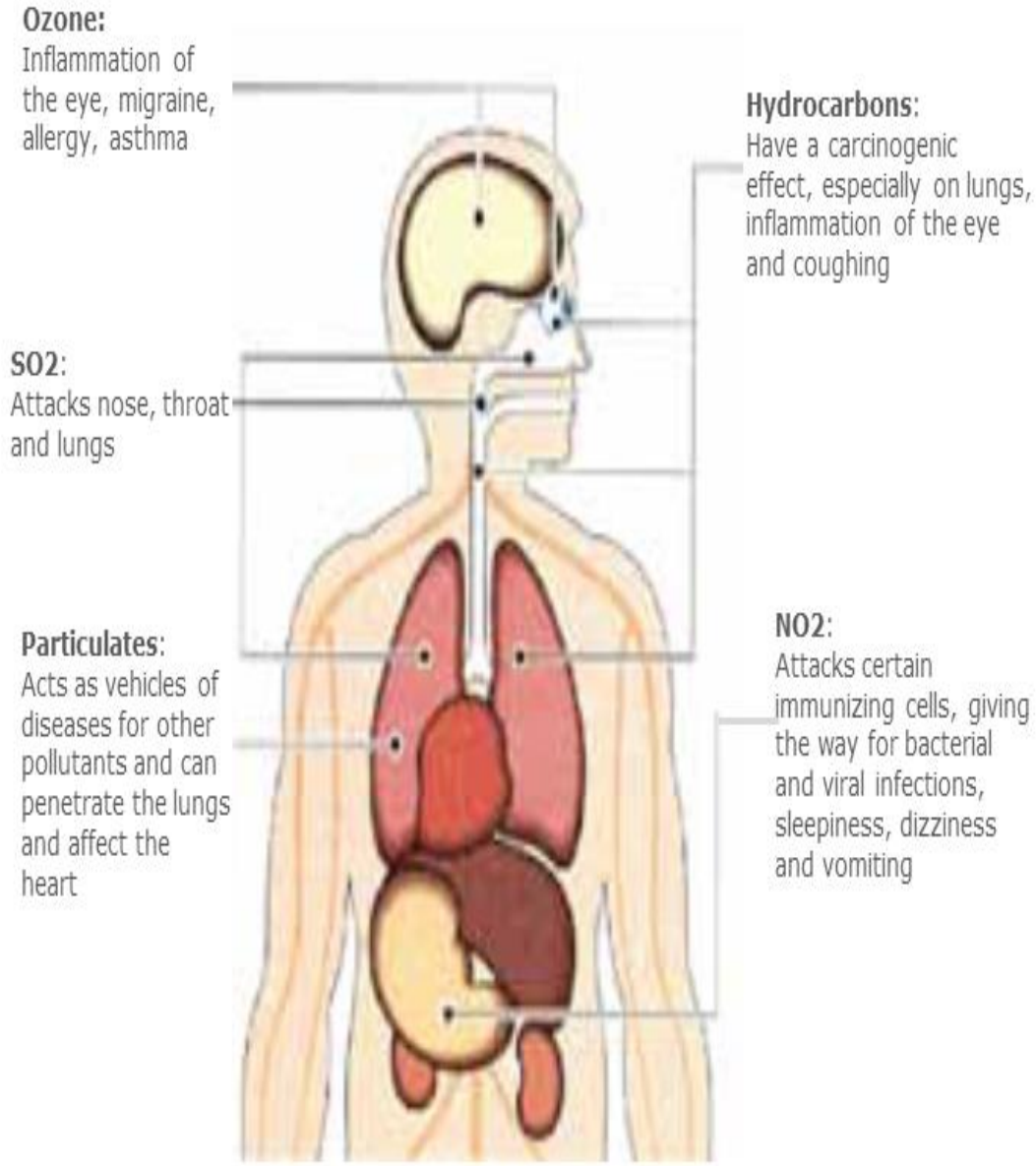


4.Symptoms of CO poisoning

3.2. Hydrocarbons (benzene)

Exhaust fumes contain certain hydrocarbons (compounds containing chains of hydrogen and carbon atoms), particularly benzene, which has dangerous consequences to our health both immediately and over the long term. As a well-known carcinogen (something that causes cancer), benzene is known to severely impact bone marrow, which could lead to a drop in the number of red blood cells, leading to anemia.

According to the Department of Health and Human Services (DHHS), benzene can cause cancer of the blood-forming organs (or leukemia) if one is exposed over a long period of time



5.Effects of pollution on a human body

3.3. Cotton

According to NPTEL

Fibers composed of pure cellulose can be classified as:

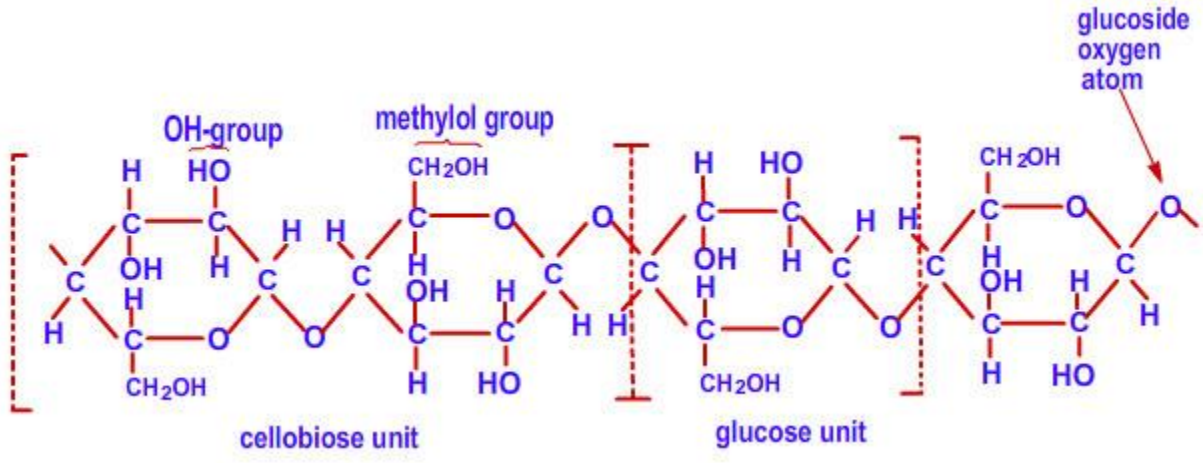
- **Natural cellulose fibers:** jute, flax, coir, cotton, kenaf etc.
- **Man-made rayon fibers:** cuprammonium and viscose rayon.

Cotton is the most important naturally derived, vegetable fiber, a shrub in the *malvaceae* family, making up more than half of textile fiber consumption worldwide. Cotton is a soft, staple fiber that grows in a form known as a boll around the seeds of the cotton plant, a shrub native to tropical and subtropical regions around the world, including the Americas, India and Africa. The fiber is generally transformed into yarn which is woven to manufacture fabrics. The density of the fiber is 1.52 g/cm 3, which makes cotton a rather heavy fiber.

The polymer system of cotton

Cotton is a linear, cellulose polymer. The repeating unit in the cotton has two glucose units, called cellobiose. Cotton consists of about 5000 cellobiose units. Its degree of polymerization is thus 5000. Hence it is a very long, linear polymer, about 5000 nm in length and about 0.8 nm thick.

The most important chemical groups on the cotton polymer are the hydroxyl groups or -OH groups which are also present as methylol groups or $–CH_2OH$. Due to the presence of hydroxyl group, polar nature of polymer gives rise to hydrogen bonds between the OH-groups of adjacent cotton polymers.



6.The chemical formula of the cellulose polymer

Polymer system of cotton is crystalline in nature. It consists of about 65 to 70 per cent crystalline and about 35-30 per cent amorphous regions. Polymer system of cotton shows well ordered and oriented crystalline regions. The maximum distance across which hydrogen bonds can form between polymers is 0.5nm in crystalline regions. Hydrogen bonds are the dominant forces of attraction present in the polymer system of cotton. Van der Waals forces which are also present have little relevance. The polymer system of cotton can be imagined as a roll of wire netting. The

crystalline regions are therefore the well-ordered lines and rows of hexagonal holes of the wire netting. The amorphous regions are a disarrangement of these orderly lines.

Physical properties

Tenacity

The strength of cotton fibers is due to the 70 per cent crystallinity of its long fiber. It is one of the few fibers which gains strength when wet. It occurs because of a temporary improvement in polymer alignment in the amorphous regions of the polymer system. The improved alignment when wet results in an increase in the number of hydrogen bonds, with an approximate 5 per cent increase in fiber tenacity.

Elastic-plastic nature

Crystalline polymer system imparts inelastic nature to cotton fiber, and due to this reason cotton textiles wrinkle and crease easily. Under strain cotton polymers slide past one another. They are usually prevented from by their extreme length and countless hydrogen bonds, which hold them within their polymer system. Bending or crushing of cotton textile materials places strain on the fibers polymer systems and cause polymer fracture as the crystallinity of the polymer system makes it difficult for cotton polymer to be displaced. Polymer fracture results in weak points due to polymer disarrangements, and hence weak areas in the cotton fiber structure. Such weakening of the polymer system causes cotton textile materials to crease and wrinkle readily.

Hygroscopic nature

The cotton fiber is very absorbent due to countless polar -OH groups present in its polymers. Water molecule can only enter the polymer system through its amorphous regions, as the inter-polymer spaces in the crystalline regions are too small for entrance. Aqueous swelling of the cotton fiber is due to a separation of polymers by the water molecules in the amorphous regions only.

The hygroscopic nature prevents cotton textile materials from developing static electricity. The polarity of the water molecules are attracted to the hydroxyl group on the polymers, and resist the formation of static charge.

Thermal properties

Cotton fibers conduct heat energy, minimizing any destructive heat accumulation. As a result, they can withstand hot ironing temperatures. Excessive application of heat energy results in the cotton fiber to burn, without any prior melting, thus cotton is not thermoplastic. It is due to the extremely long polymer of cotton and the countless hydrogen bonds it consists. These prevent the polymers from assuming new positions when heat is applied, as would be the case with the shorter polymers of thermoplastic fibers. On application of high kinetic energy, polymers of cotton fiber will begin to vibrate or become so excited and disintegrate, which results in violent chemical reactions observed as fiber combustion.

- These properties make cotton perfect for car engines.

3.4. Polymer

According to the website: Scientificamerican, scientist at the University of Southern California, used a polymer called a polyethylenimine (PEI) as the basis for their new materials, which offered several advantages over existing strategies to filter carbon. Because I know that cotton is a polymer, I hardly believe that waste clothes will be able to absorb the toxic fumes.

4. GOALS

We know that:

1. *Polymer can be used to decrease the air pollution*
2. *Cotton is a type of polymer*
3. *Clothes are made of cotton*
4. *Waste clothes pollute the air*

So, my hypothesis is: If we use waste cotton and other waste clothes materials as well as tea bags and inedible biomass, we will be able to reduce the amount of CO, CO_2, HC and increase the amount of Oxygen in the exhaust fumes from cars.

Our goals are to:

- Decrease the amount of carbon monoxide emitted
- Decrease the amount of carbon dioxide emitted
- Decrease the amount of Hydrocarbon emitted
- Increase the amount of oxygen emitted

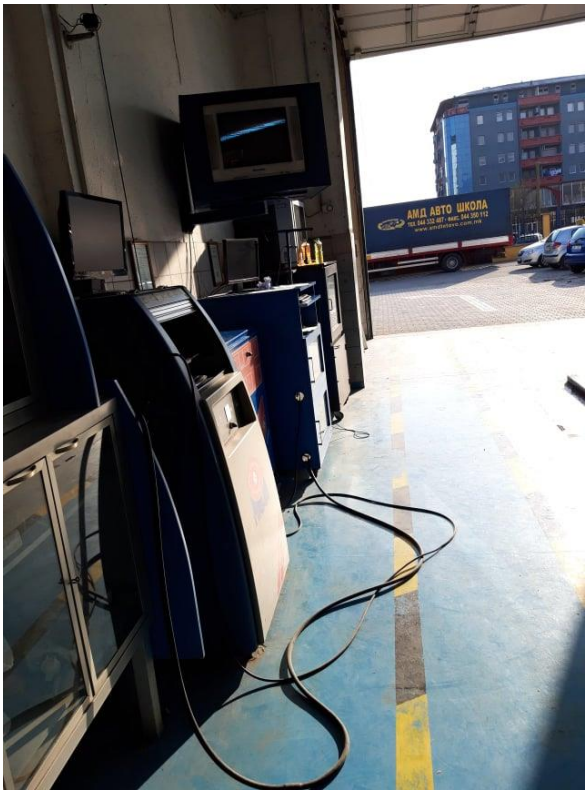
5. MATHERIALS AND PROCEDURES

In order to get precise and professionally acceptable measurements of the amount of toxic gases released, with a big help of my family, we contacted local company which checks if the cars are in a god condition to be driven. It also checks if they pollute the environment by measuring the amount of toxic gases, they release which was exactly what I needed.

- For each experiment I use the same measuring method.

- Firstly, we measured the amount of gases that were released without a filter and then we did the same process for the all seven filters on three different cars. One of the cars uses petrol, the other one diesel and the third one PG.

- I made seven filters using different types of materials in order to see which one will absorb the biggest amount of toxic fumes.



7.The equipment and the place we used to do the precise measurements

5.1. 1st FILTER (COTTON)

5.1.1. Materials used to construct the filter:

- 39 cm long tube
- 25.94 g cotton
- Rubber bands
- Web
- Round tube part

5.1.2. Procedures:

I put the materials in the tube and I put pieces of net on the ends in order to make sure everything stays in place while transport. Before we measured, I took of the net pieces and put on the round tube part in order to be able to attach the filter to the car.

8.Measuring approximately 25 g fabric

9.Prepared filter

5.2. 2nd FILTER (SYNTHETIC MATERIAL)

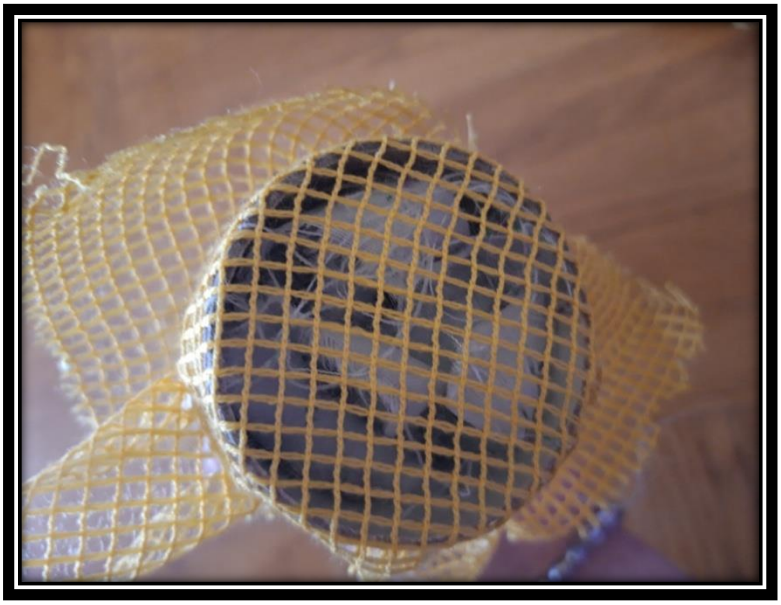
5.2.1. Materials used to construct the filter:

- 39 cm long tube
- 25.94 g synthetic material
- Rubber bands
- Net
- Round tube part

5.2.2 Procedures:

I put the materials in the tube and I put pieces of net at the ends in order to make sure everything stays in place while transport. Before we measured, I took of the net pieces and put on the round tube part in order to be able to attach the filter to the car.

10.Measuring approximately 25 g fabric



11.Prepared filter

5.3. 3rd FILTER (GEORGETTE)

5.3.1. Materials used to construct the filter:

- 39 cm long tube
- 25 g georgette
- Rubber bands
- Net
- Round tube part

5.3.2. Procedures:

I put the materials in the tube and I put pieces of net at the ends in order to make sure everything stays in place while transport. Before we measured, I took of the net pieces and put on the round tube part in order to be able to attach the filter to the car.

12.Measuring approximately 25 g fabric

13.Prepared filter

5.4. 4th FILTER ("PORHET"-COTTON)

5.4.1. Materials used to construct the filter:

- 39 cm long tube
- 25 g "Porhet"-cotton
- Rubber bands
- Net
- Round tube part

5.4.2. Procedures:

I put the materials in the tube and I put pieces of net at the ends in order to make sure everything stays in place while transport. Before we measured, I took of the net pieces and put on the round tube part in order to be able to attach the filter to the car.

14.Measuring approximately 25 g fabric

15.Prepared filter

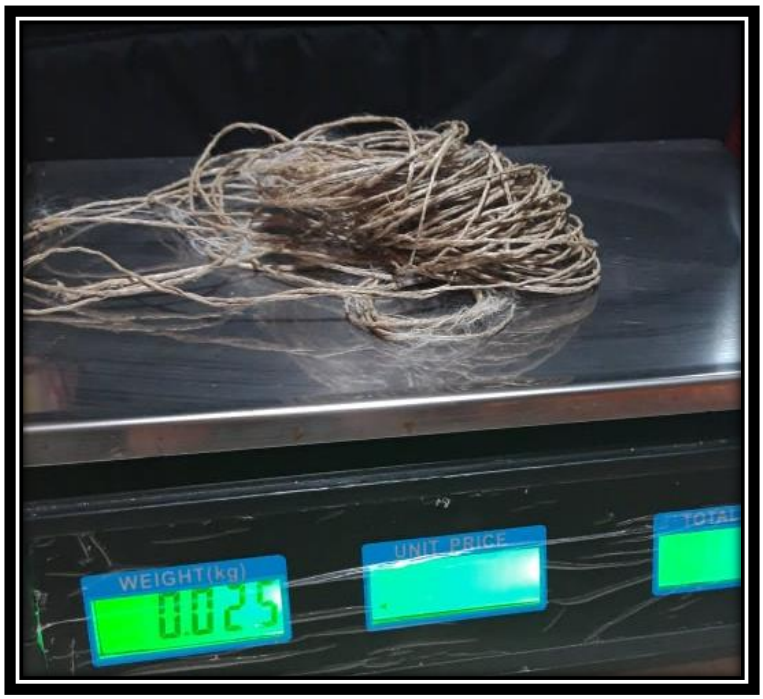
5.5. 5th FILTER (CORD)

5.5.1 Materials used to construct the filter:

- 28 cm long tube
- 25 g cord
- Rubber bands
- Net
- Round tube part

5.5.2. Procedures:

I put the materials in the tube and I put pieces of net at the ends in order to make sure everything stays in place while transport. Before we measured, I took of the net pieces and put on the round tube part in order to be able to attach the filter to the car.



16.Measuring 25 g cord

17.Prepared filter

5.6. 6th FILTER (INEDIBLE BIOMASS)

5.6.1 Materials used to construct the filter:

- 32 cm long tube
- 100 g inner inedible part of a cabbage
- 30 g peels of mandarins
- Rubber bands
- Net
- Round tube part

5.6.2. Procedures:

I put the materials in the tube and I put pieces of net at the ends in order to make sure everything stays in place while transport. Before we measured, I took of the net pieces and put on the round tube part in order to be able to attach the filter to the car.

18.Measuring 100 g inner , inedible part of cabbage

19.Measuring 30 g peels of mandarines

20.Prepared filter

5.7. 7th FILTER (USED TEA BEGS)

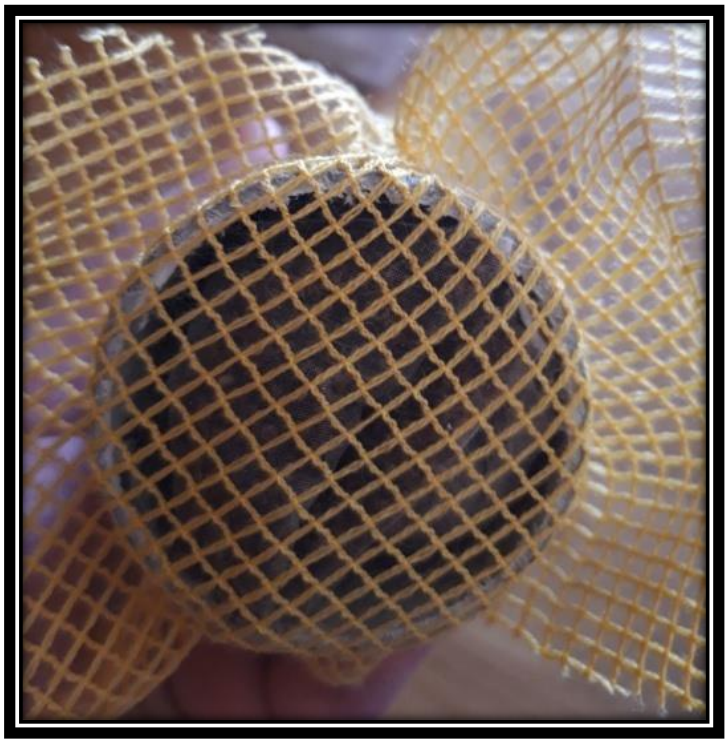
5.7.1 Materials used to construct the filter:

- 28cm long tube
- 10 used tea bags (30 grams)
- Rubber bands
- Net
- Round part of a tube

5.7.2 Procedures:

I put the materials in the tube and I put pieces of net at the ends in order to make sure everything stays in place while transport. Before we measured, I took of the net pieces and put on the round tube part in order to be able to attach the filter to the car.

21.Measuring 30 g used tea bags



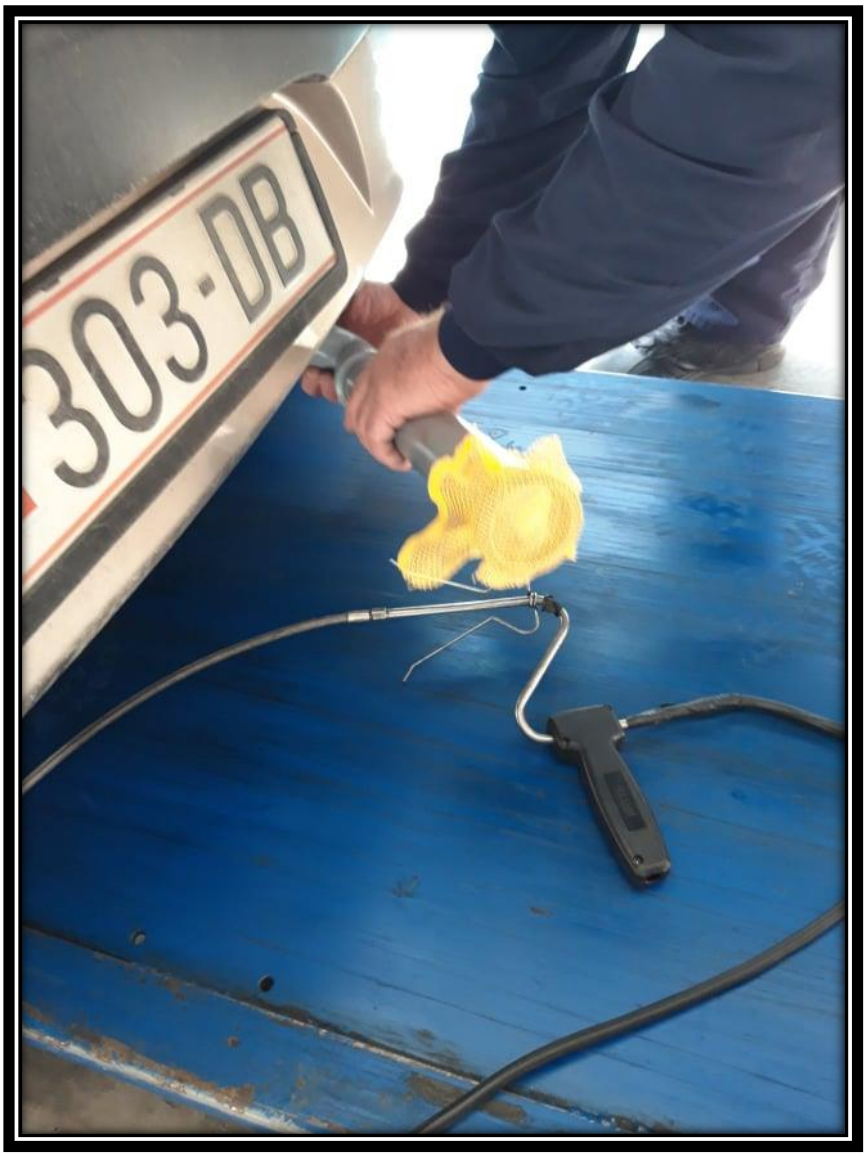
22.Prepared filter

5.8. Measuring information and pictures

In order to get the results, we measured the amount of toxic gases without filter and then by using all of the seven previously mentioned filters.

We measured on 3 different types of cars:

- Hyundai i20 -2008 (uses gasoline)
- Mitsubishi Outlander – 2004 (uses LPG)
- Peugeot Partner -2011 (uses diesel)

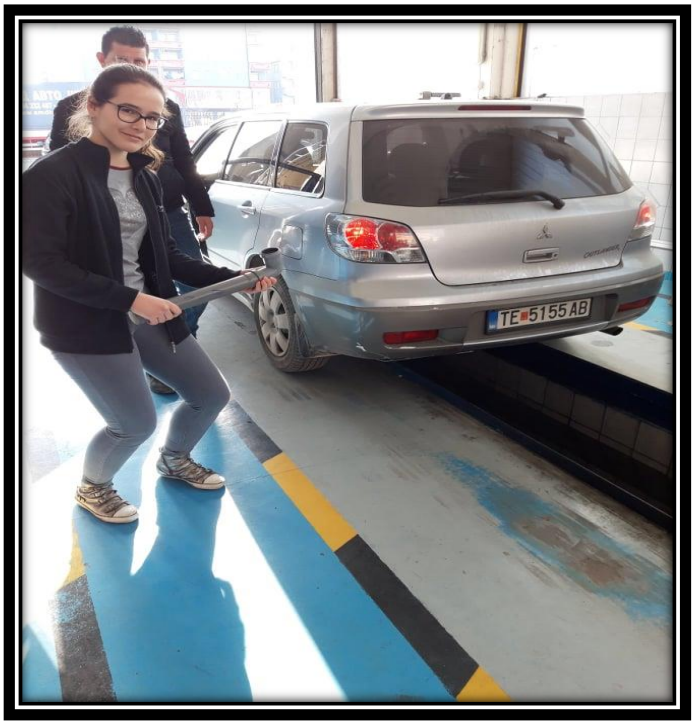


23.Process of measuring

24.Getting prepared

25.Car that uses gasoline

26.Car that uses diesel oil



27.Car that uses LPG

6.RESULTS OF THE EXPERIMENTS

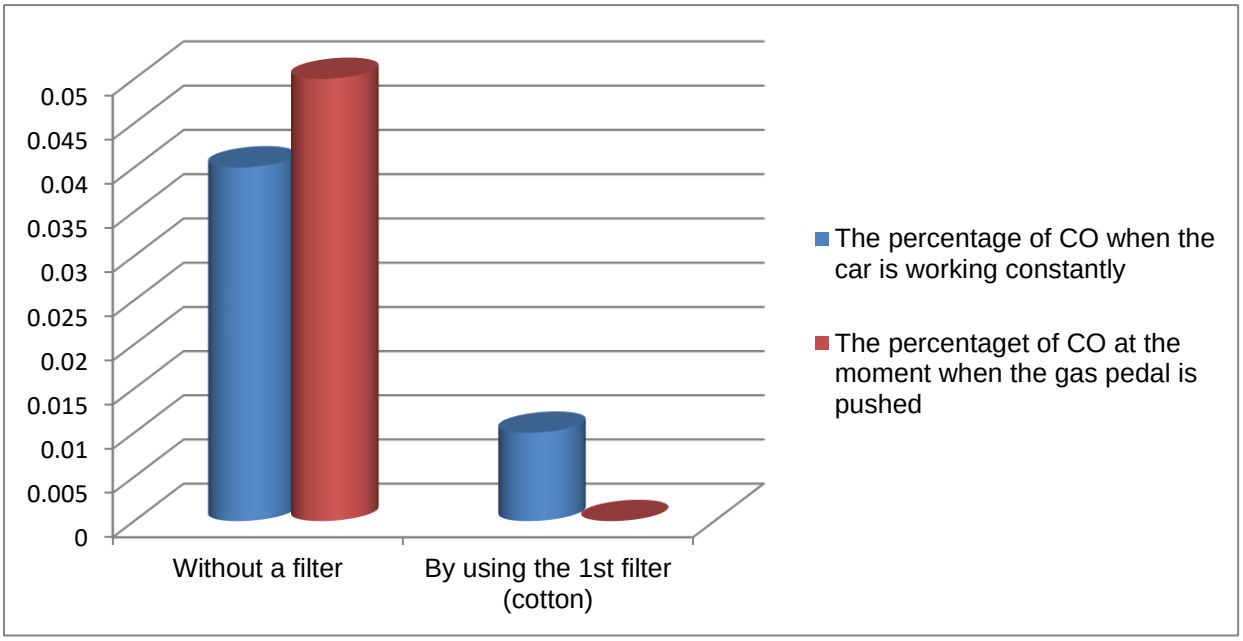
6.1. The first part of the experiment tested the filters on a car which uses gasoline as a fuel

6.1.1. Carbon monoxide

Without any filter, when the car was working constantly the 0.04 % of the released gases was Carbon monoxide and at the moment when the gas pedal was pushed it was 0.05%.

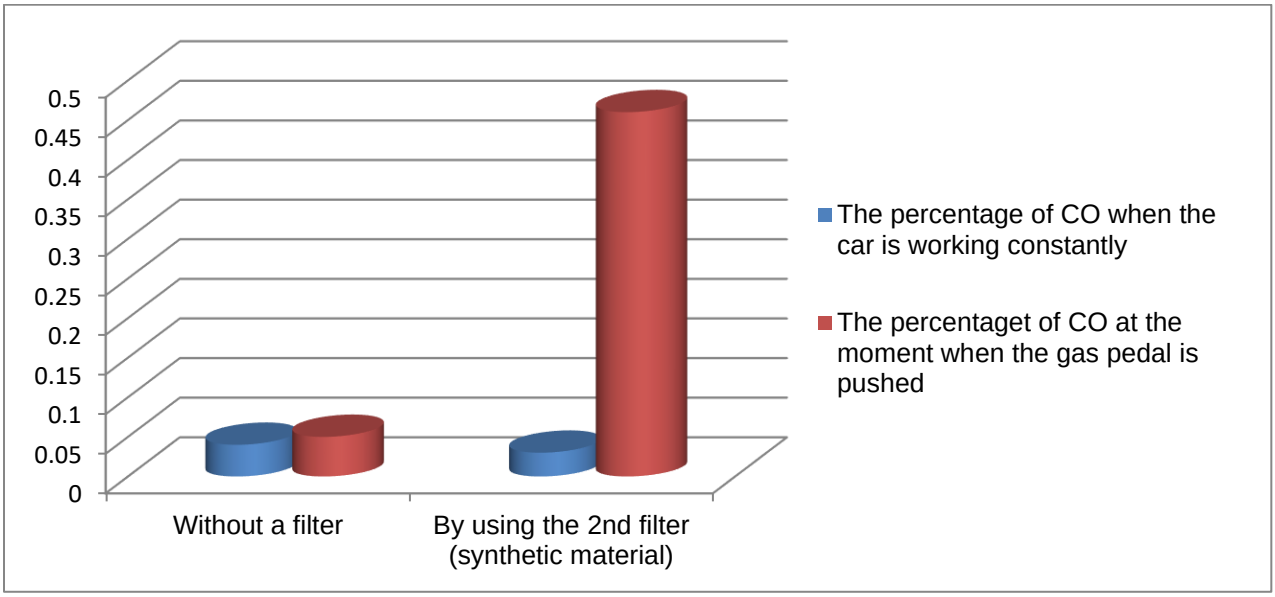
6.1.1.1.

By using the **first filter (cotton)** it rapidly decreased to 0.01% when the car was working constantly and 0% (nothing at all) when the gas pedal was pushed.



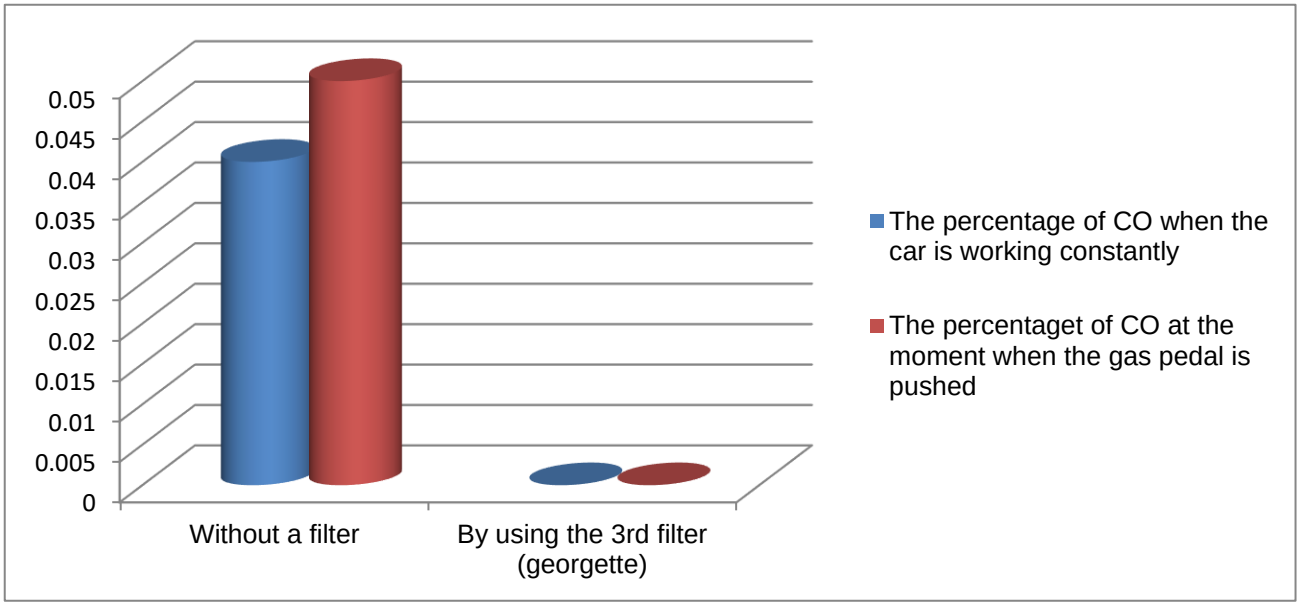
6.1.1.2.

By using the **second filter (synthetic material)** it decreased to 0.03% when the car was working constantly and increased to 0.46% at the moment when the gas pedal was pushed.



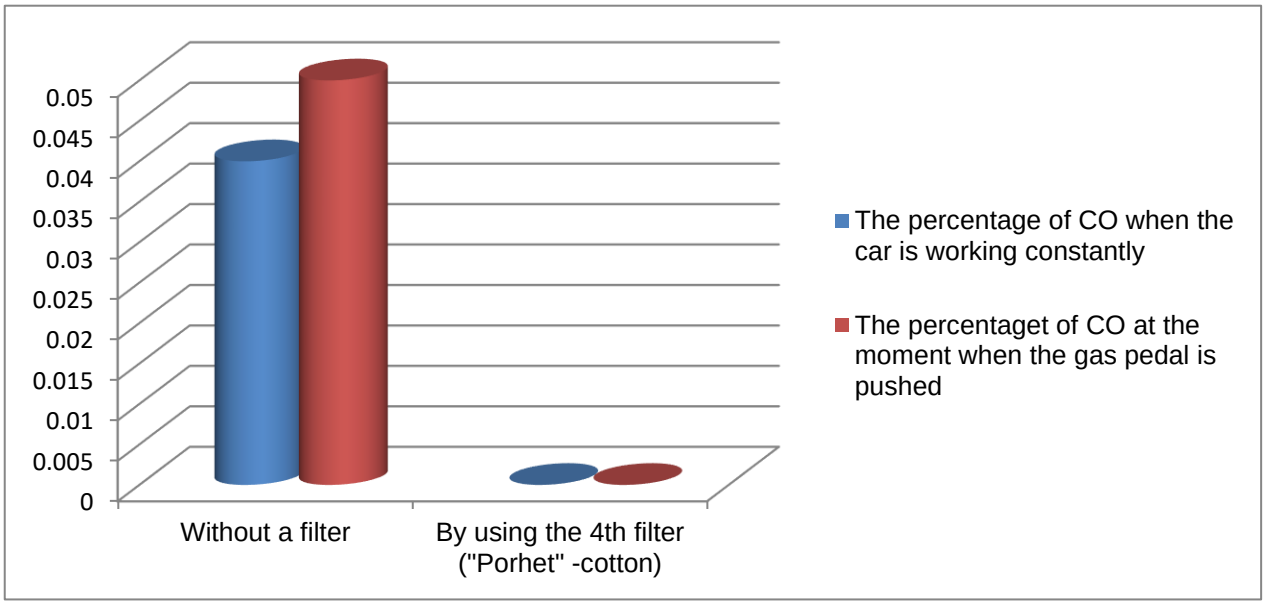
6.1.1.3.

By using the **third filter (georgette)** it rapidly decreased to 0% (no emission at all) in both cases, when the car was working constantly and at the moment when the gas pedal was pushed.



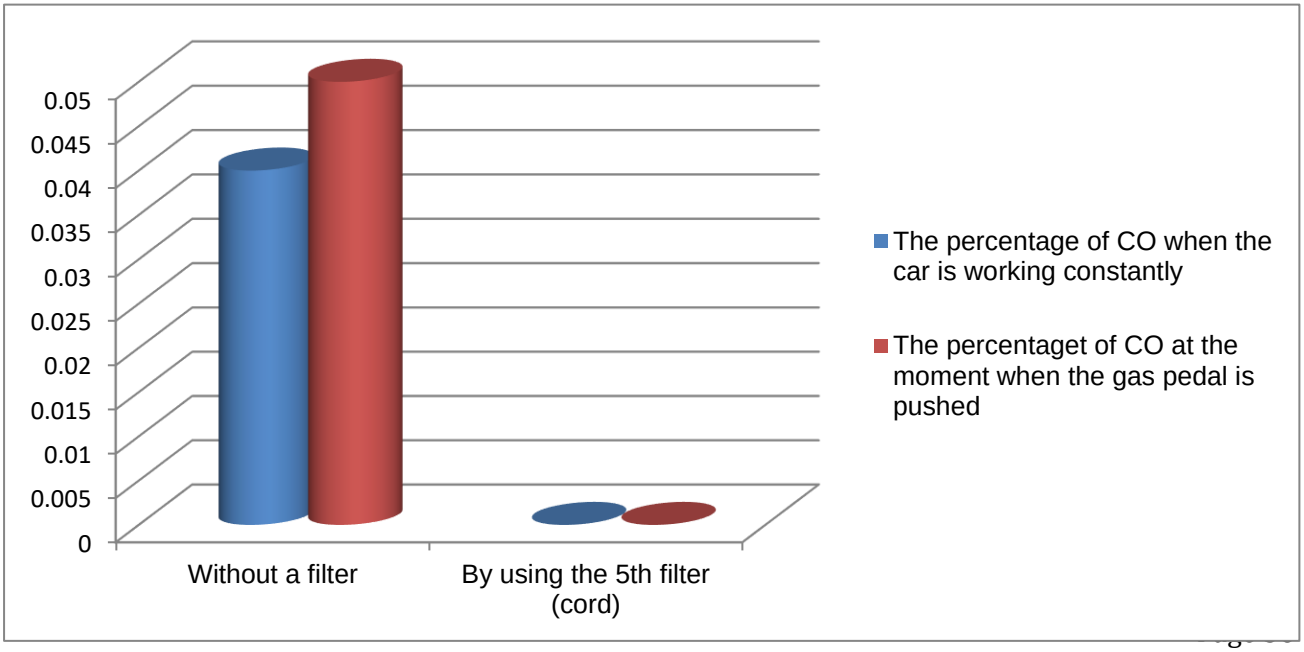
6.1.1.4.

By using the **fourth filter ("Porhet"-cotton)** it rapidly decreased to 0% (no emission at all) in both cases, when the car was working constantly and at the moment when the gas pedal was pushed.



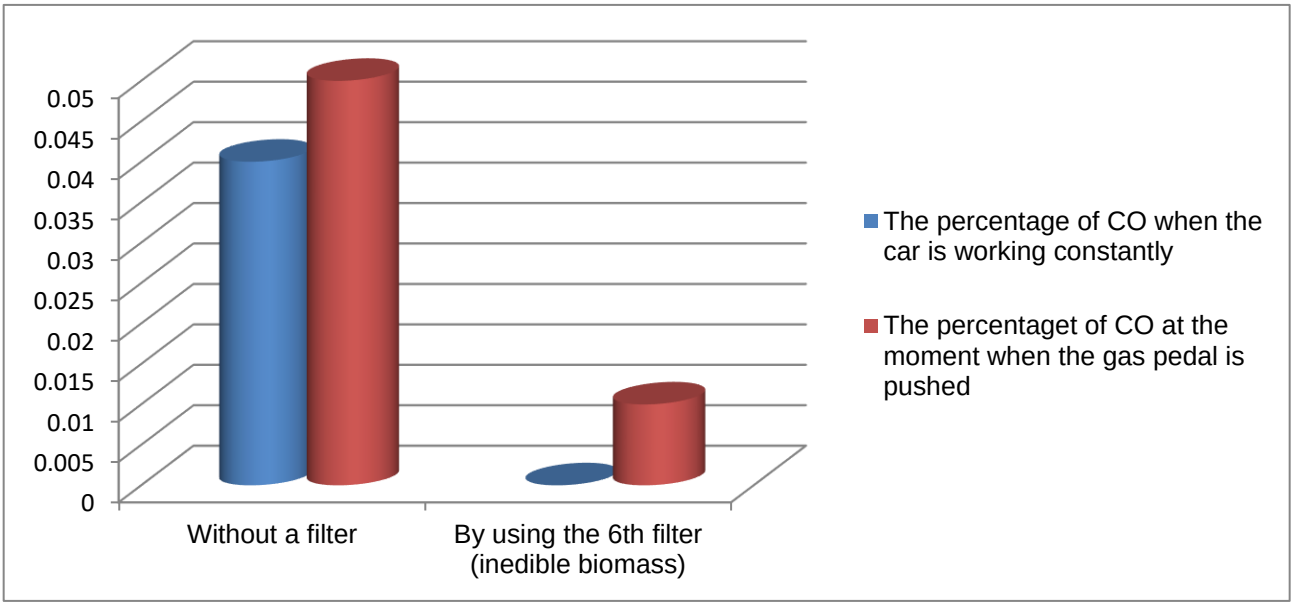
6.1.1.5.

By using **the fifth filter (cord)** it rapidly decreased to 0% (nothing at all) in both cases, when the car was working constantly and at the moment when the gas pedal was pushed.



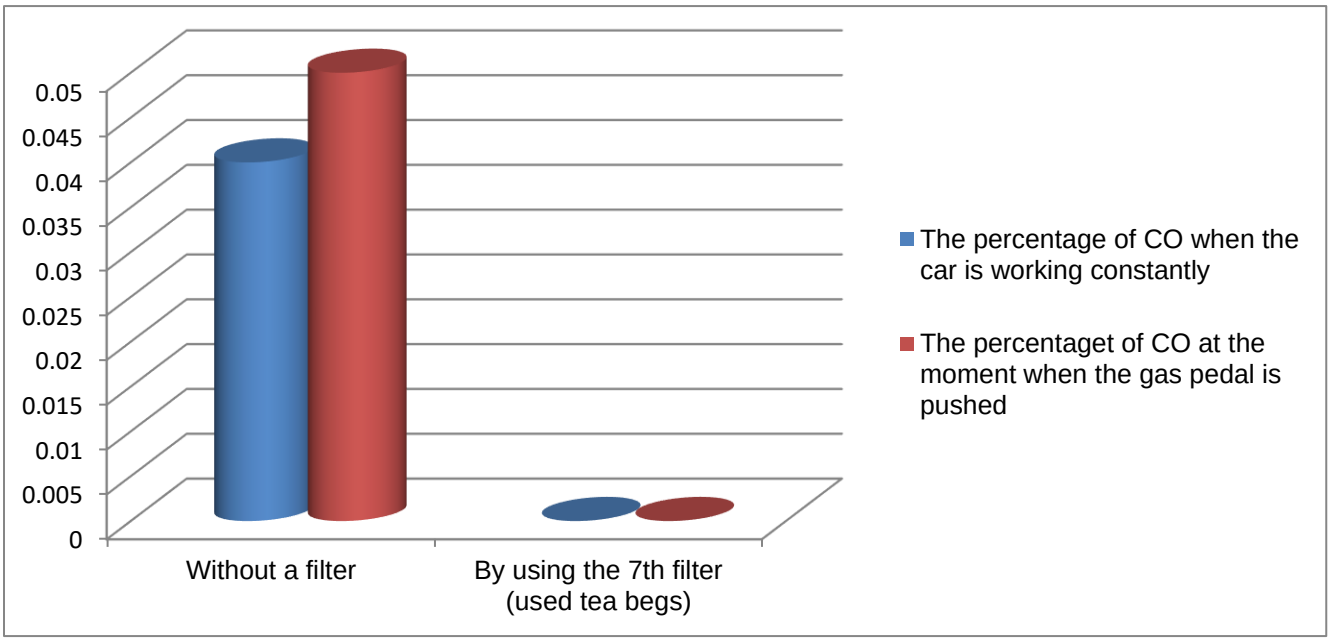
6.1.1.6.

By using **the sixth filter (inedible biomass)** it rapidly decreased to 0% (no emission at all) when the car was working constantly and 0.01 under a gas.

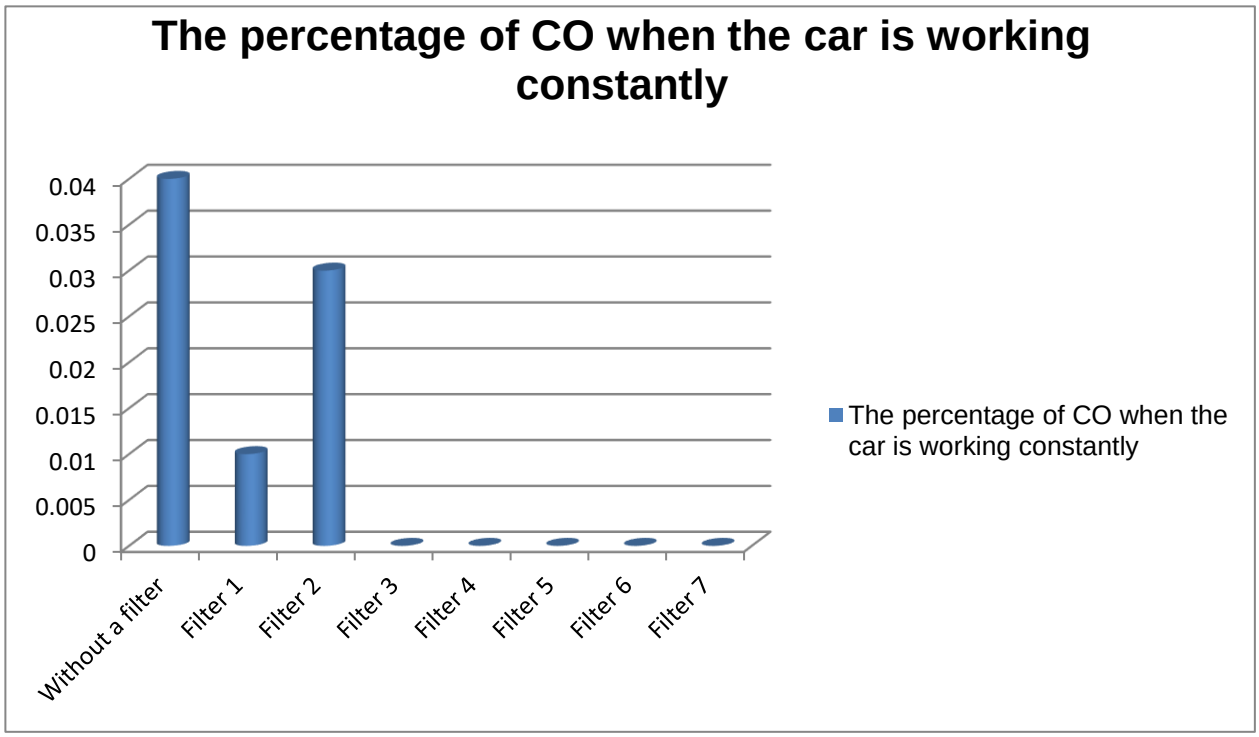


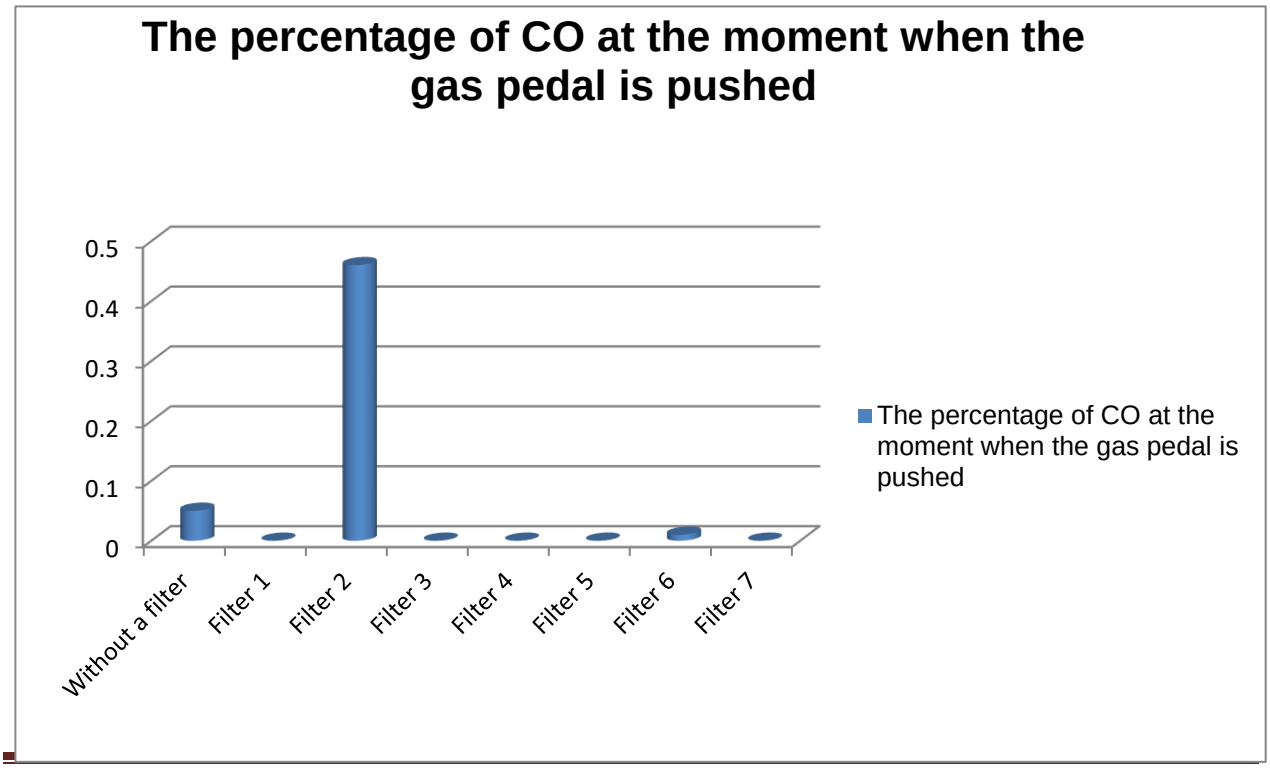
6.1.1.7.

By using **the seventh filter (used tea bags)** it rapidly decreased to 0% (nothing at all) in both cases, when the car was working constantly and at the moment when the gas pedal was pushed.



6.1.1.8.


The percentage of CO when the car is working constantly
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
Without a filter
Filter 1
Filter 2
Filter 3
Filter 4
Filter 5
Filter 6
Filter 7
The percentage of CO when the car is working constantly

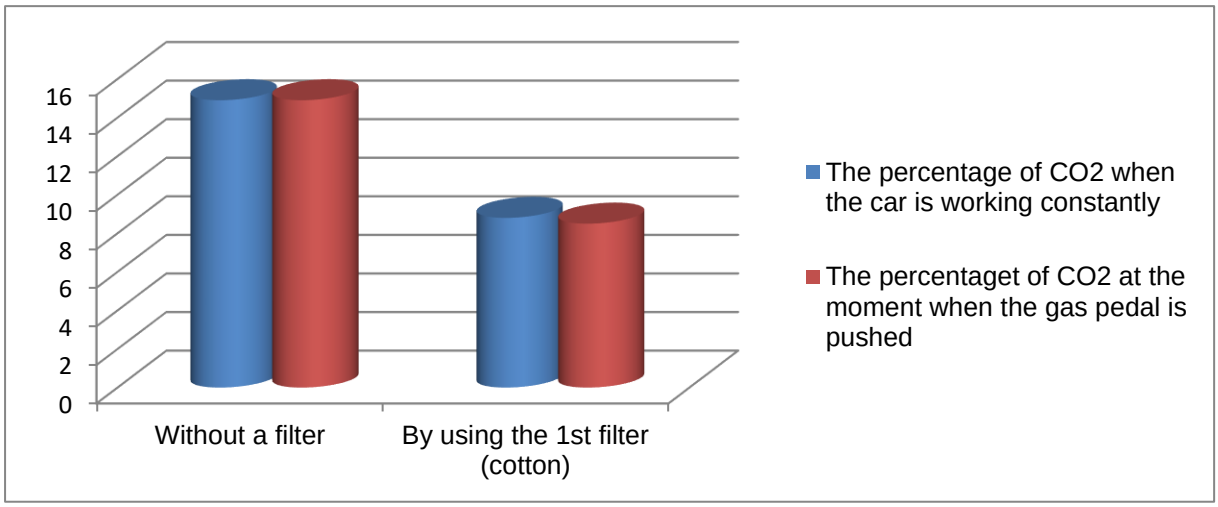

The percentage of CO at the moment when the gas pedal is pushed
0.5
0.4
0.3
0.2
0.1
0
Without a filter
Filter 1
Filter 2
Filter 3
Filter 4
Filter 5
Filter 6
Filter 7
The percentage of CO at the moment when the gas pedal is pushed

6.1.2. Carbon dioxide

Without any filter, when the car was working constantly the 14.90% of the released gases was Carbon monoxide and at the moment when the gas pedal is pushed it was 14.90%.

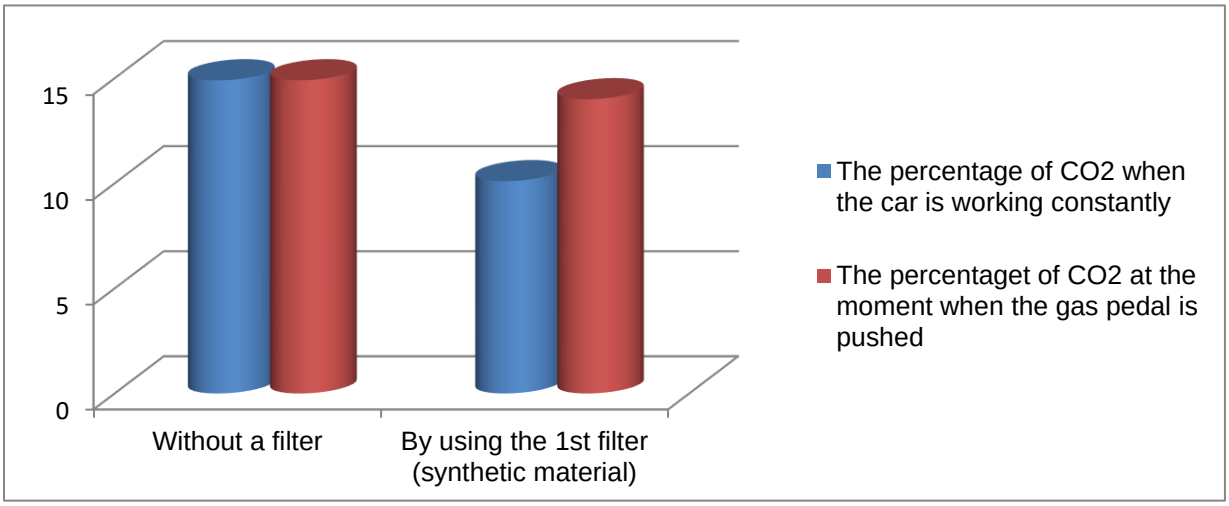
6.1.2.1.

By using the **1st filter (cotton)** it rapidly decreased to 8.80% when the car was working constantly and 8.50% when the gas pedal was pushed.



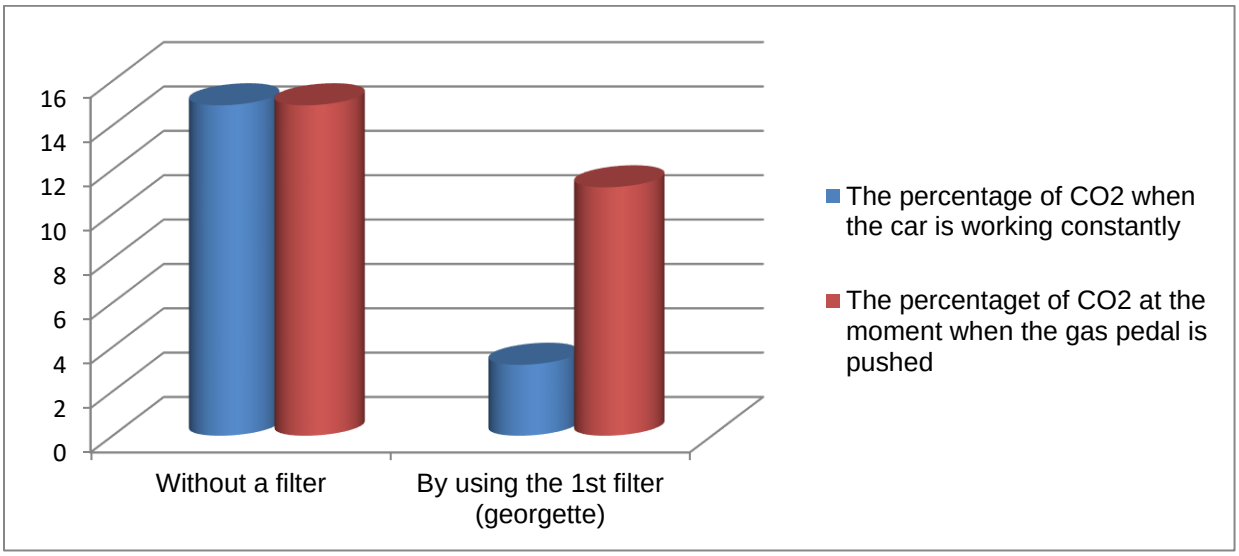
6.1.2.2.

By using the **2nd filter (synthetic material)** it decreased to 10.10% when the car was working constantly and 14.00% when the gas pedal was pushed.



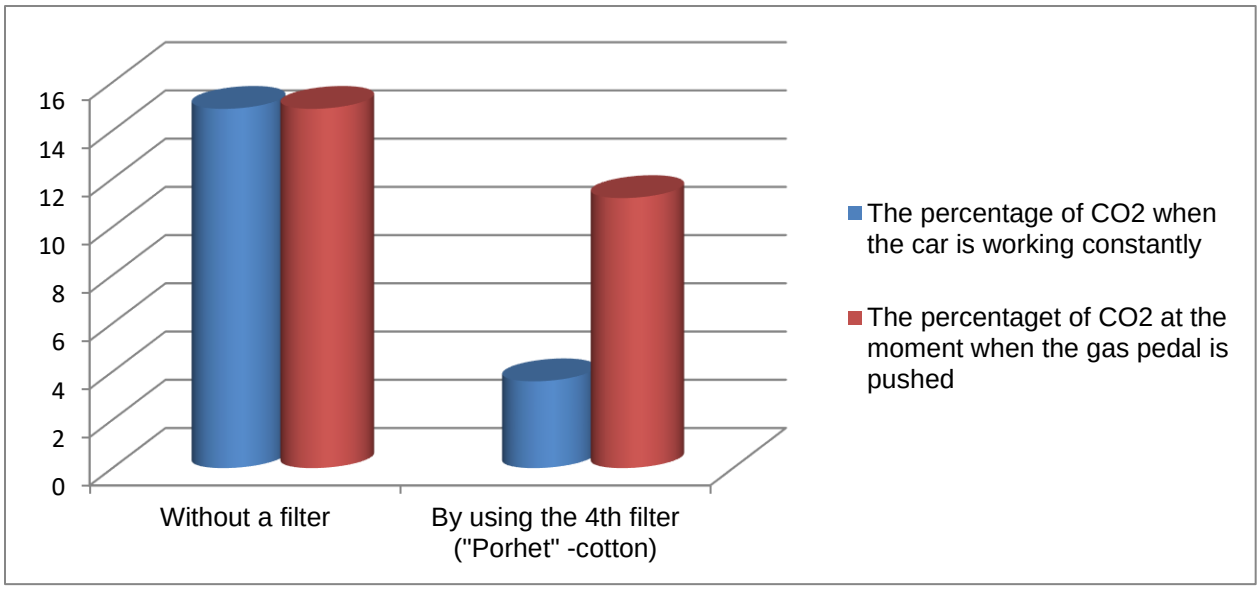
6.1.2.3.

By using the **3rd filter (georgette)** it rapidly decreased to 3.20% when the car was working constantly and 11.20% when the gas pedal was pushed.



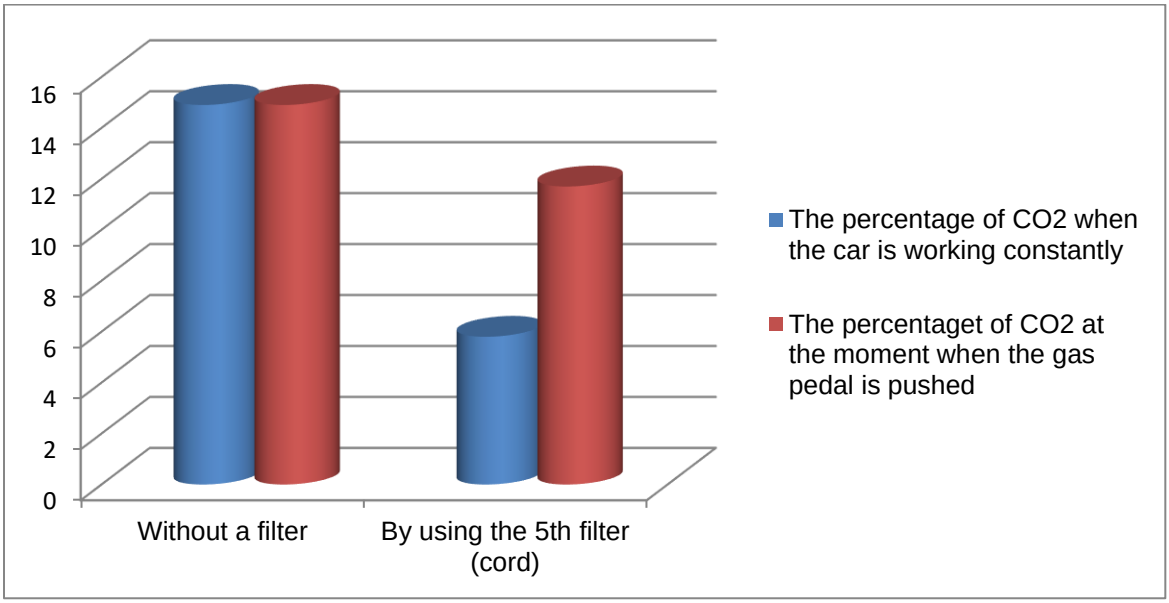
6.1.2.4.

By using the **4th filter ("Porhet"- cotton)** it rapidly decreased to 3.60% when the car was working constantly and 11.20% when the gas pedal was pushed.



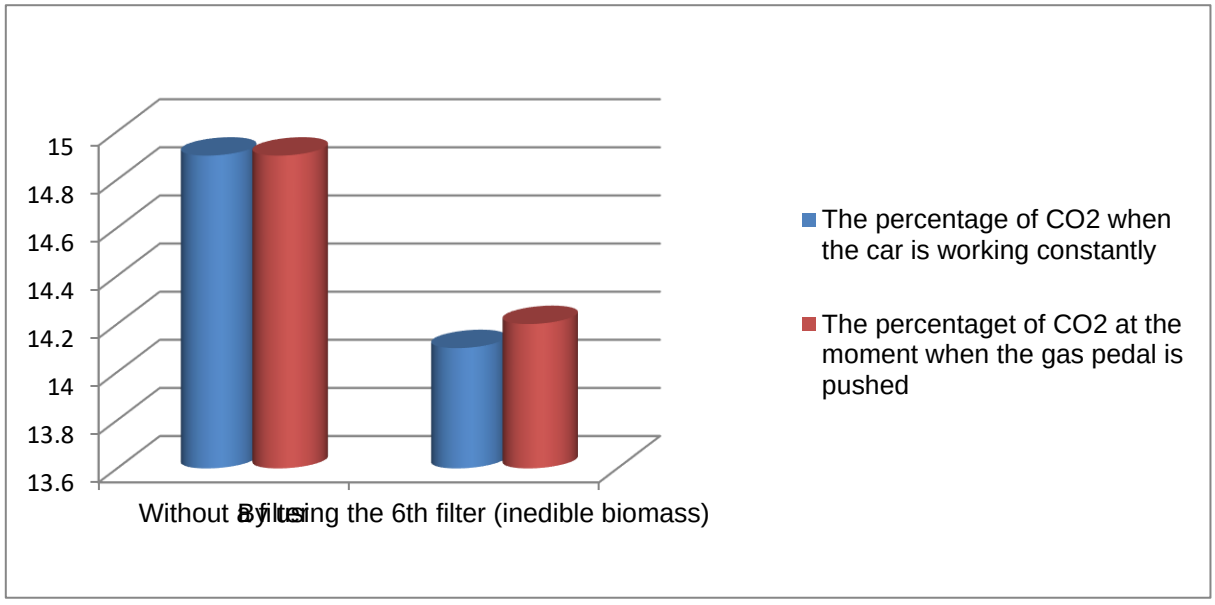
6.1.2.5.

By using the **5th filter (cord)** it rapidly decreased to 5.80% when the car was working constantly and 11.70% when the gas pedal was pushed.



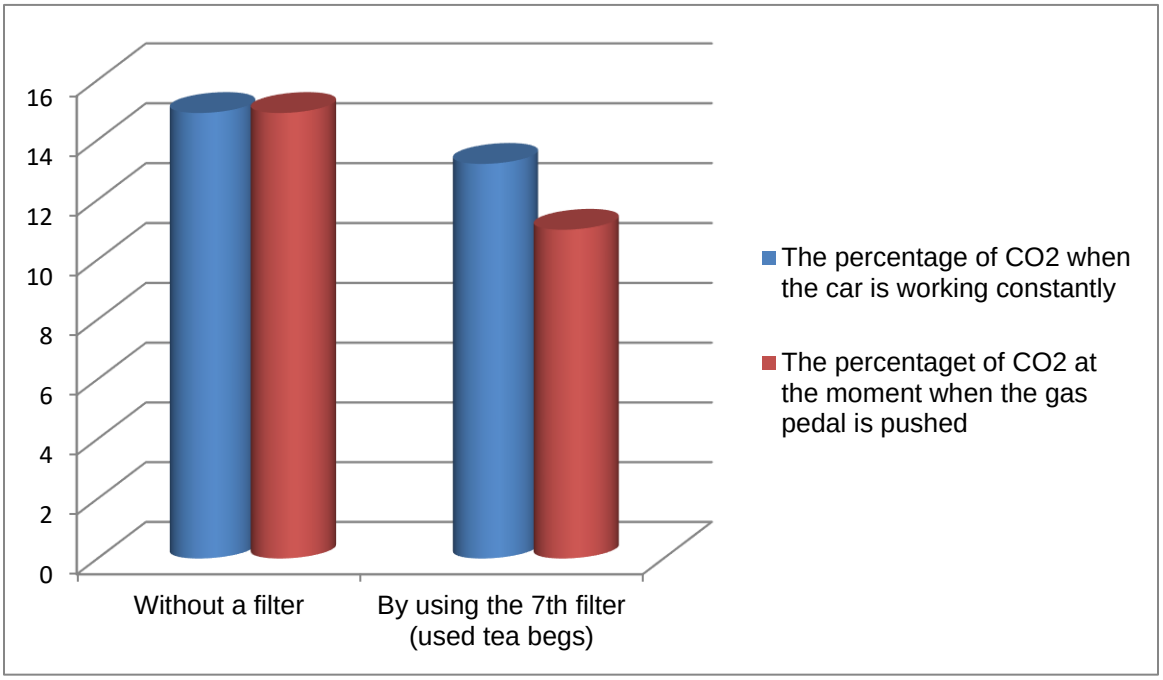
6.1.2.6.

By using the **6th filter (inedible biomass)** it decreased to 14.10 % when the car was working constantly and 14.20% when the gas pedal was pushed.

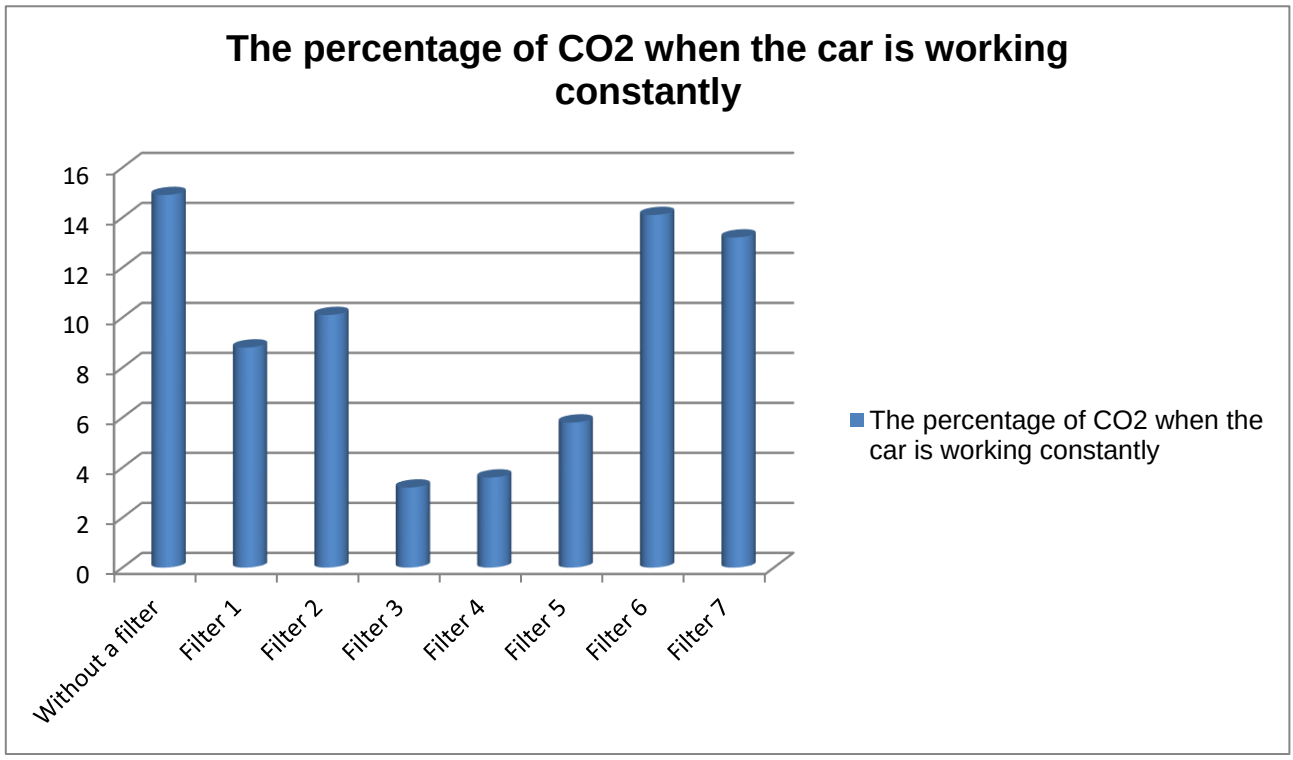


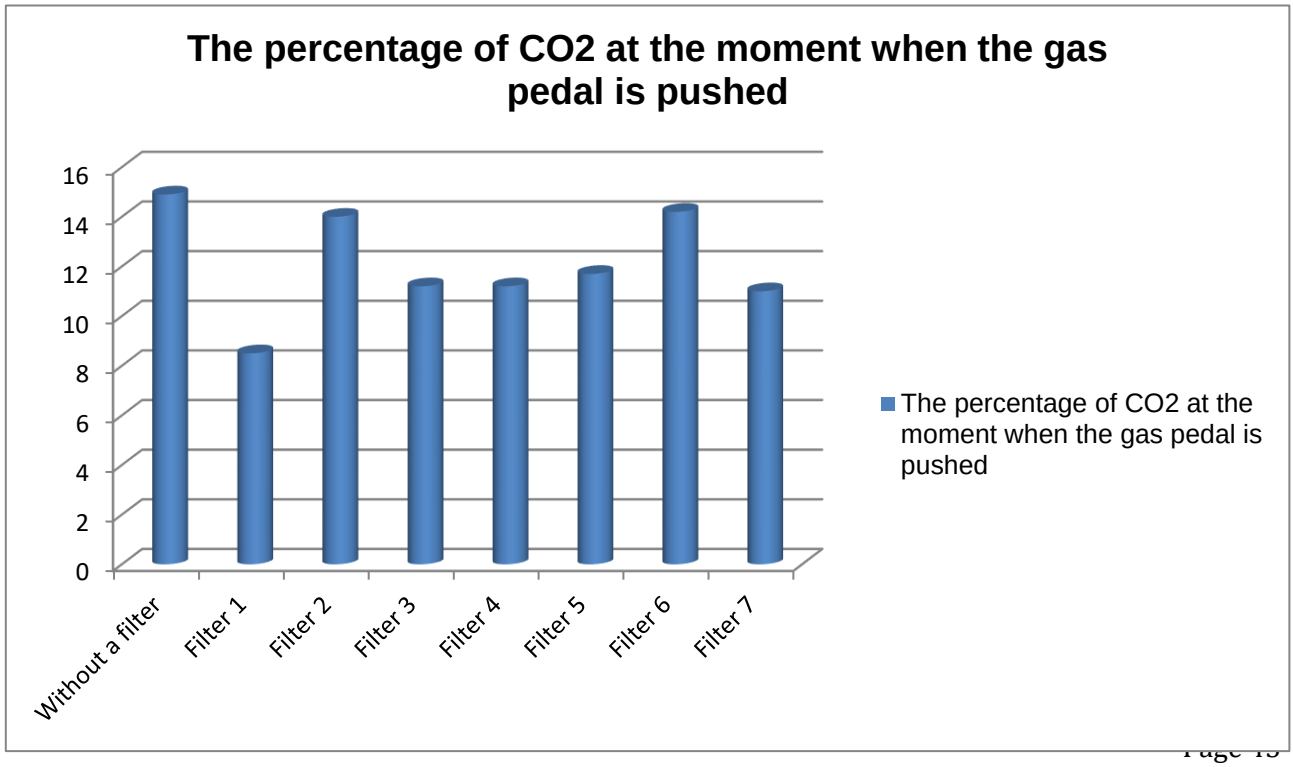
6.1.2.7.

By using the **7th filter (used tea bags)** it decreased to 13.20 % when the car was working constantly and 11.00 % when the gas pedal was pushed.



6.1.2.8.


The percentage of CO2 when the car is working constantly
16
14
12
10
8
6
4
2
0
Without a filter
Filter 1
Filter 2
Filter 3
Filter 4
Filter 5
Filter 6
Filter 7
The percentage of CO2 when the car is working constantly

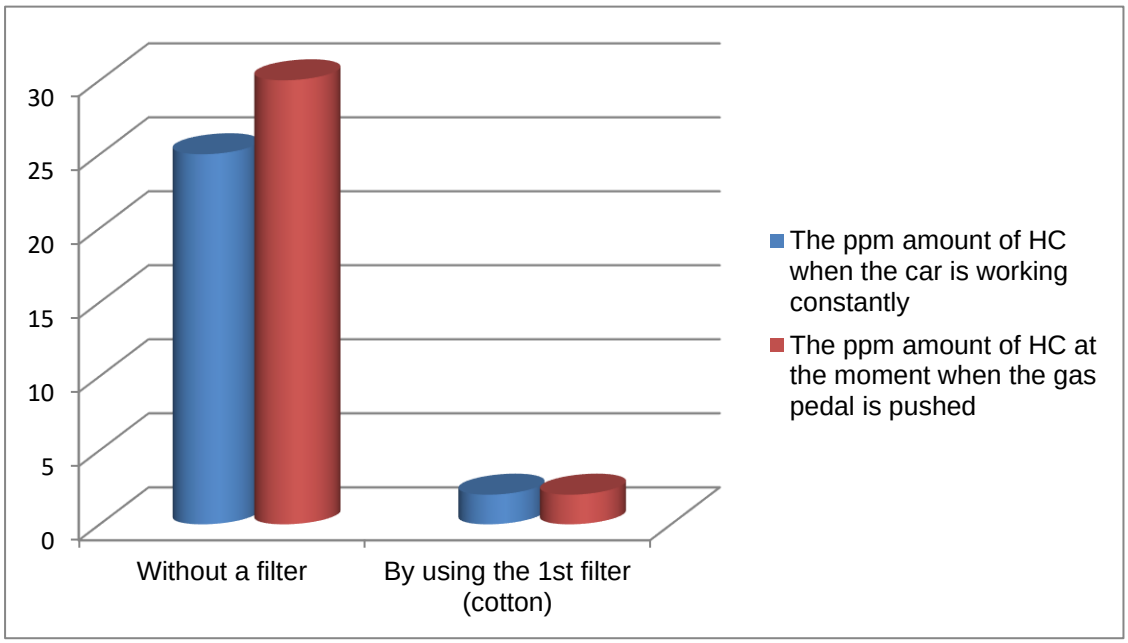

The percentage of CO2 at the moment when the gas pedal is pushed
16
14
12
10
8
6
4
2
0
Without a filter
Filter 1
Filter 2
Filter 3
Filter 4
Filter 5
Filter 6
Filter 7
The percentage of CO2 at the moment when the gas pedal is pushed

6.1.3. Hydrocarbon

Without any filter, when the car was working constantly 25 ppm of Hydrocarbon were released and 30 ppm at the moment when the gas pedal was pushed.

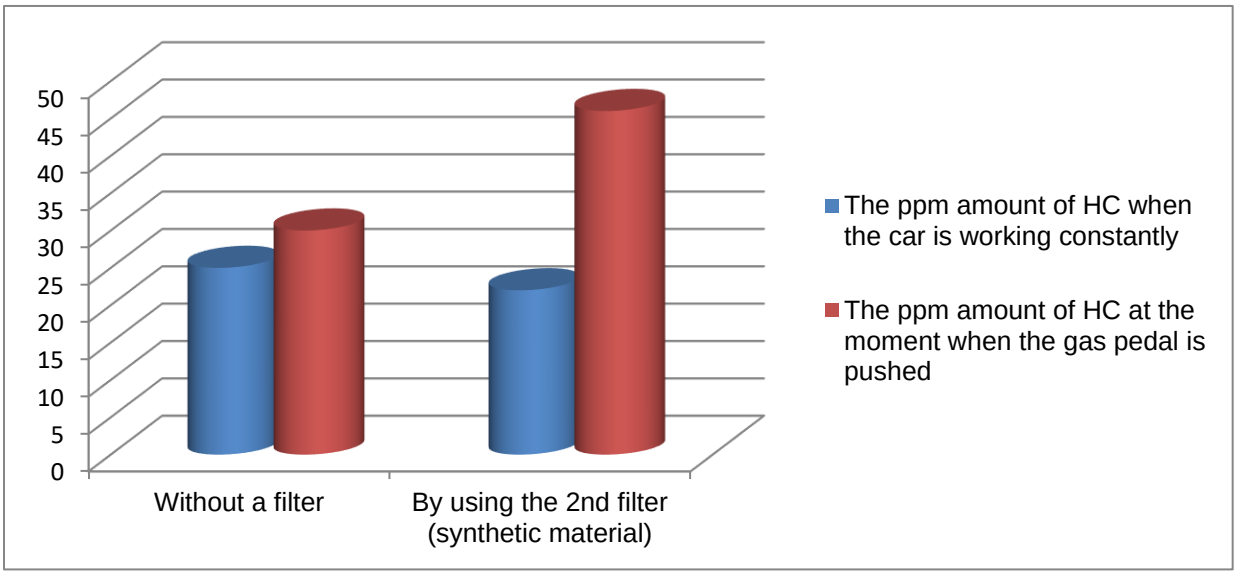
6.1.3.1.

By using the **1st filter (cotton)** it rapidly decreased to 2 ppm in both cases, when the car was working constantly and when the gas pedal was pushed.



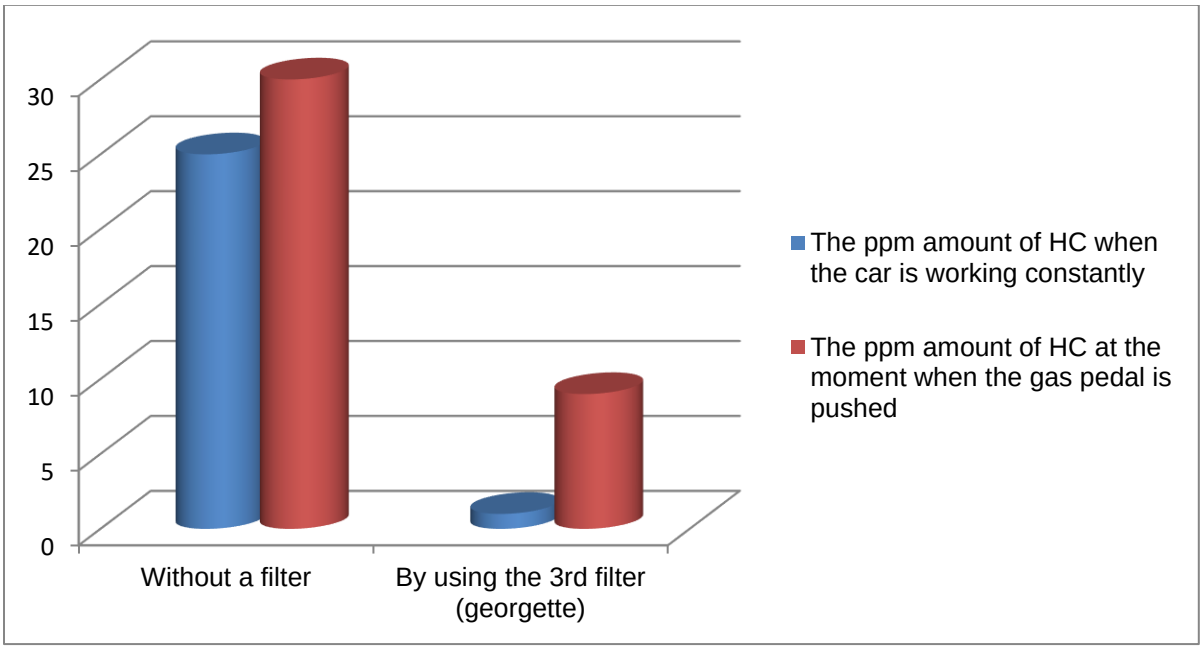
6.1.3.2.

By using the **2nd filter (synthetic material)** it decreased to 22 ppm when the car was working and increased to 46 ppm when the gas pedal was pushed.



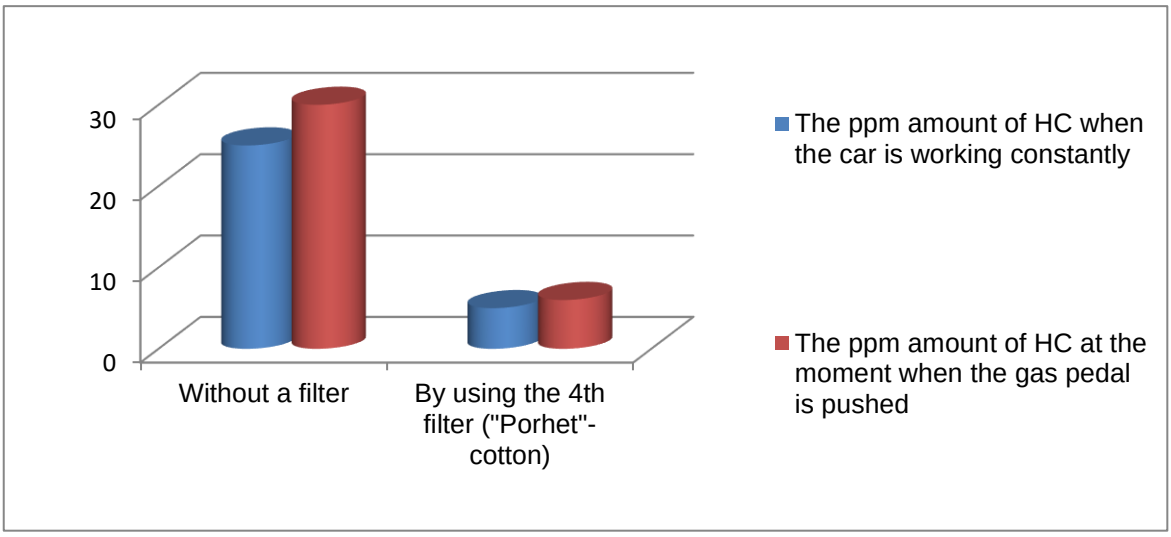
6.1.3.3.

By using the **3rd filter (georgette)** it rapidly decreased to 1 ppm when the car was working and 9 ppm when the gas pedal was pushed.



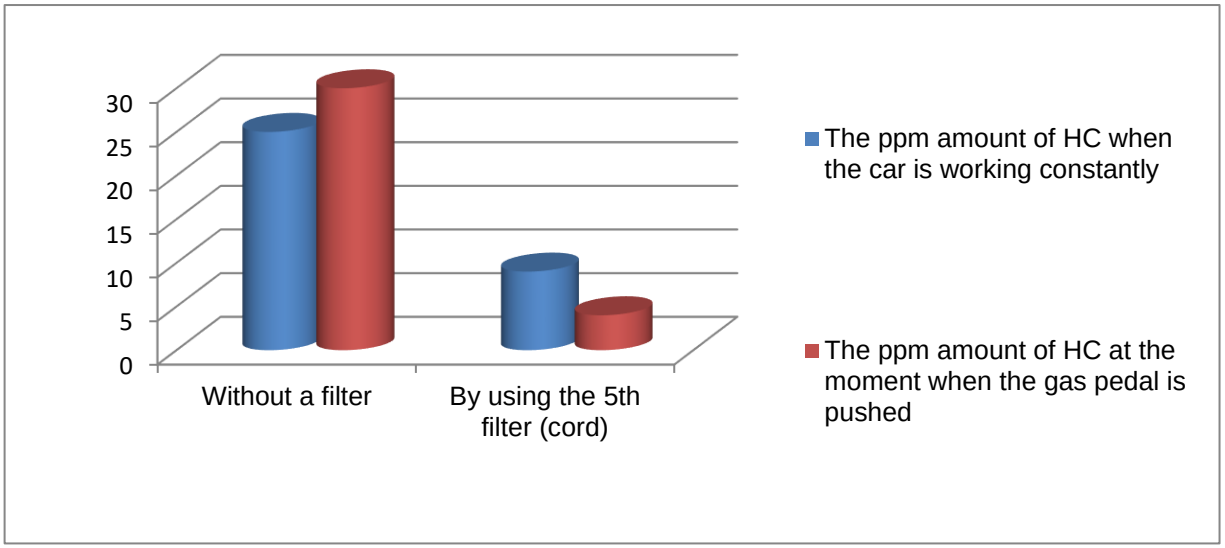
6.1.3.4.

By using the **4th filter ("Porhet" –cotton)** it rapidly decreased to 5 ppm when the car was working and 6 ppm when the gas pedal was pushed.



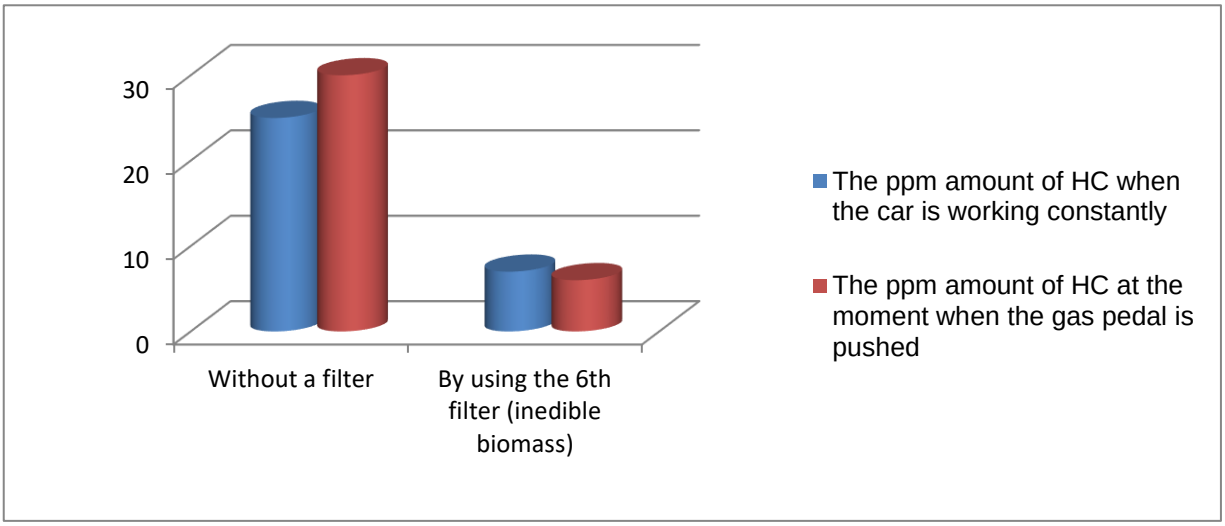
6.1.3.5.

By using the **5th filter (cord)** it rapidly decreased to 9 ppm when the car was working and 4 ppm when the gas pedal was pushed.



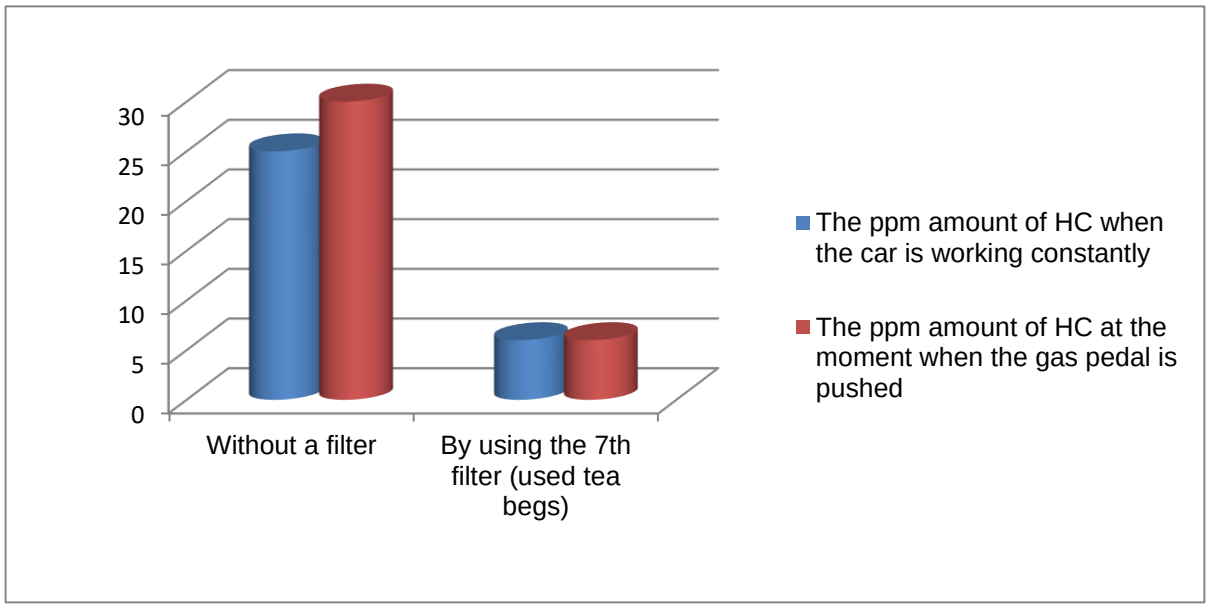
6.1.3.6.

By using the **6th filter (inedible biomass)** it rapidly decreased to 7 ppm when the car was working and 6 ppm when the gas pedal was pushed.

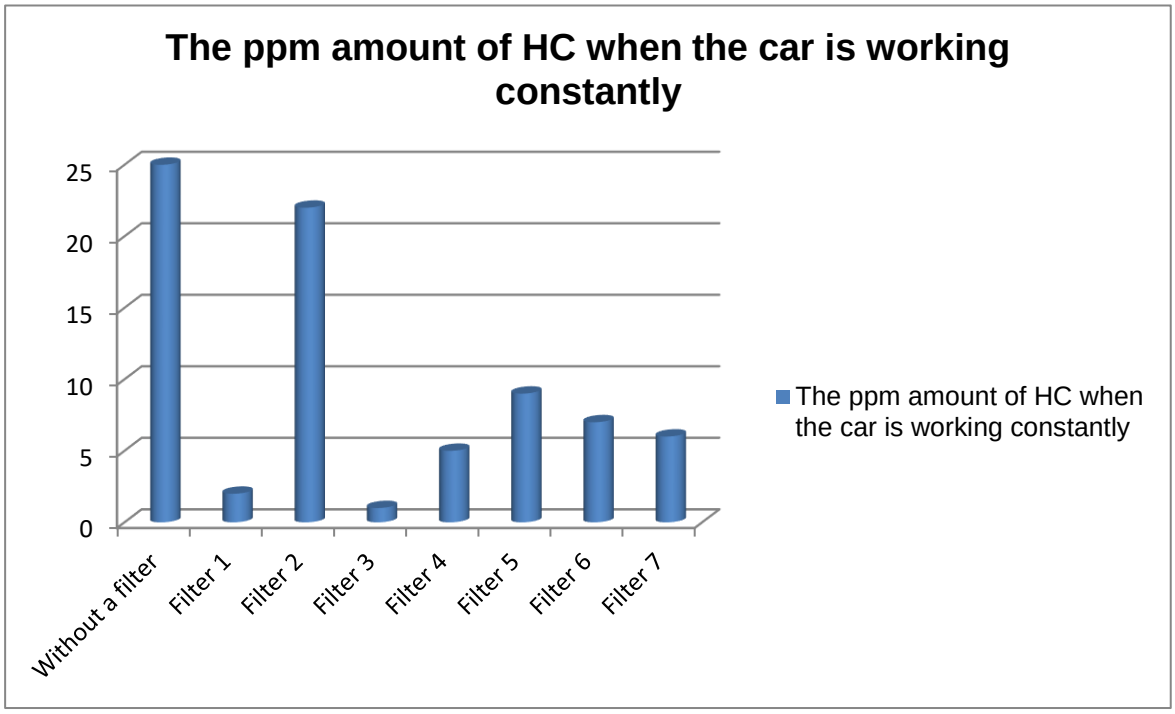


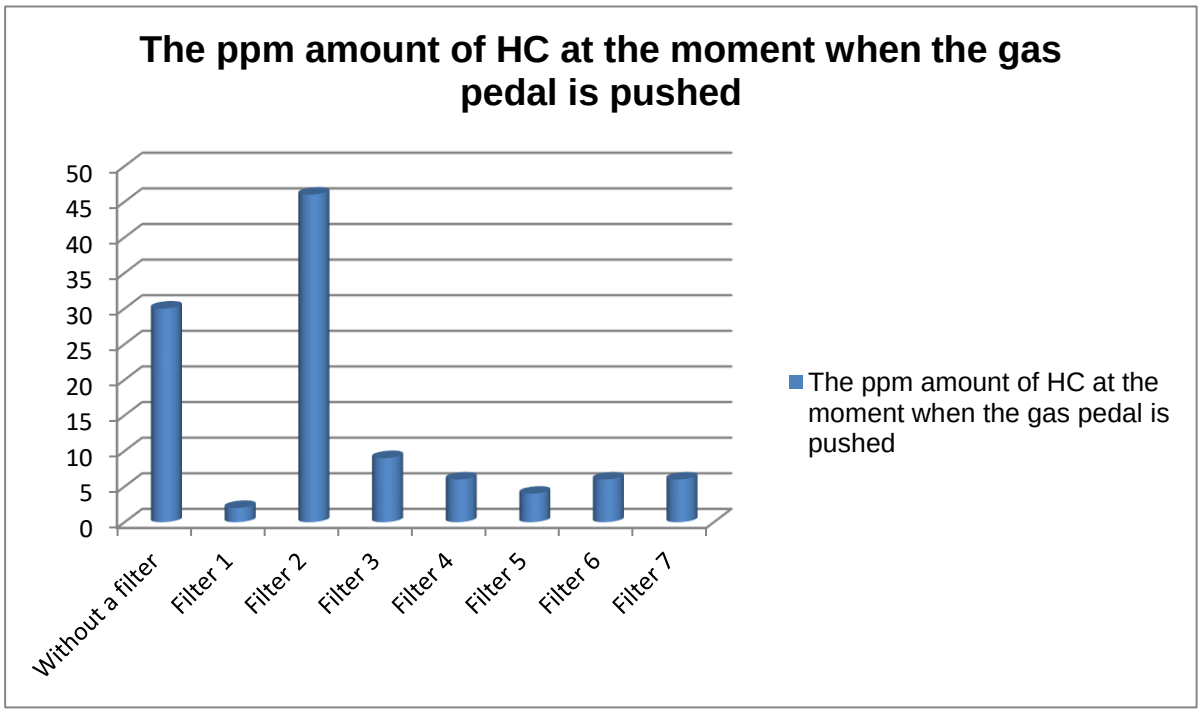
6.1.3.7.

By using the **7th filter (used tea bags)** it rapidly decreased to 6 ppm in both cases, when the car was working constantly and when the gas pedal was pushed.



6.1.3.8.


The ppm amount of HC when the car is working constantly
25
20
15
10
5
0
Without a filter
Filter 1
Filter 2
Filter 3
Filter 4
Filter 5
Filter 6
Filter 7
The ppm amount of HC when the car is working constantly

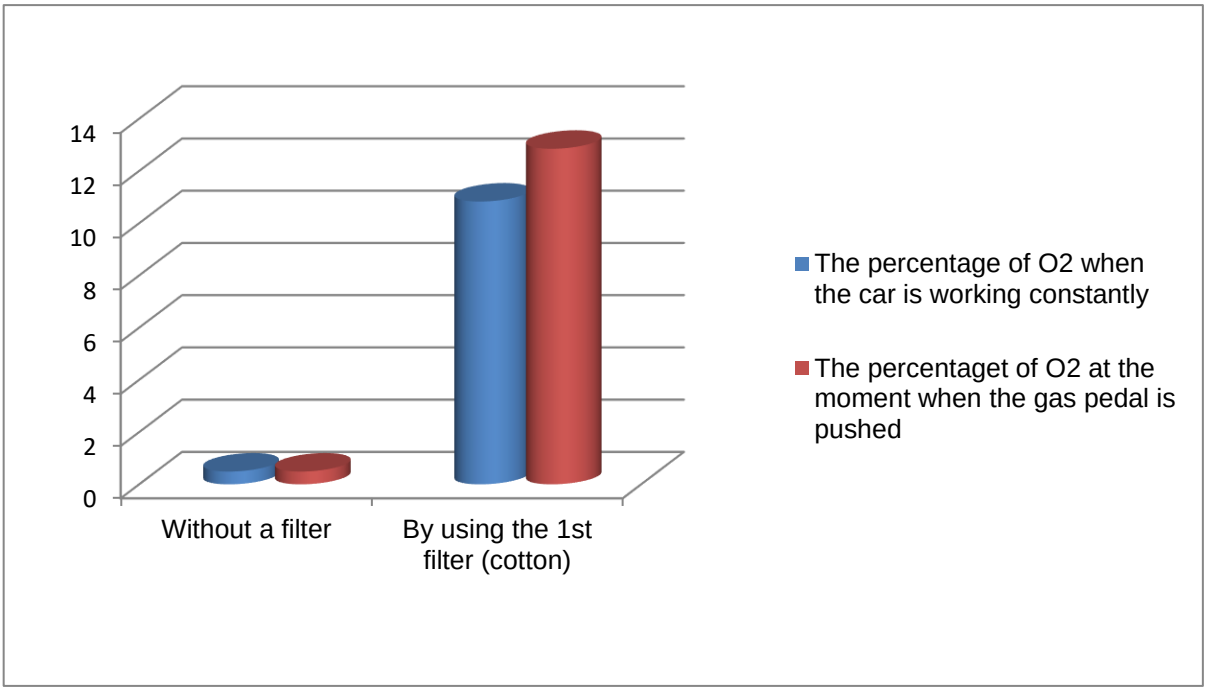

The ppm amount of HC at the moment when the gas pedal is pushed
50
45
40
35
30
25
20
15
10
5
0
Without a filter
Filter 1
Filter 2
Filter 3
Filter 4
Filter 5
Filter 6
Filter 7
The ppm amount of HC at the moment when the gas pedal is pushed

6.1.4. Oxygen

Without any filter, when the car was working constantly the 0.49% of the released gases was Oxygen and at the moment when the gas pedal was pushed it was 0.41.

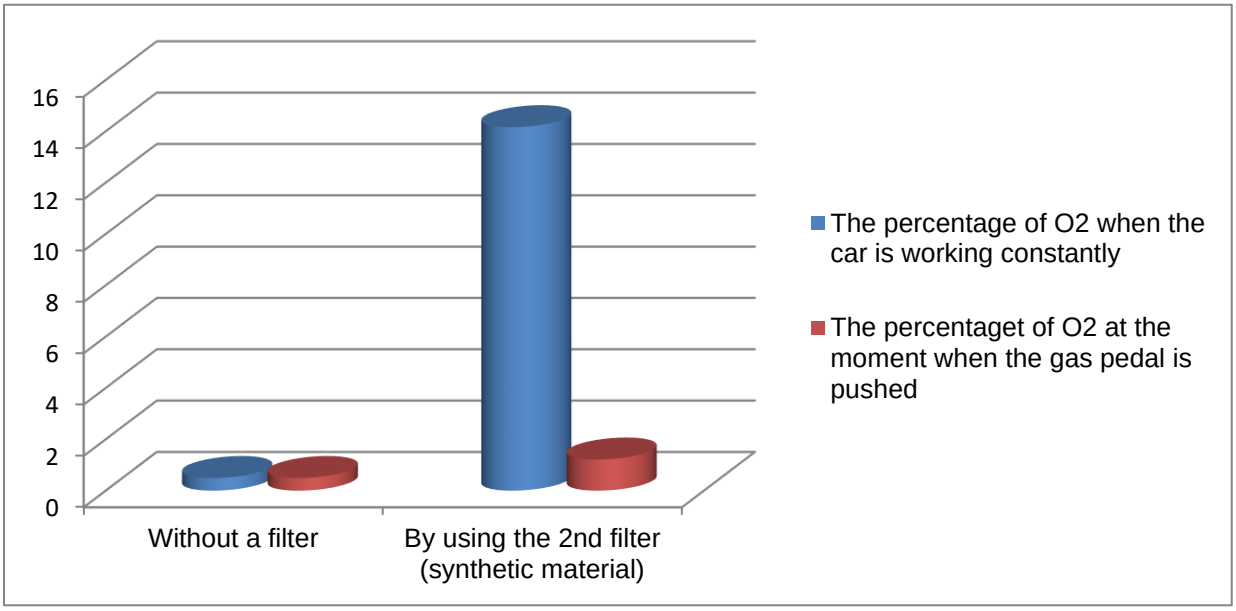
6.1.4.1.

By using the **1st filter (cotton)** it rapidly increased to 10.83% when the car was working constantly and 12.85% when the gas pedal was pushed.



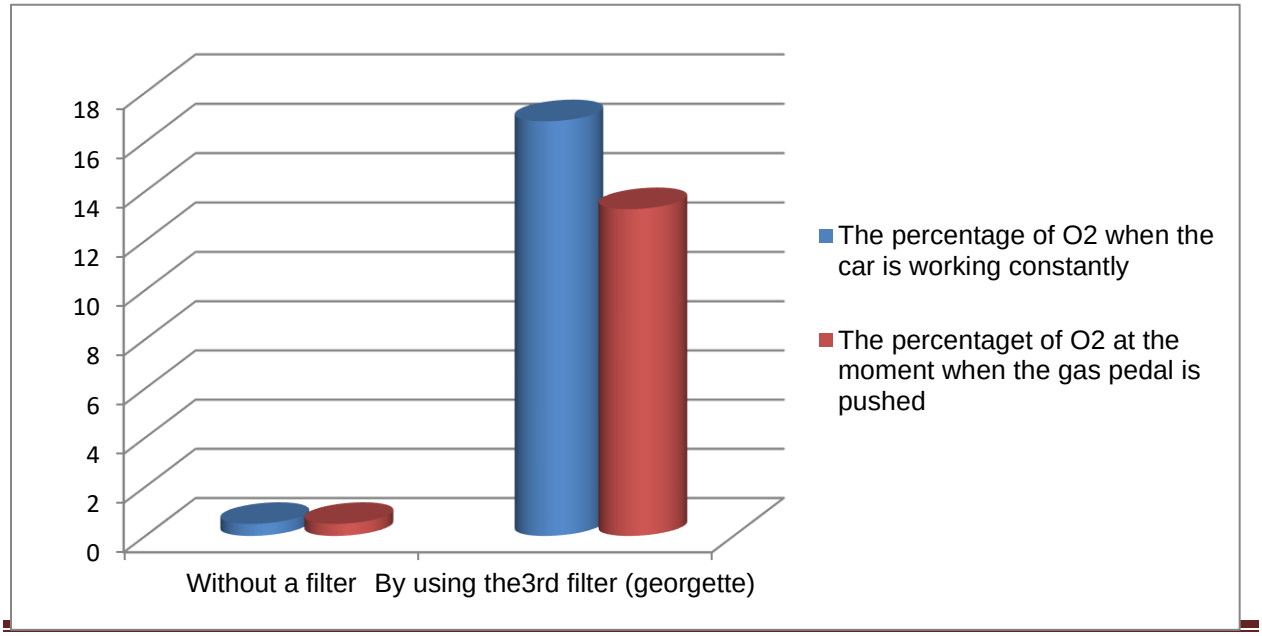
6.1.4.2.

By using **the 2nd filter (synthetic material)** it increased to 14.16 % when the car was working constantly and 1.21% when the gas pedal was pushed.



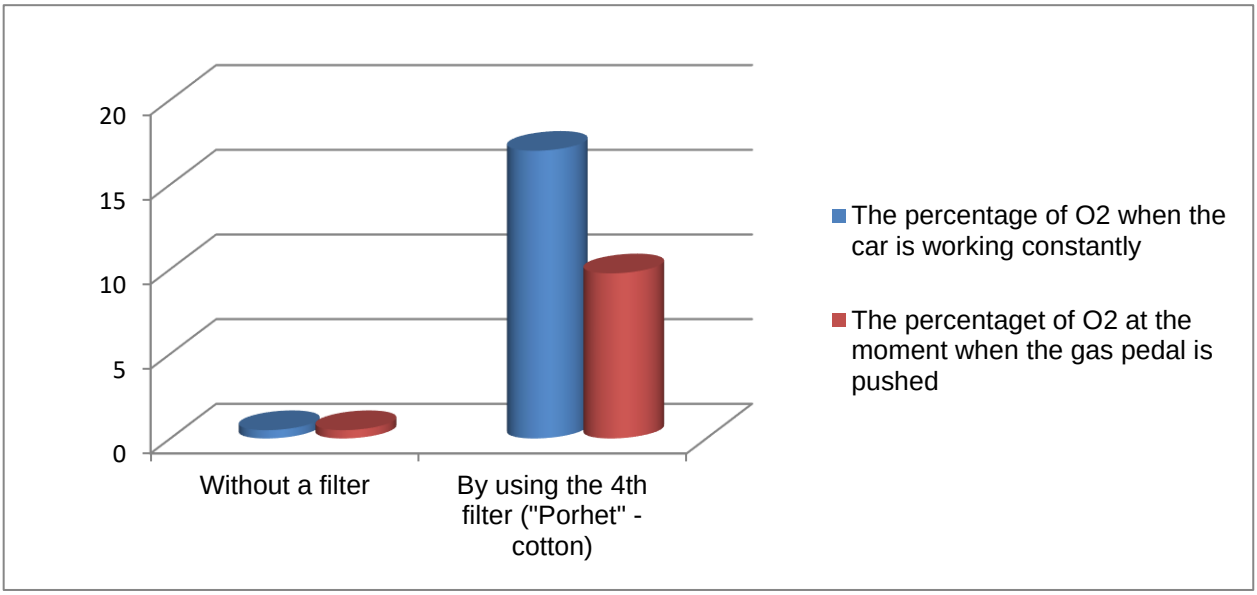
6.1.4.3.

By using the **3rd filter (georgette)** it rapidly increased to 16.83% when the car was working constantly and 13.27% when the gas pedal was pushed.



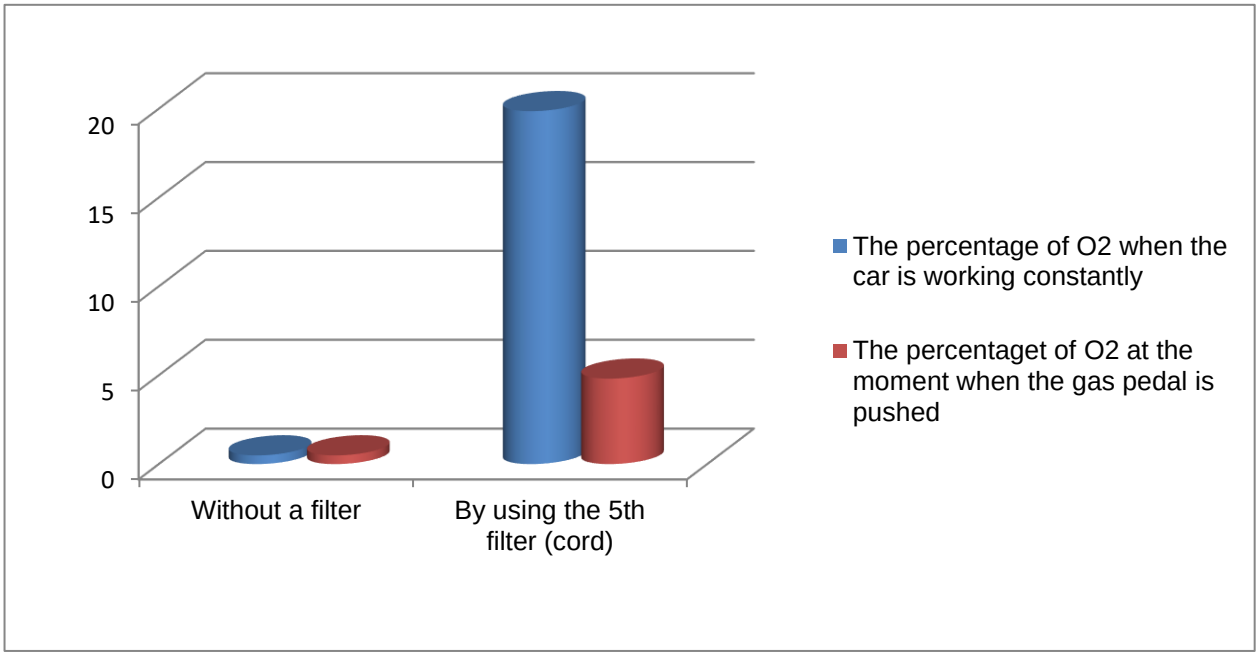
6.1.4.4.

By using the **4th filter ("Porhet" – cotton)** it rapidly increased to 16.99% when the car was working constantly and 9.75% when the gas pedal was pushed.



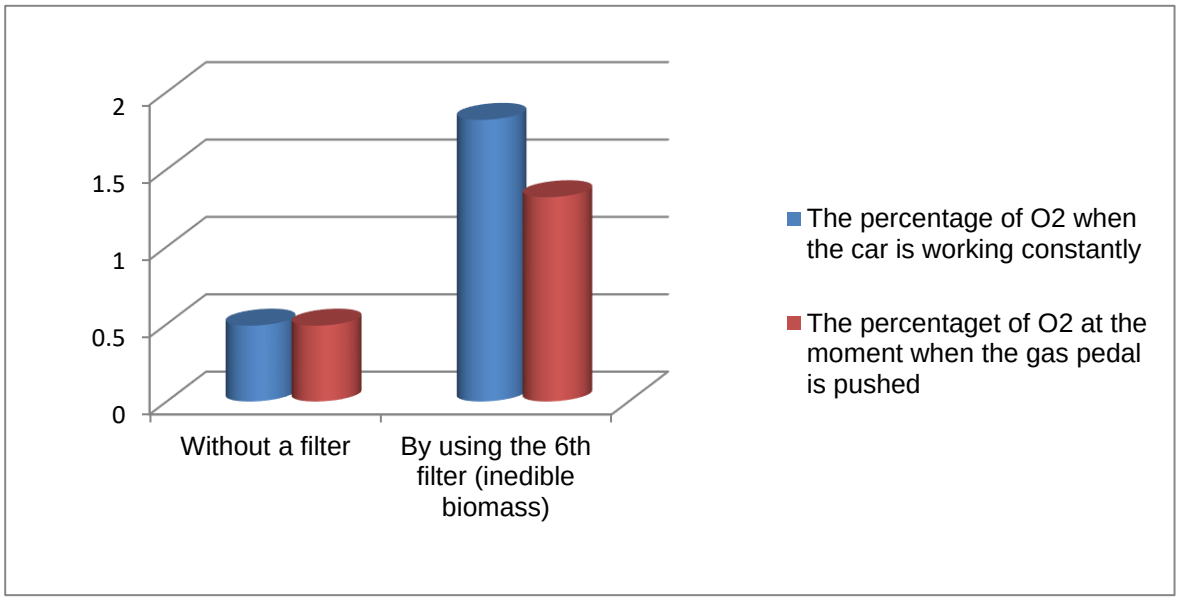
6.1.4.5.

By using the **5th filter (cord)** it rapidly increased to 19.86% when the car was working constantly and 4.81% when the gas pedal was pushed.



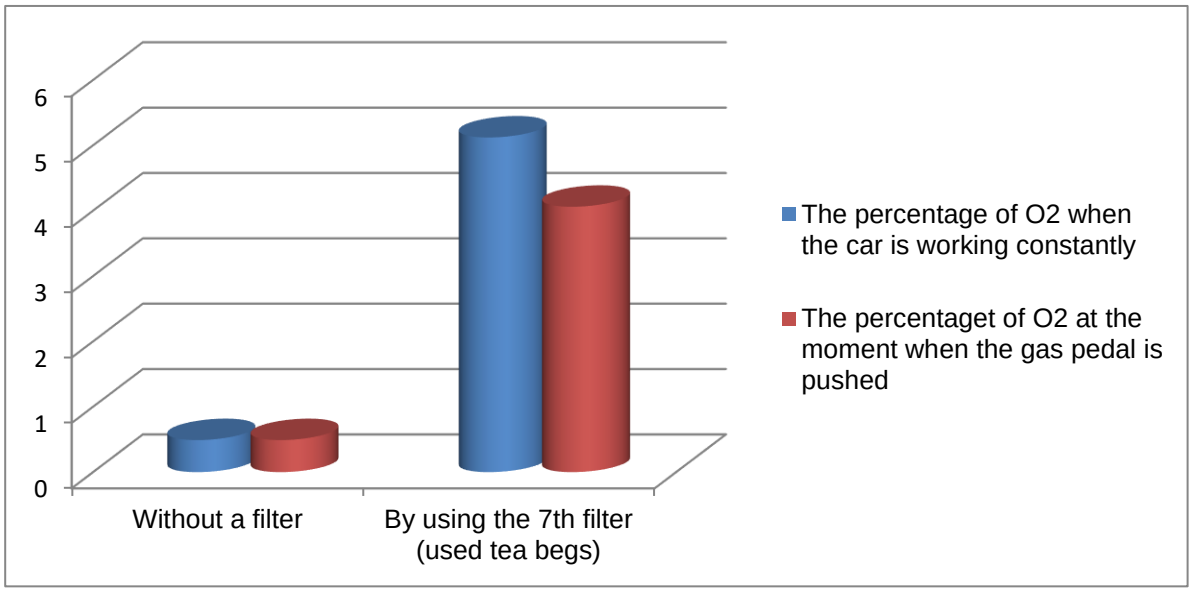
6.1.4.6.

By using **the 6th filter (inedible biomass)** it increased to 1.82% when the car was working constantly and 1.32% when the gas pedal was pushed.

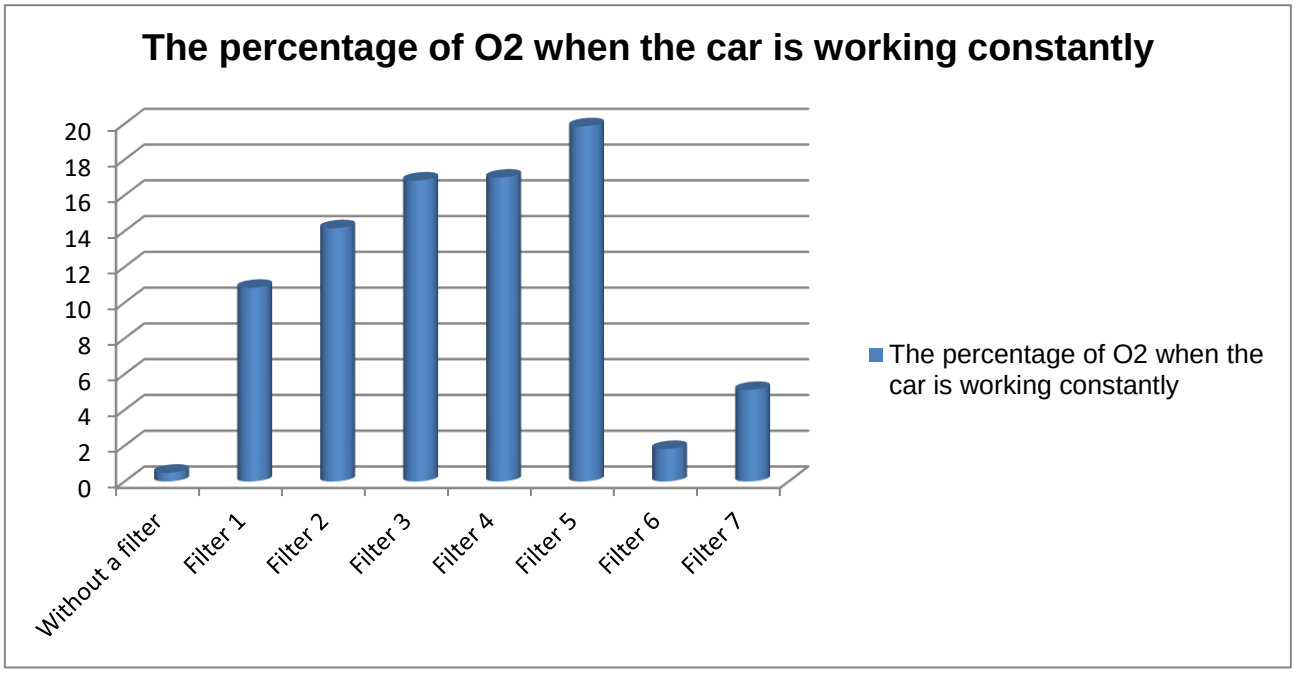


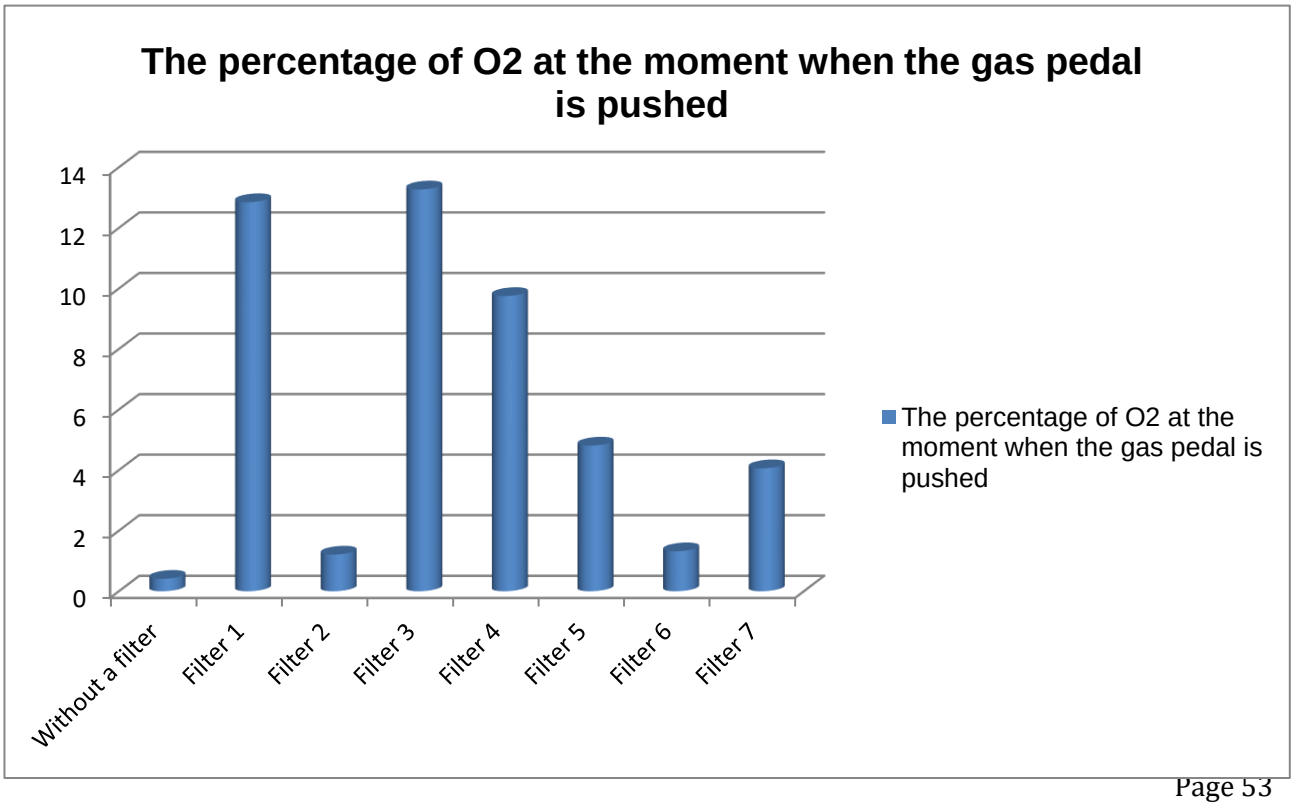
6.1.4.7.

By using the **7th filter (used tea bags)** it increased to 5.12% when the car was working constantly and 4.06% when the gas pedal was pushed.



6.1.4.8.


The percentage of O2 when the car is working constantly
20
18
16
14
12
10
8
6
4
2
0
Without a filter
Filter 1
Filter 2
Filter 3
Filter 4
Filter 5
Filter 6
Filter 7
The percentage of O2 when the car is working constantly


The percentage of O2 at the moment when the gas pedal is pushed
14
12
10
8
6
4
2
0
Without a filter
Filter 1
Filter 2
Filter 3
Filter 4
Filter 5
Filter 6
Filter 7
The percentage of O2 at the moment when the gas pedal is pushed

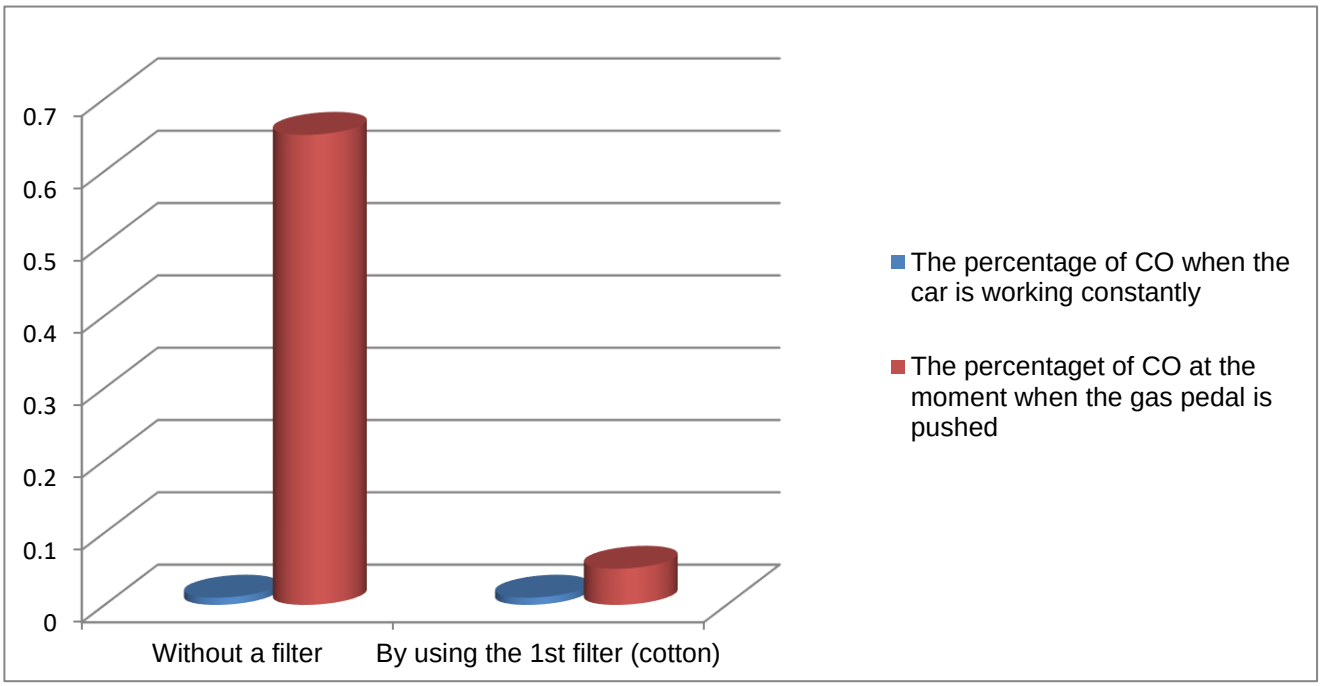
6.2. The second part of the experiment tested the filters on a car which uses LPG as a fuel

6.2.1. Carbon monoxide

Without any filter, when the car was working constantly the 0.01 % of the released gases was Carbon monoxide and at the moment when the gas pedal is pushed it was 0.65%.

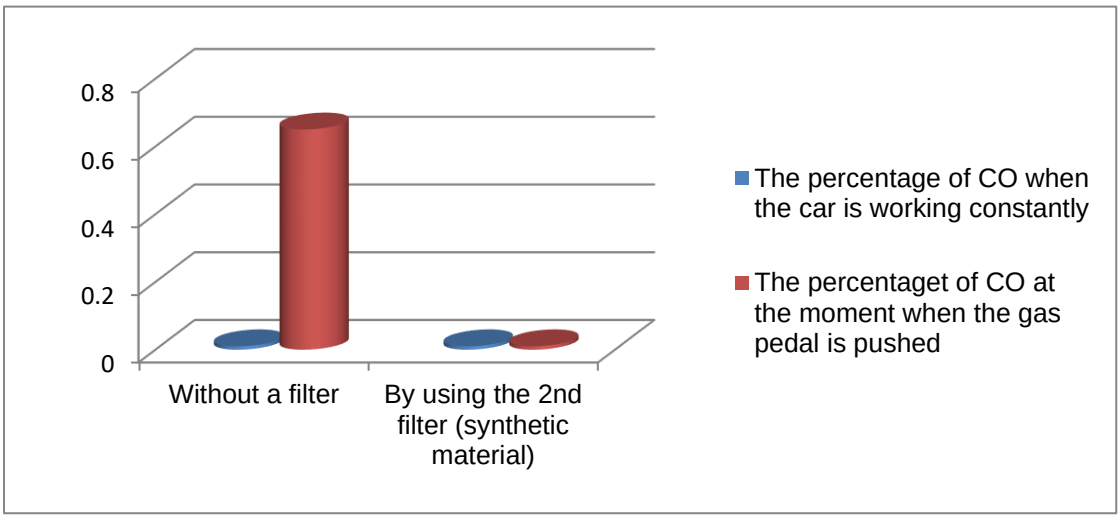
6.2.1.1.

By using the **first filter (cotton)** the percentage stayed the same, 0.01%, when the car was working constantly and decreased to 0.05% at the moment when the gas pedal was pushed.



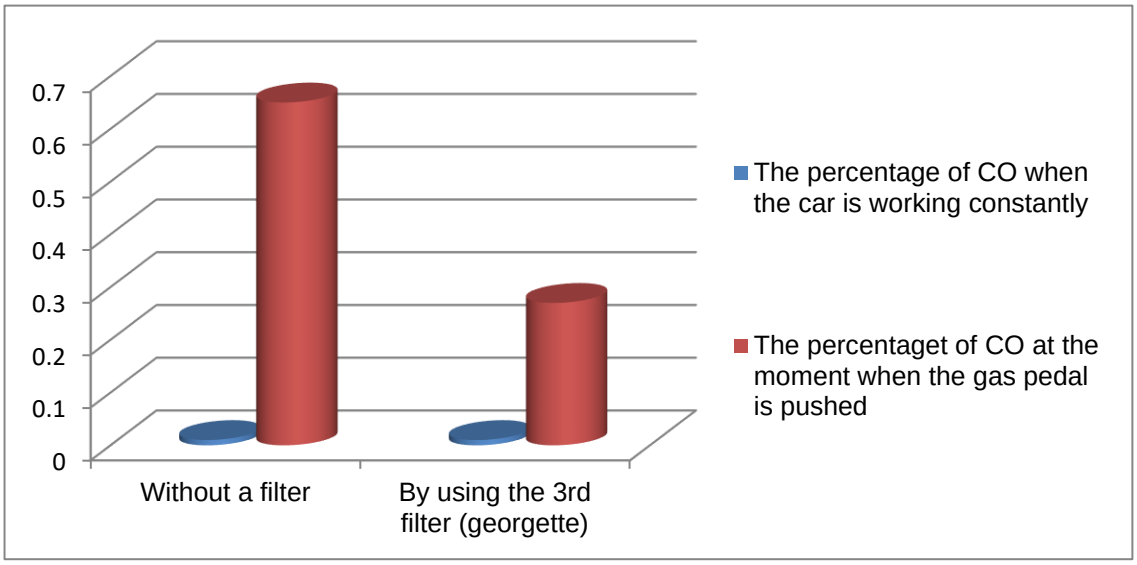
6.2.1.2.

By using the **second filter (synthetic material)** it decreased to 0.01% in both cases, when the car was working constantly and at the moment when the gas pedal was pushed.



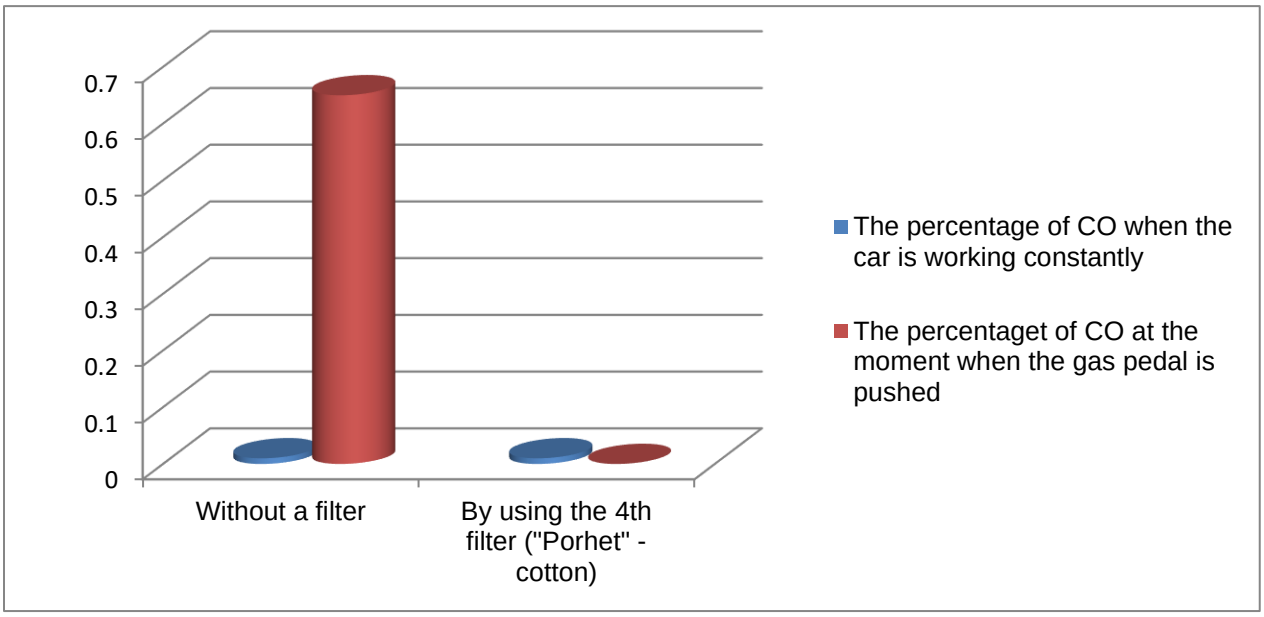
6.2.1.3.

By using **the third filter (georgette)** the percentage stayed the same, 0.01%, when the car was working constantly and decreased to 0.27% at the moment when the gas pedal was pushed.



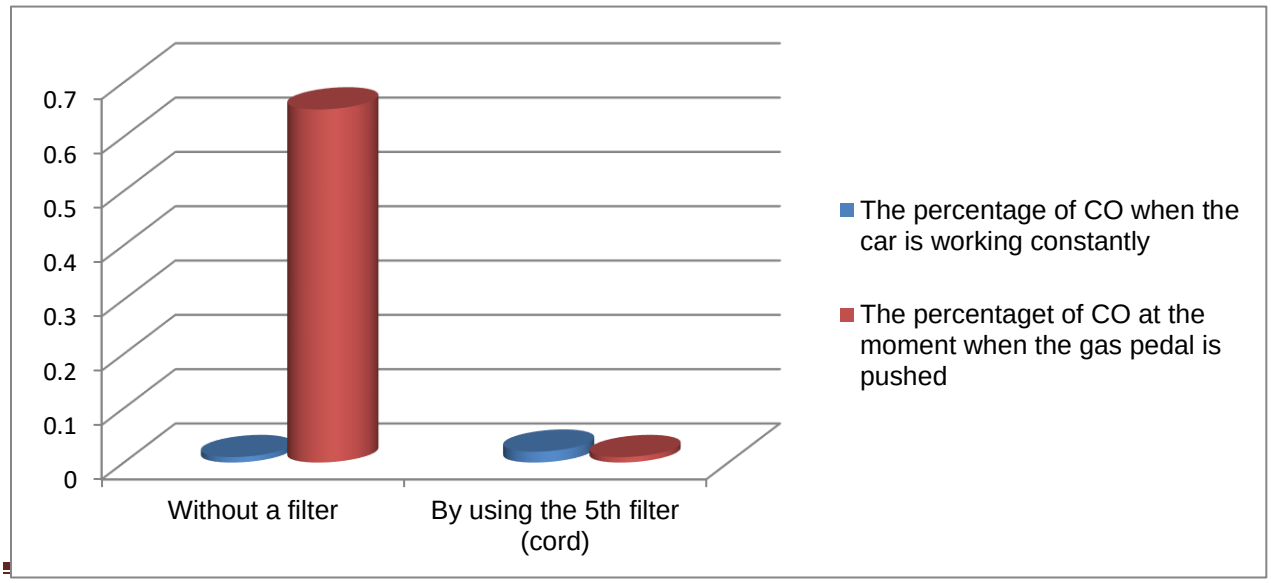
6.2.1.4.

By using the **fourth filter ("Porhet"-cotton)** the percentage stayed the same, 0.01%, when the car was working constantly and decreased to 0% (no emission at all) at the moment when the gas pedal was pushed.



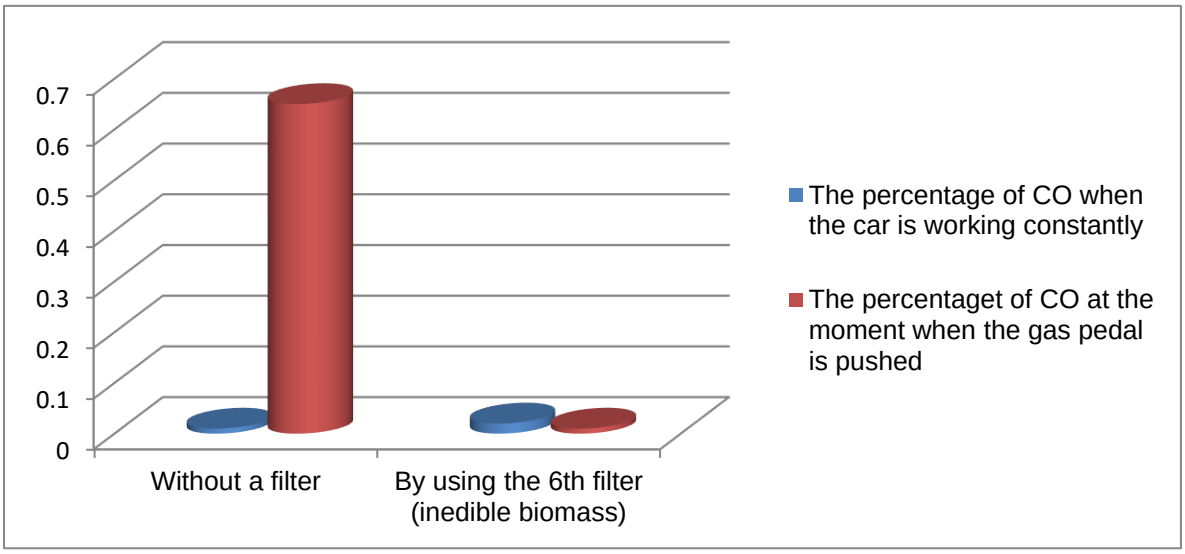
6.2.1.5.

By using **the fifth filter (cord)** the percentage slightly increased to 0.02% when the car was working constantly and decreased to 0.01% at the moment when the gas pedal was pushed.



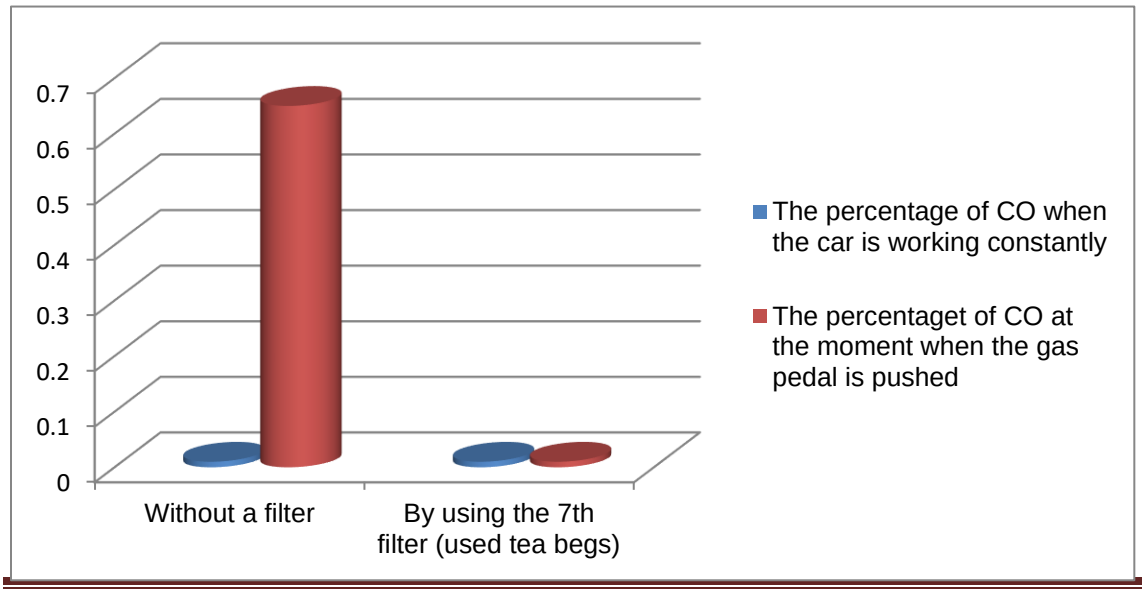
6.2.1.6.

By using the **sixth filter (inedible biomass)** the percentage slightly increased to 0.02% when the car was working constantly and decreased to 0.01% at the moment when the gas pedal was pushed.

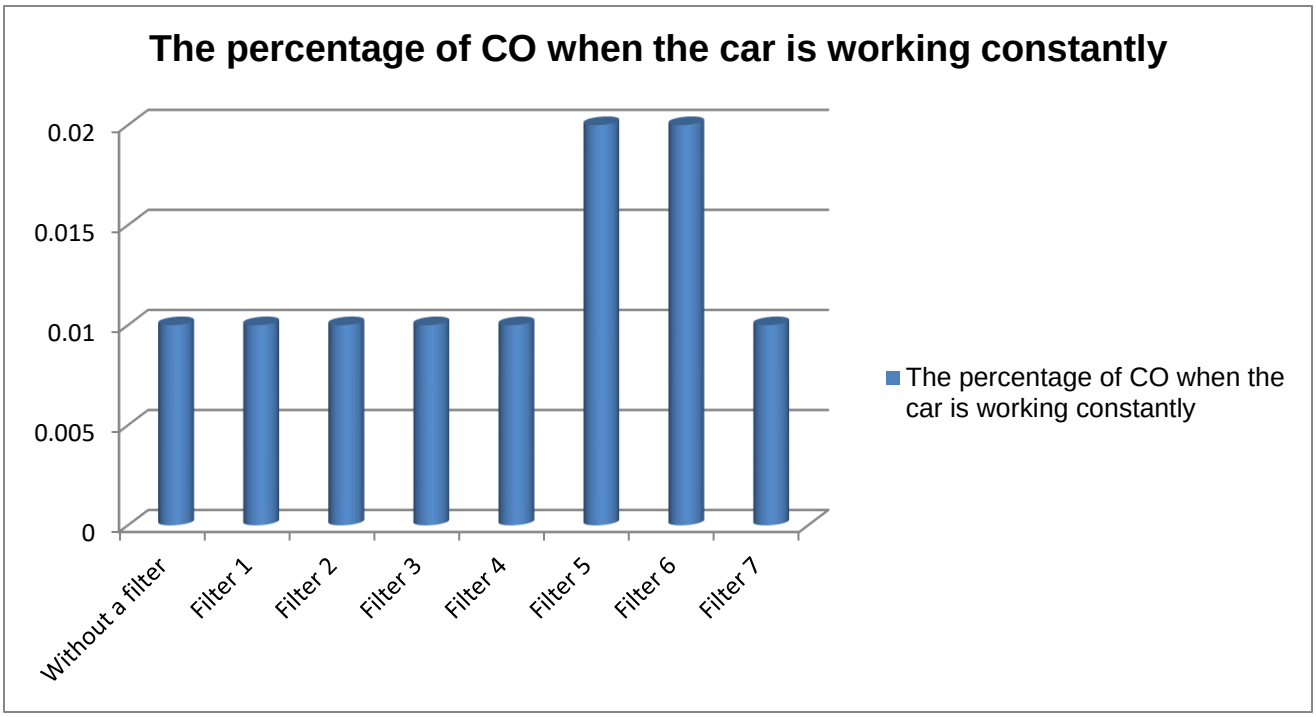


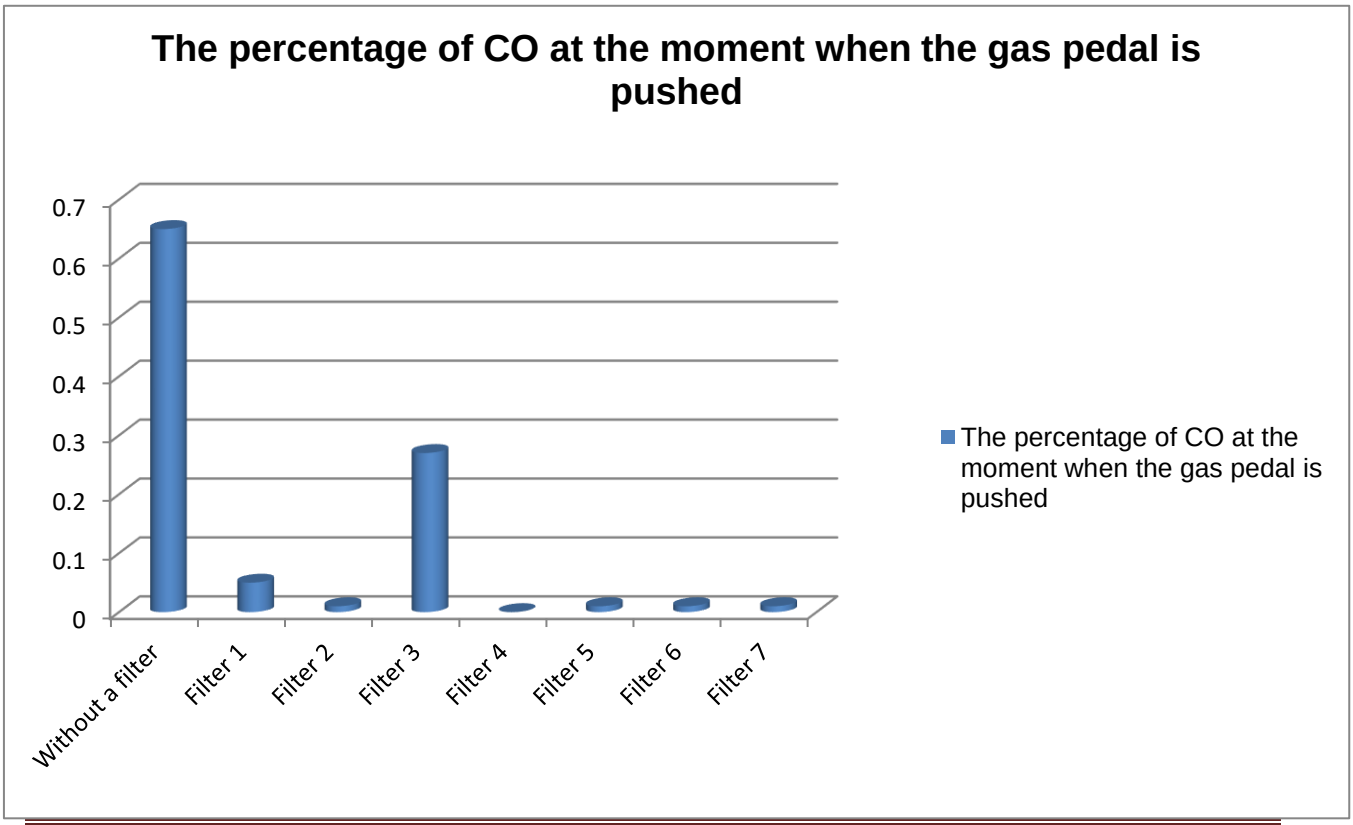
6.2.1.7.

By using the **seventh filter (used tea bags)** it decreased to 0.01% in both cases, when the car was working constantly and at the moment when the gas pedal was pushed.



6.2.1.8.


The percentage of CO when the car is working constantly
0.02
0.015
0.01
0.005
0
Without a filter
Filter 1
Filter 2
Filter 3
Filter 4
Filter 5
Filter 6
Filter 7
The percentage of CO when the car is working constantly

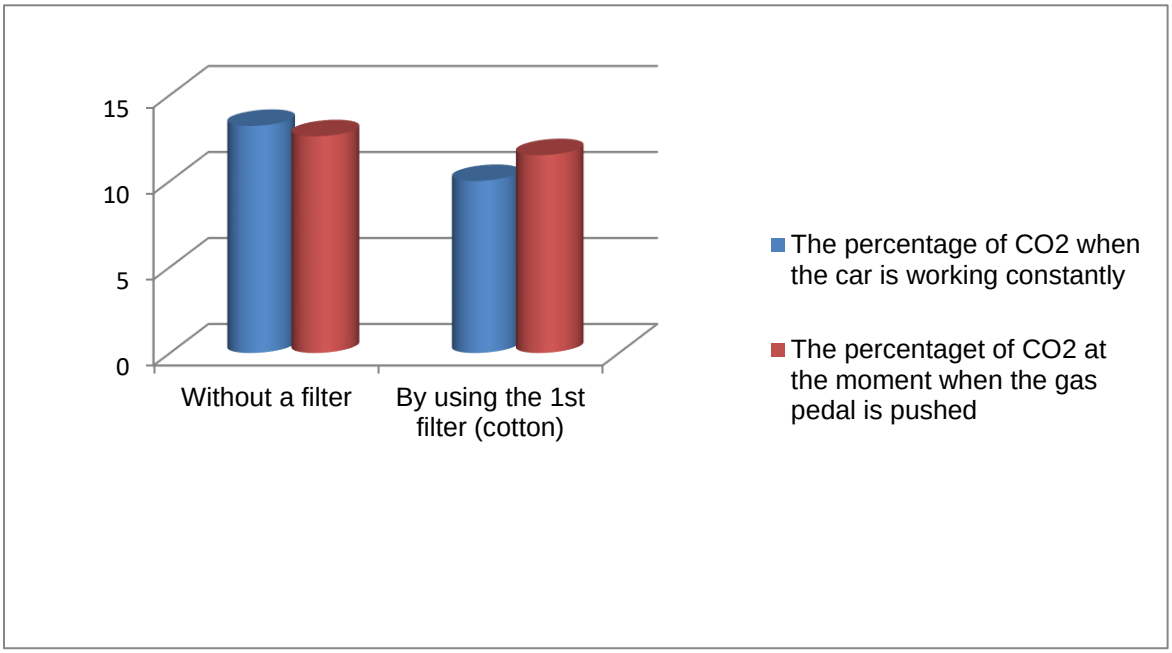

The percentage of CO at the moment when the gas pedal is pushed
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Without a filter
Filter 1
Filter 2
Filter 3
Filter 4
Filter 5
Filter 6
Filter 7
The percentage of CO at the moment when the gas pedal is pushed

6.2.2. Carbon dioxide

Without any filter, when the car was working constantly the 13.20% of the released gases was Carbon monoxide and at the moment when the gas pedal is pushed it was 12.60.

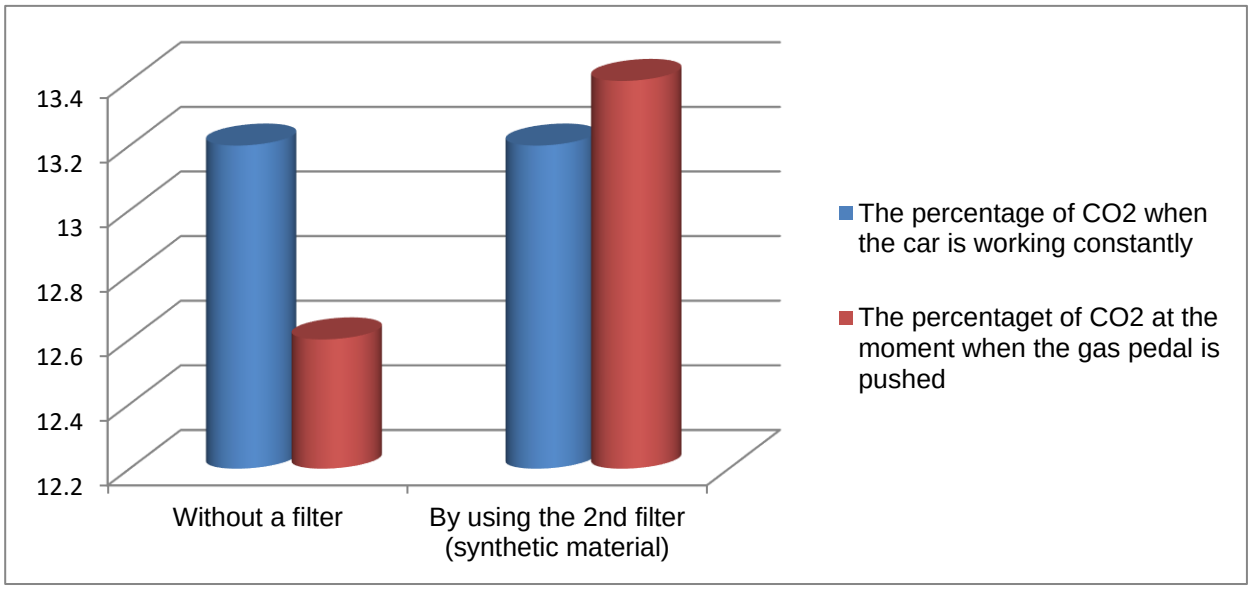
6.2.2.1.

By using the **1st filter (cotton)** it decreased to 10.00% when the car was working constantly and 11.50% at the moment when the gas pedal was pushed.



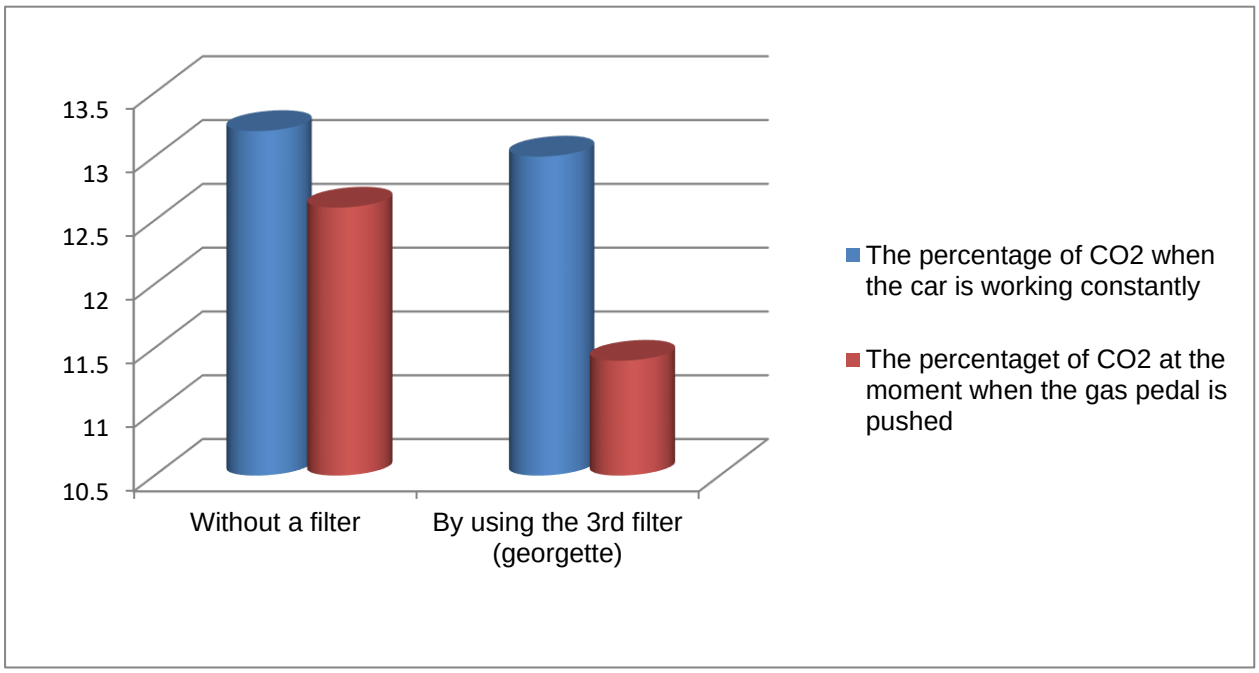
6.2.2.2.

By using the **2nd filter (synthetic material)** it stayed the same ,13.20%, when the car was working constantly and increased to 13.40% when the gas pedal was pushed.



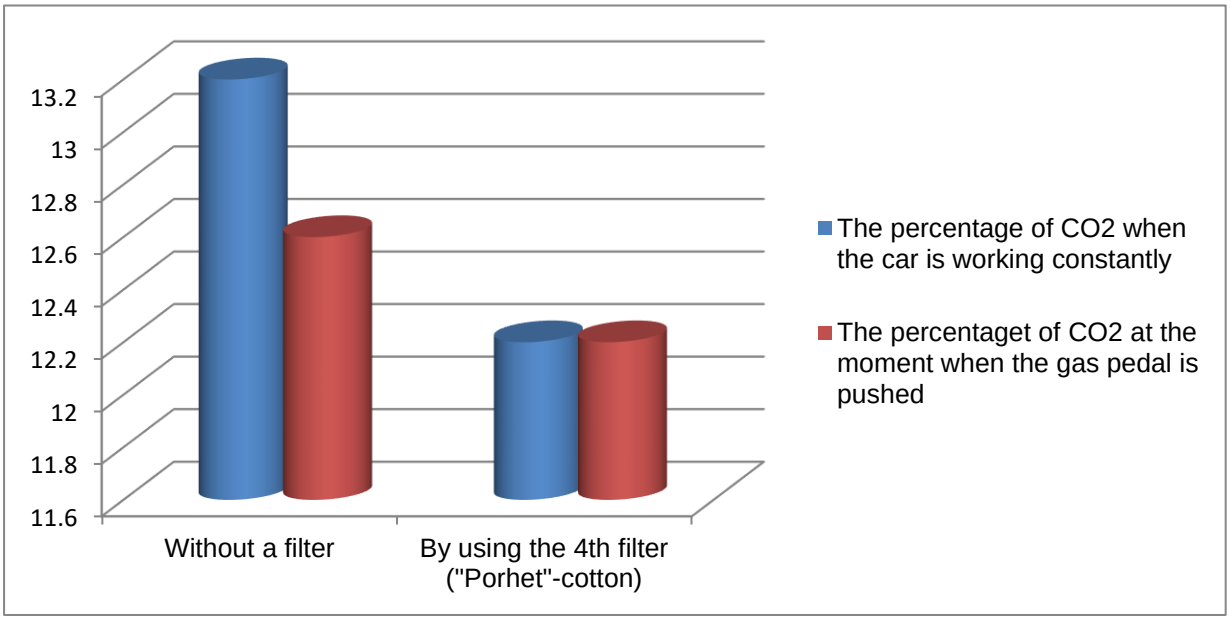
6.2.2.3.

By using the **3rd filter (georgette)** it decreased to 13.00% when the car was working constantly and 11.40% when the gas pedal was pushed.



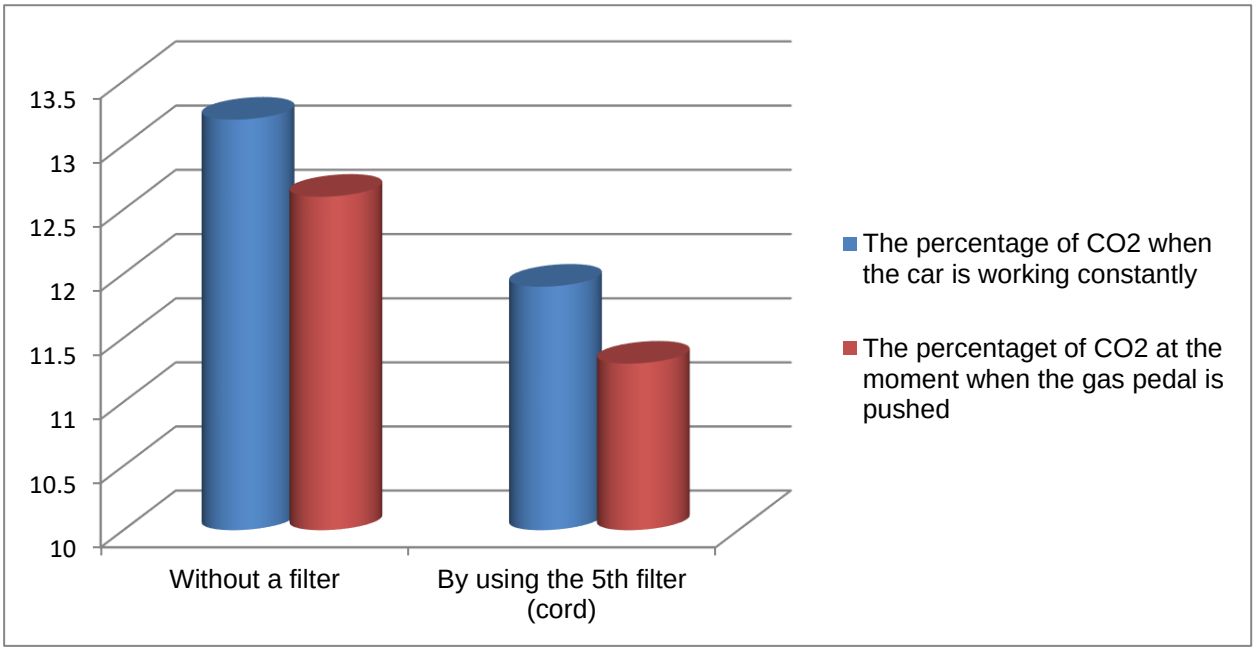
6.2.2.4.

By using the **4th filter ("Porhet"-cotton)** it decreased to 12.20% in both cases, when the car was working constantly when the gas pedal was pushed.



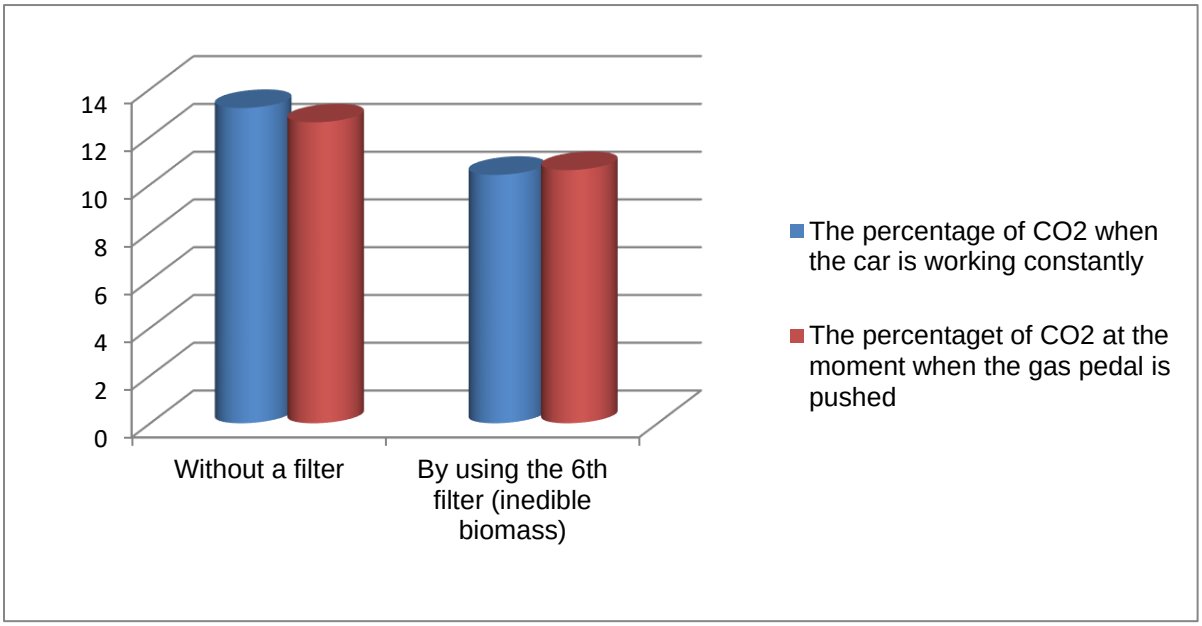
6.2.2.5.

By using the **5th filter (cord)** it rapidly decreased to 11.90% when the car was working constantly and 11.30% when the gas pedal was pushed.



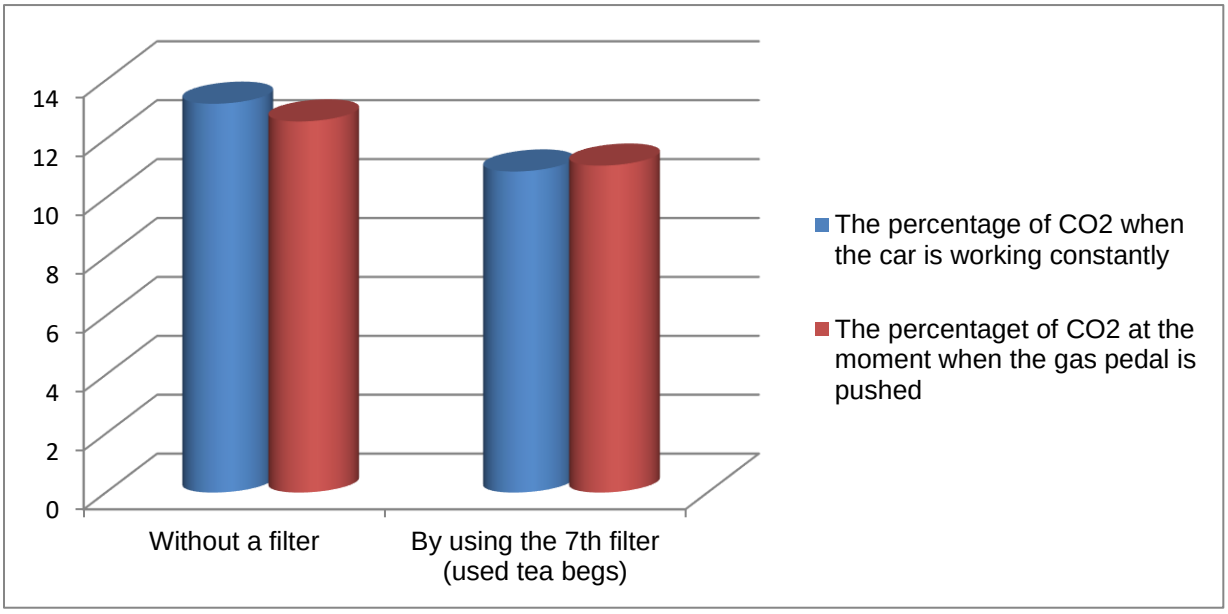
6.2.2.6.

By using the **6th filter (inedible biomass)** it rapidly decreased to 10.40% when the car was working constantly and 10.60% when the gas pedal was pushed.

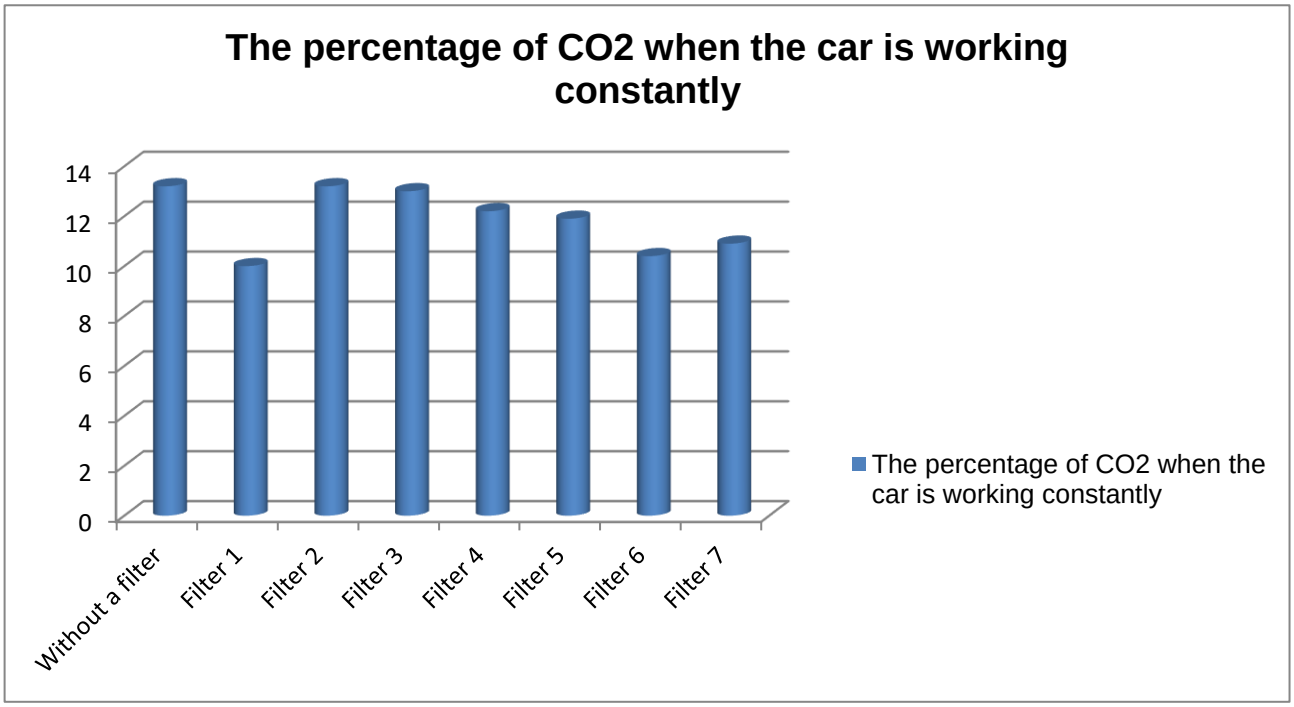


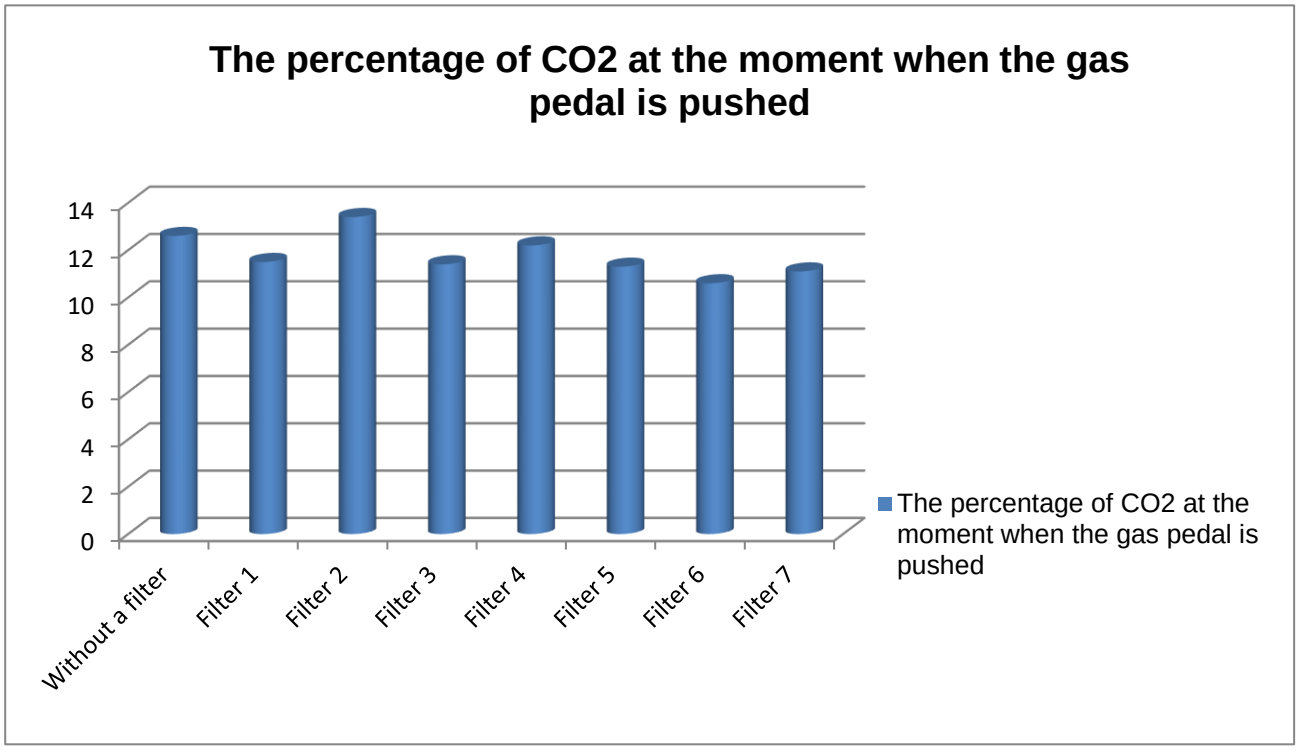
6.2.2.7.

By using the **7th filter (used tea bags)** it rapidly decreased to 10.90% when the car was working constantly and 11.10% when the gas pedal was pushed.



6.2.2.8.


The percentage of CO2 when the car is working constantly
14
12
10
8
6
4
2
0
Without a filter
Filter 1
Filter 2
Filter 3
Filter 4
Filter 5
Filter 6
Filter 7
The percentage of CO2 when the car is working constantly

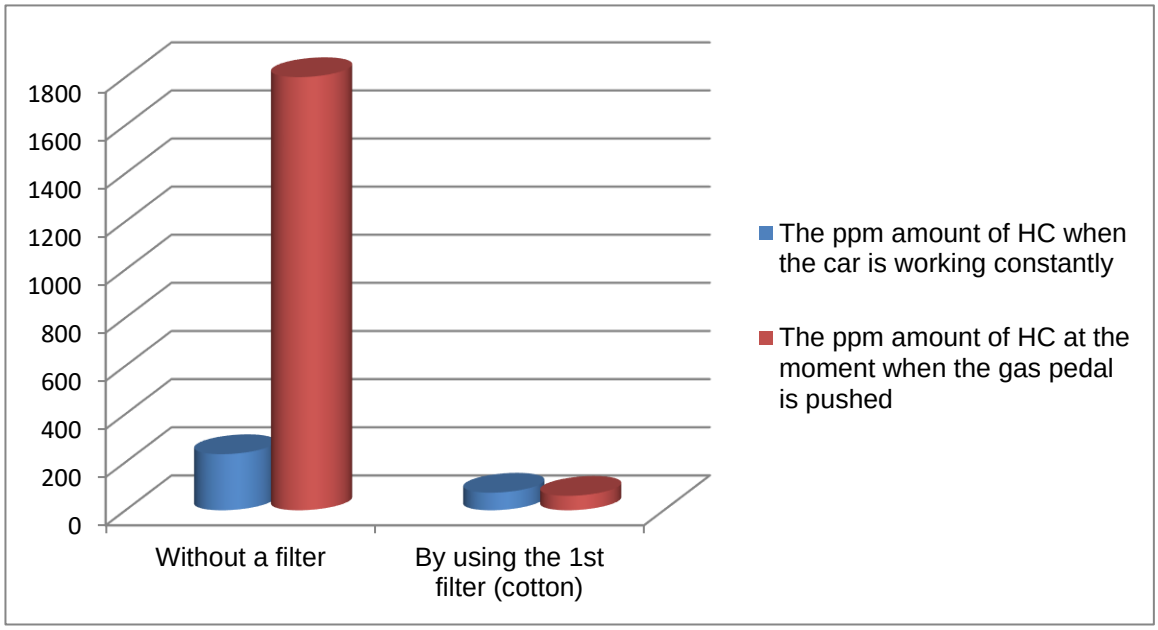

The percentage of CO2 at the moment when the gas pedal is pushed
14
12
10
8
6
4
2
0
Without a filter
Filter 1
Filter 2
Filter 3
Filter 4
Filter 5
Filter 6
Filter 7
The percentage of CO2 at the moment when the gas pedal is pushed

6.2.3. Hydrocarbon

Without any filter, when the car was working constantly 233 ppm of Hydrocarbon were released and 1800 ppm at the moment when the gas pedal was pushed.

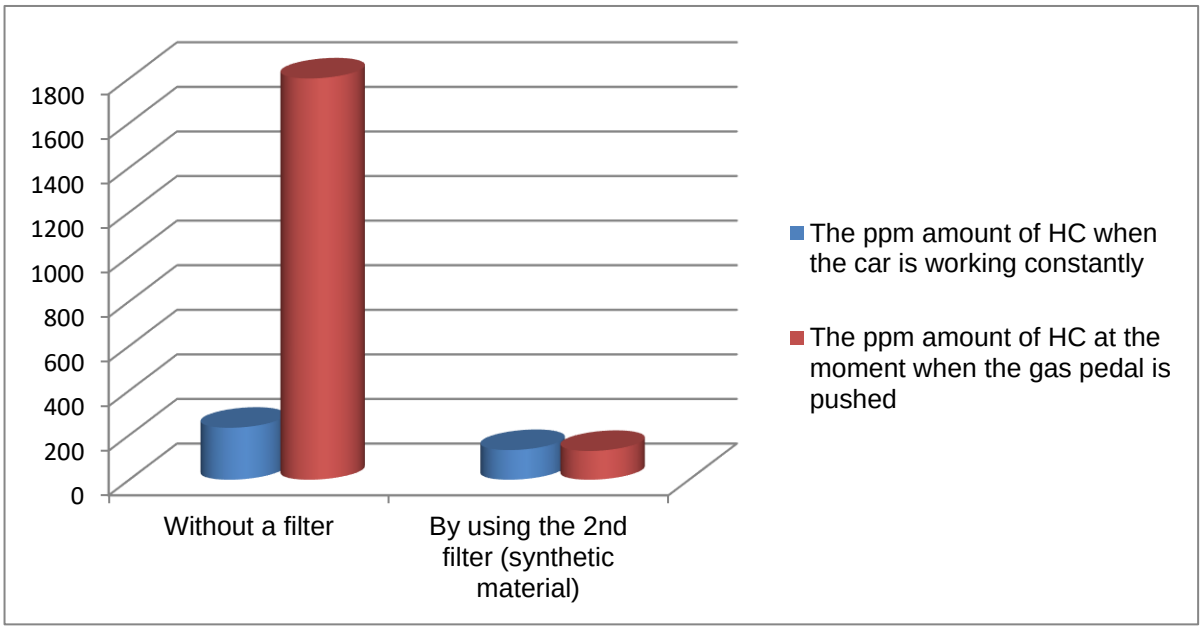
6.2.3.1

By using the **1st filter (cotton)** it rapidly decreased to 73 ppm when the car was working constantly and to 60 ppm when the gas pedal was pushed.

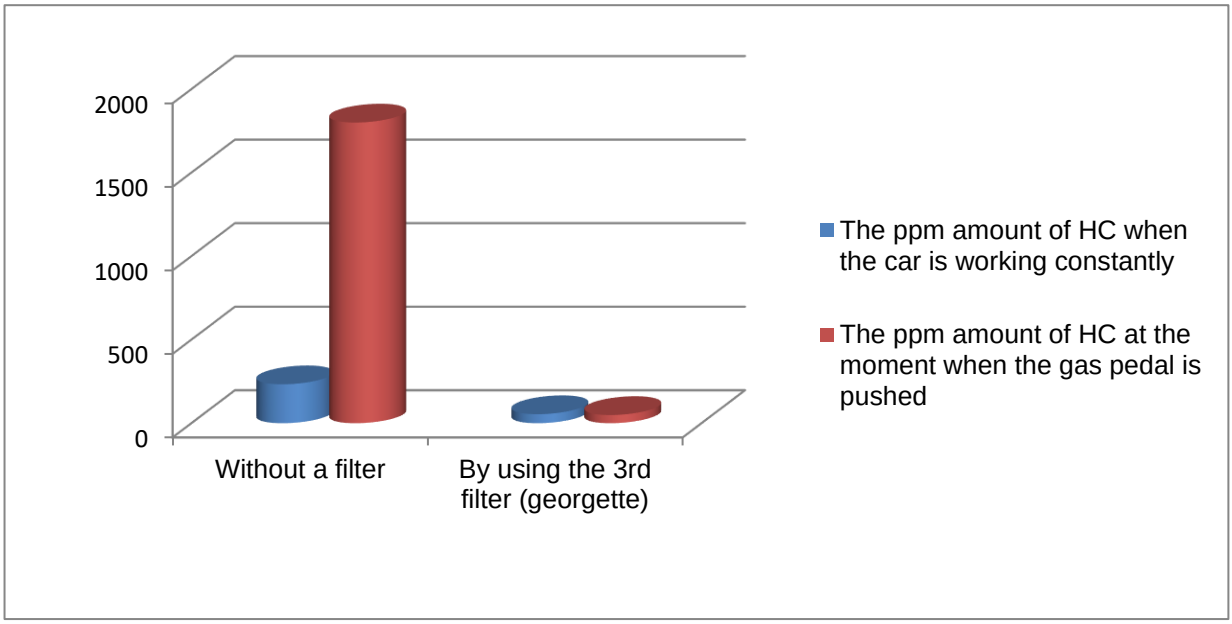


6.2.3.2.

By using the **2nd filter (synthetic material)** it rapidly decreased to 133 ppm when the car was working constantly and to 129 ppm when the gas pedal was pushed.

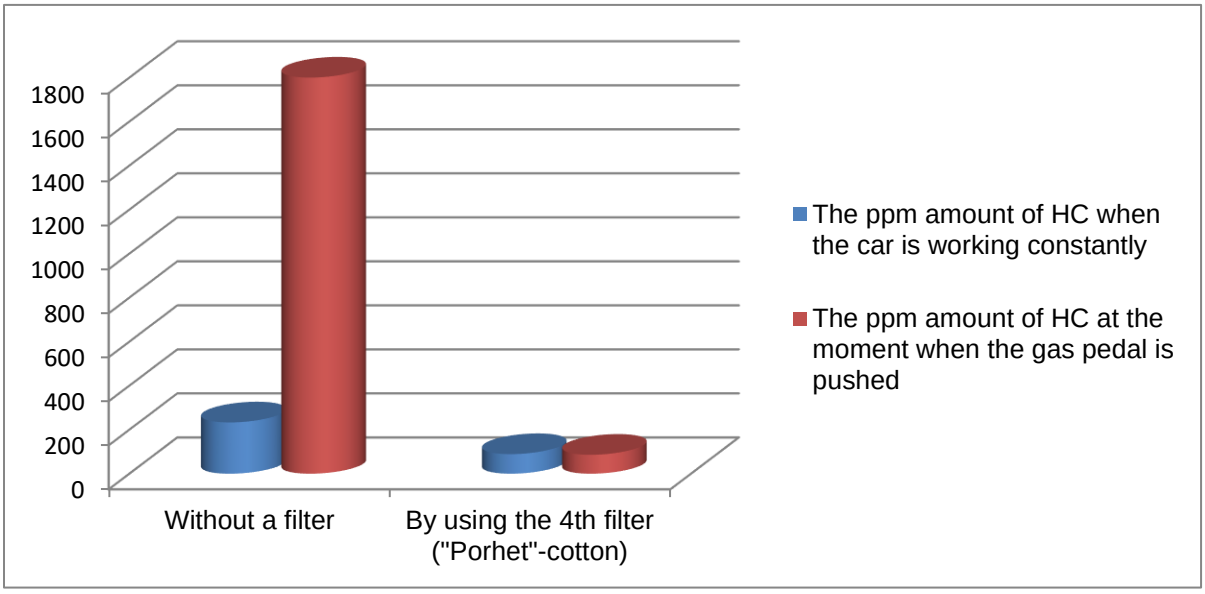


6.2.3.3. By using the **3rd filter (georgette)** it rapidly decreased to 54 ppm when the car was working constantly and to 49 ppm when the gas pedal was pushed.



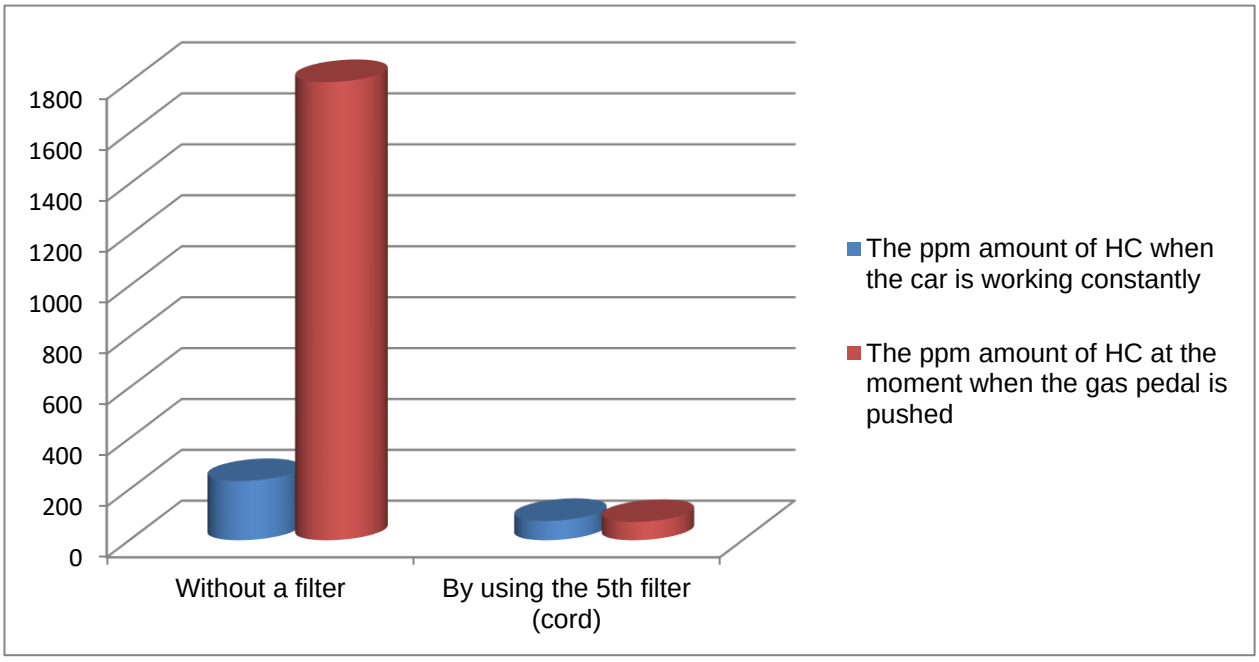
6.2.3.4.

By using **the 4th filter ("Porhet" –cotton)** it rapidly decreased to 89 ppm when the car was working constantly and to 86 ppm when the gas pedal was pushed.



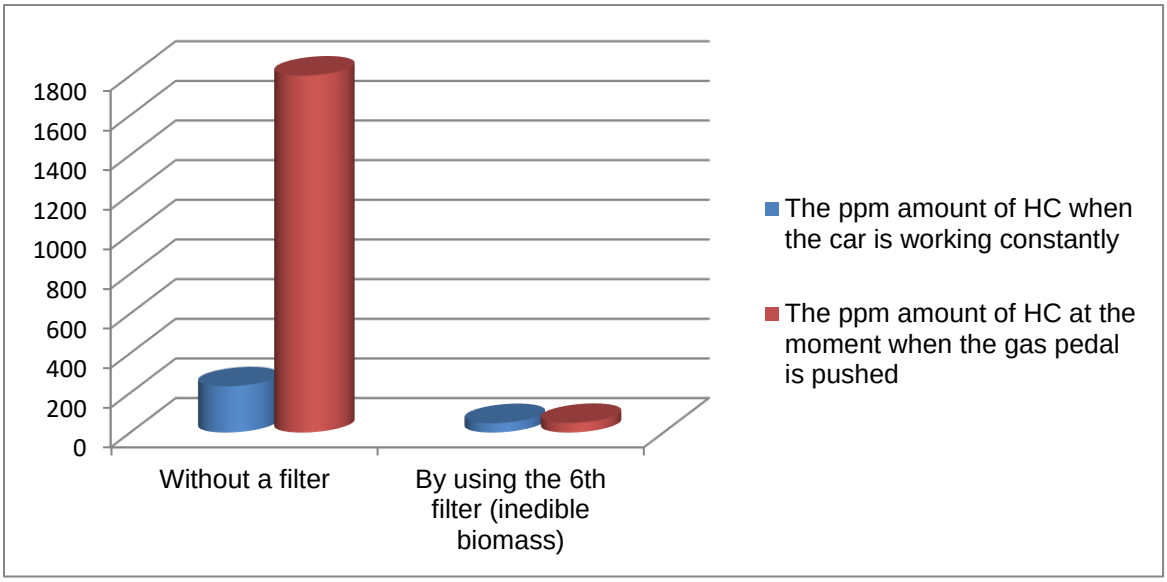
6.2.3.5.

By using **the 5th filter (cord)** it rapidly decreased to 76 ppm when the car was working constantly and to 72 ppm when the gas pedal was pushed.



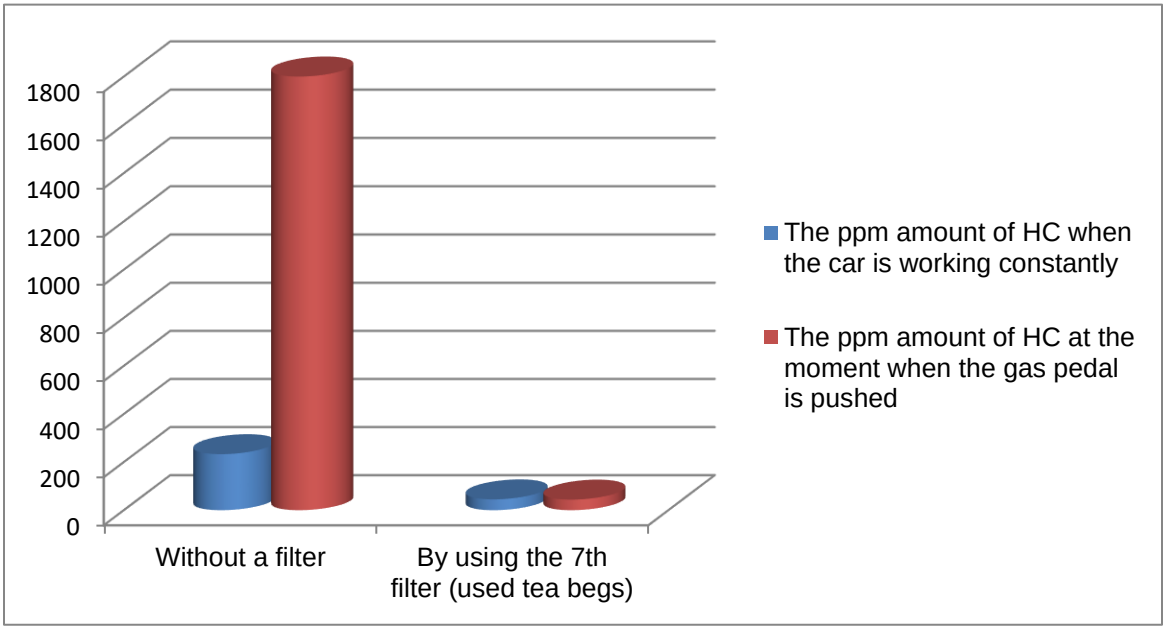
6.2.3.6.

By using **the 6th filter (inedible biomass)** it rapidly decreased to 47 ppm when the car was working constantly and to 48 ppm when the gas pedal was pushed.

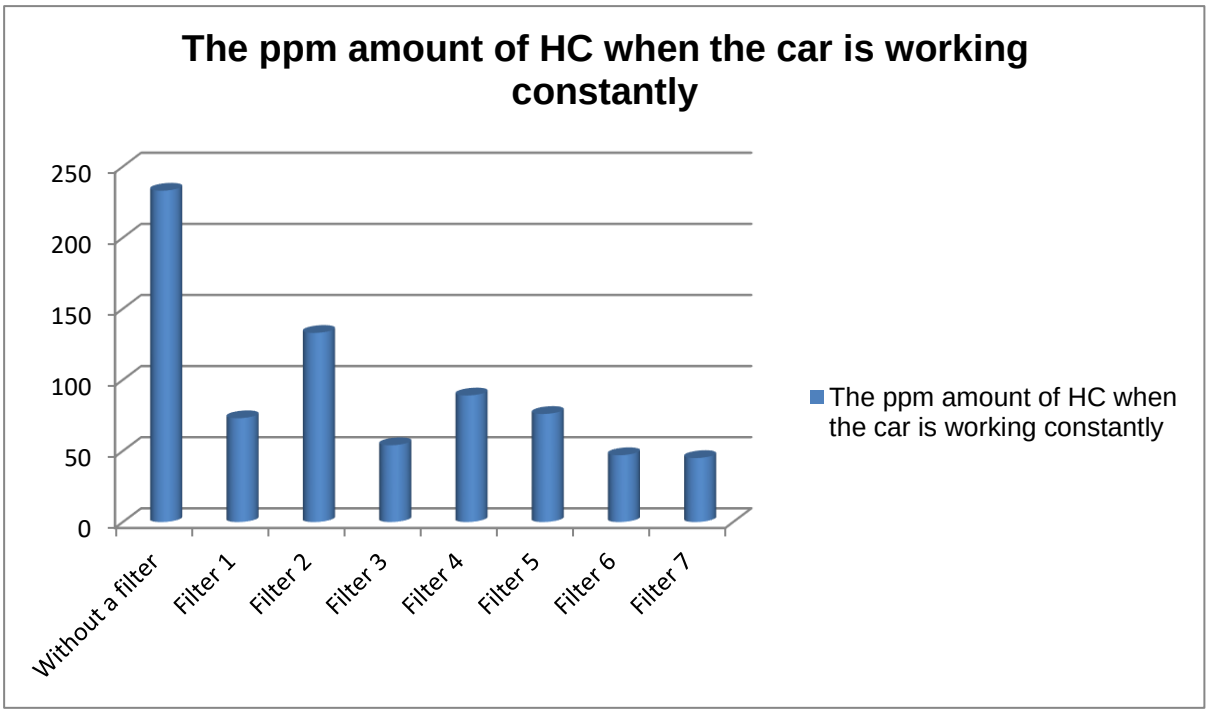


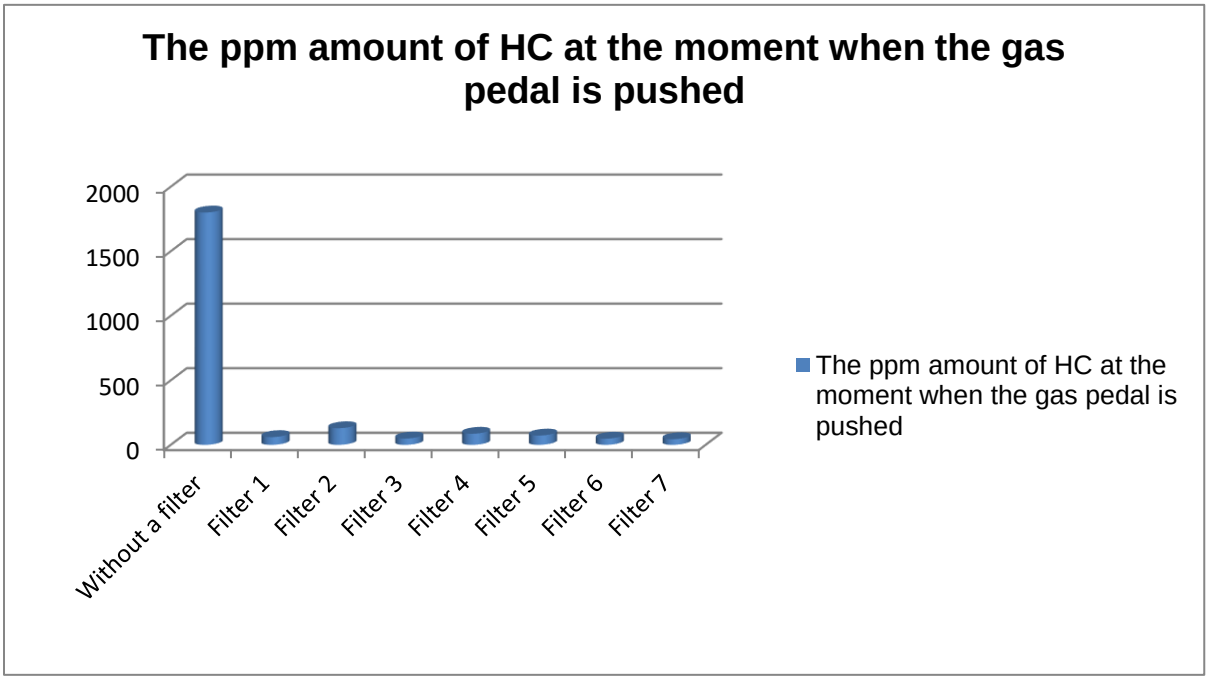
6.2.3.7.

By using the **7th filter (used tea bags)** it rapidly decreased to 45 ppm when the car was working constantly and to 44 ppm when the gas pedal was pushed.



6.2.3.8.


The ppm amount of HC when the car is working constantly
250
200
150
100
50
0
Without a filter
Filter 1
Filter 2
Filter 3
Filter 4
Filter 5
Filter 6
Filter 7
The ppm amount of HC when the car is working constantly

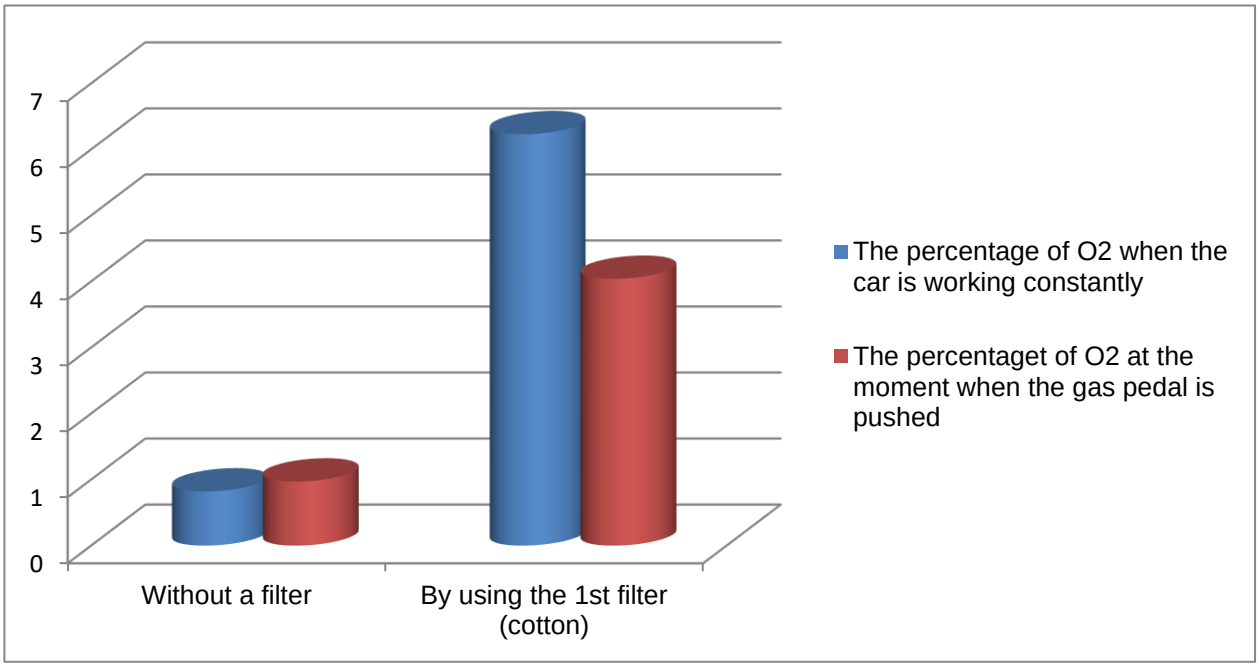

The ppm amount of HC at the moment when the gas pedal is pushed
2000
1500
1000
500
0
Without a filter
Filter 1
Filter 2
Filter 3
Filter 4
Filter 5
Filter 6
Filter 7
The ppm amount of HC at the moment when the gas pedal is pushed

6.2.4. Oxygen

Without any filter, when the car was working constantly the 0.82% of the released gases was Oxygen and at the moment when the gas pedal was pushed it was 0.97%

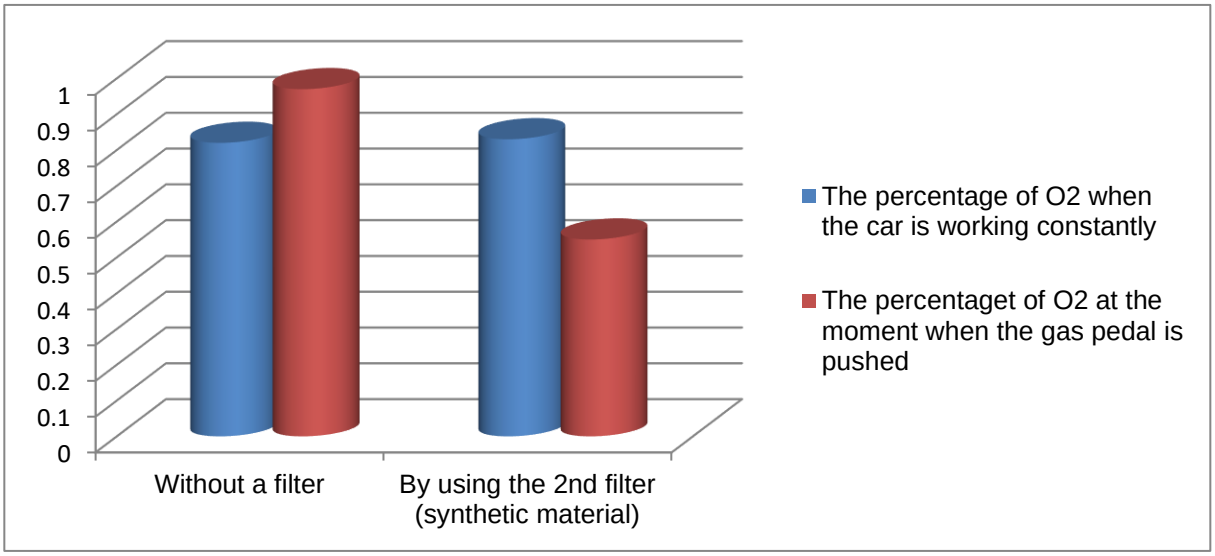
6.2.4.1.

By using the **1st filter (cotton)** it rapidly increased to 6.23% when the car was working constantly and 4.04% when the gas pedal was pushed.



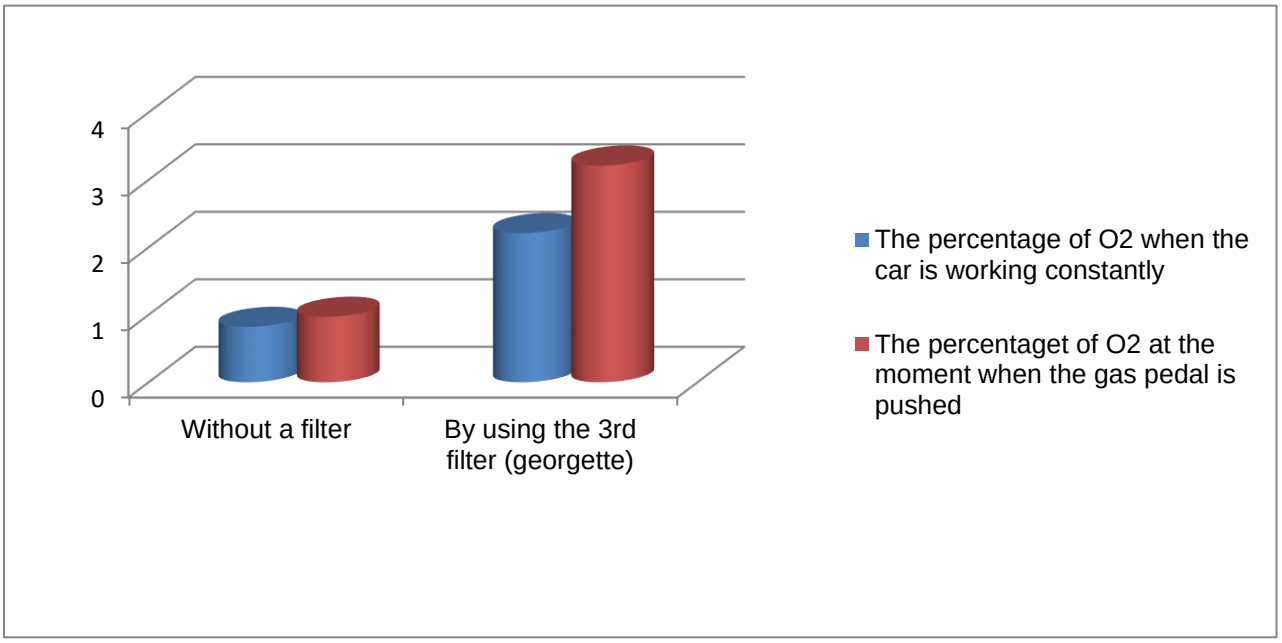
6.2.4.2.

By using the **2nd filter (synthetic material)** it increased to 0.83% when the car was working constantly and decreased to 0.55% when the gas pedal was pushed.



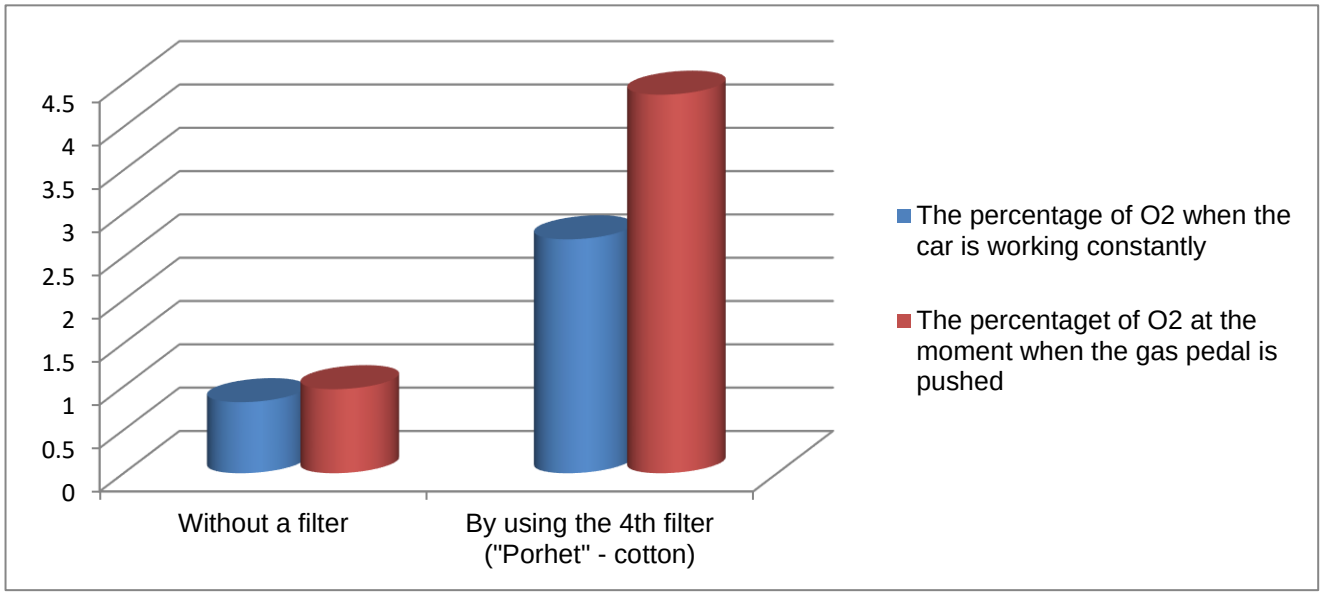
6.2.4.3.

By using the **3rd filter (georgette)** it rapidly increased to 2.21% when the car was working constantly and 3.21% when the gas pedal was pushed.



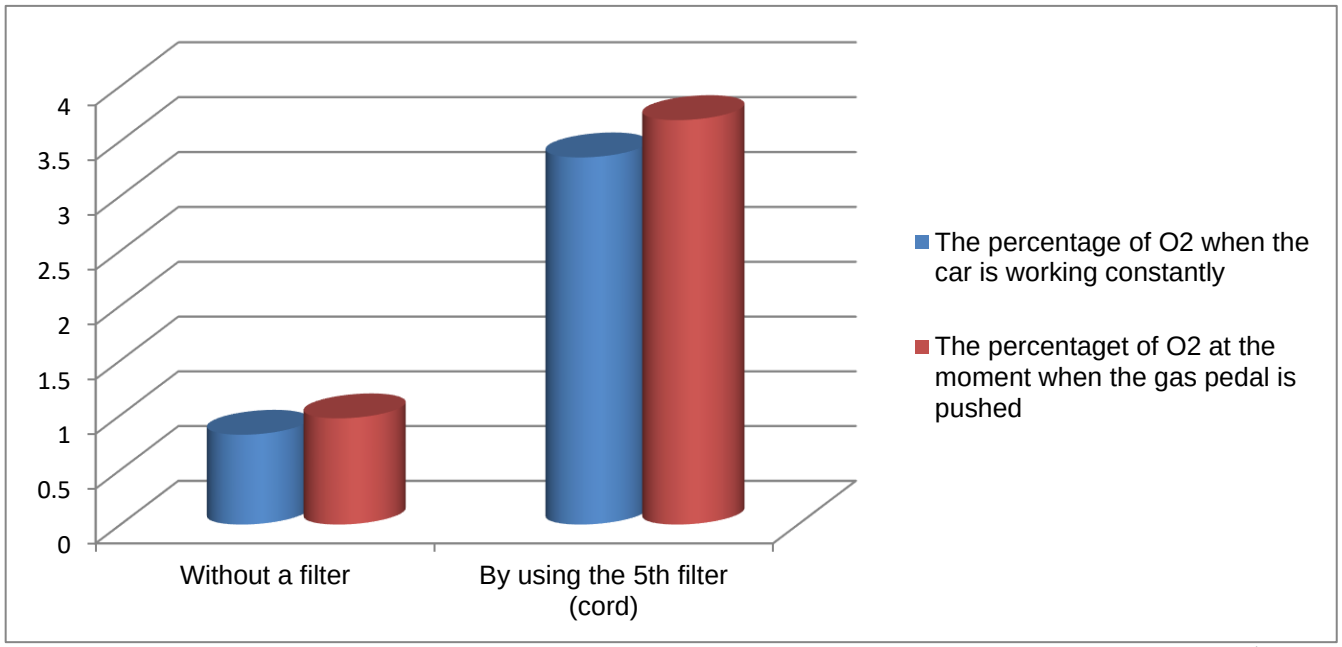
6.2.4.4.

By using **the 4th filter ("Porhet"- cotton)** it rapidly increased to 2.70% when the car was working constantly and 4.37% when the gas pedal was pushed.



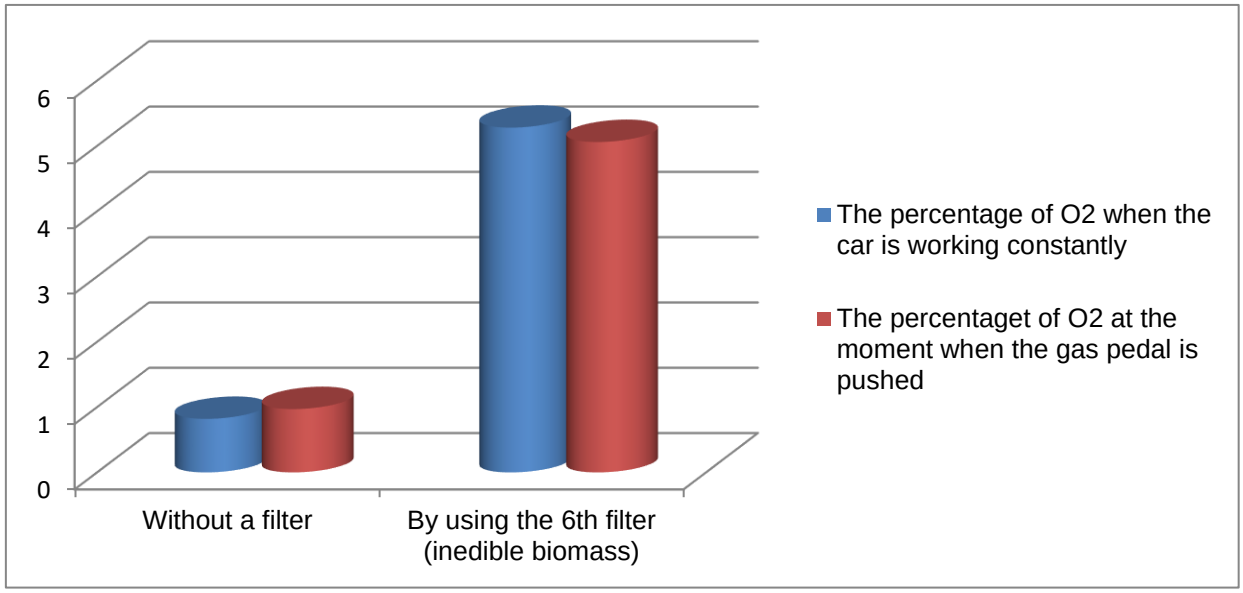
6.2.4.5.

By using the **5th filter (cord)** it rapidly increased to 3.35% when the car was working constantly and 3.69% when the gas pedal was pushed.



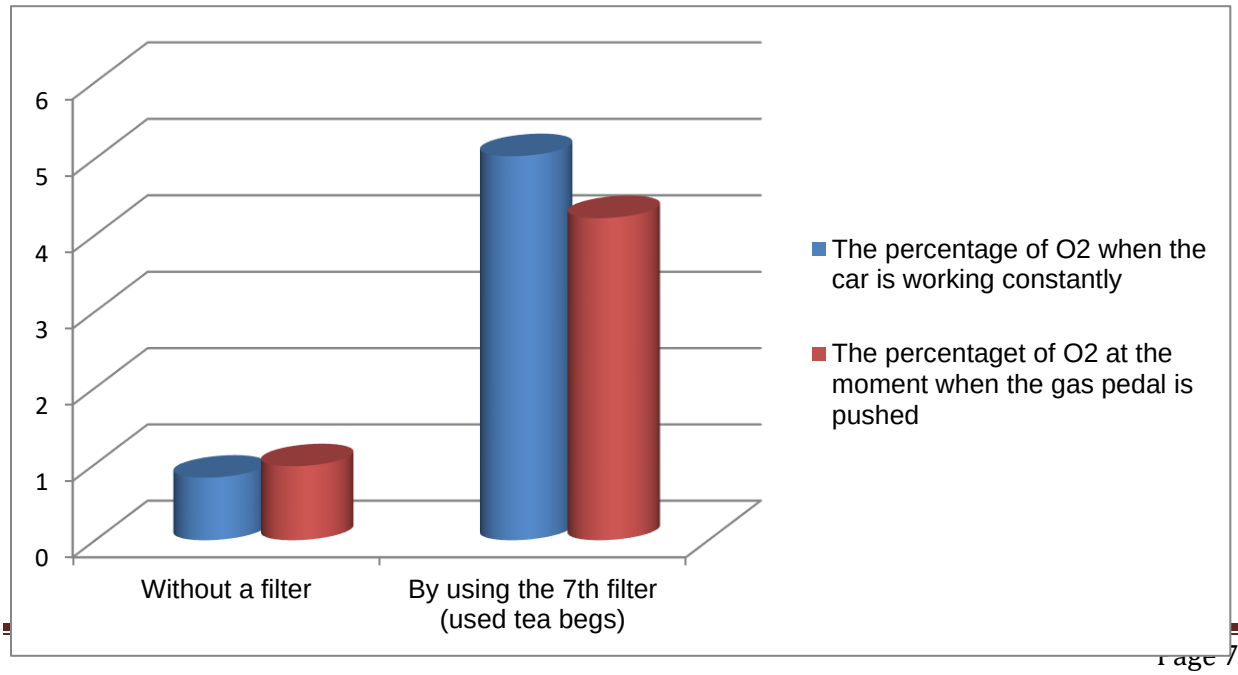
6.2.4.6.

By using **the 6th filter (inedible biomass)** it rapidly increased to 5.28% when the car was working constantly and 5.06% when the gas pedal was pushed.

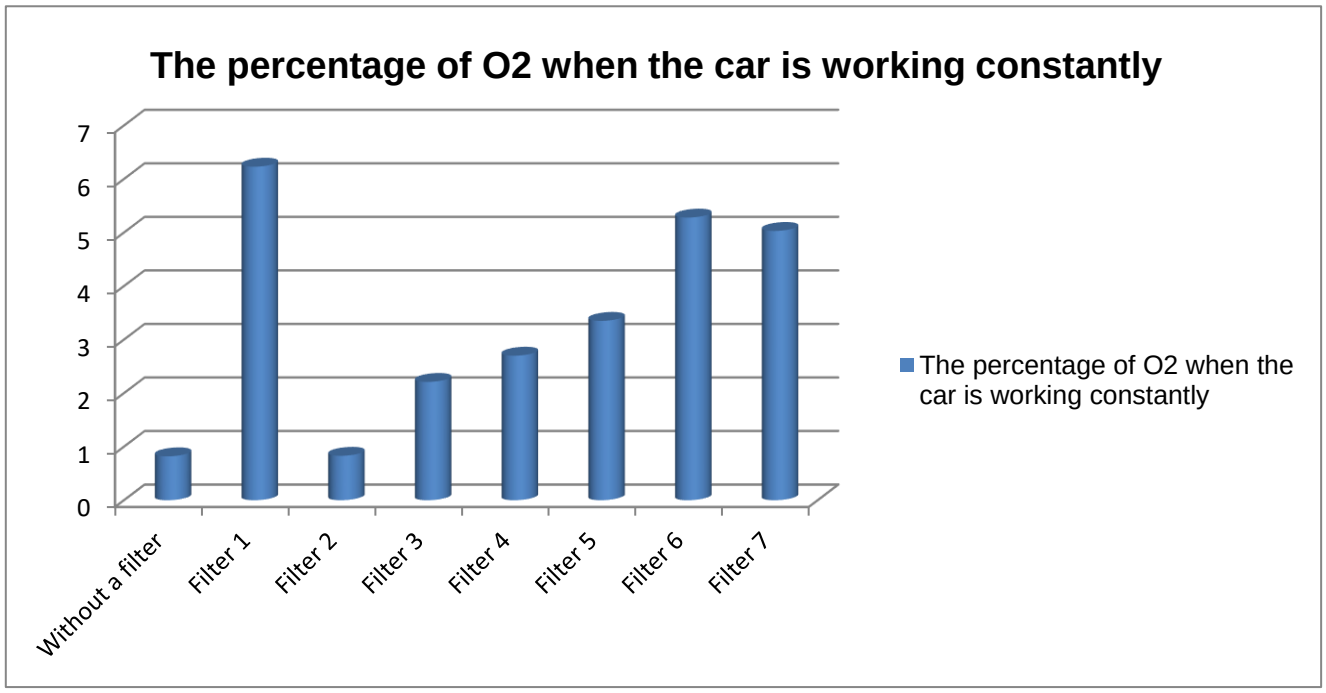


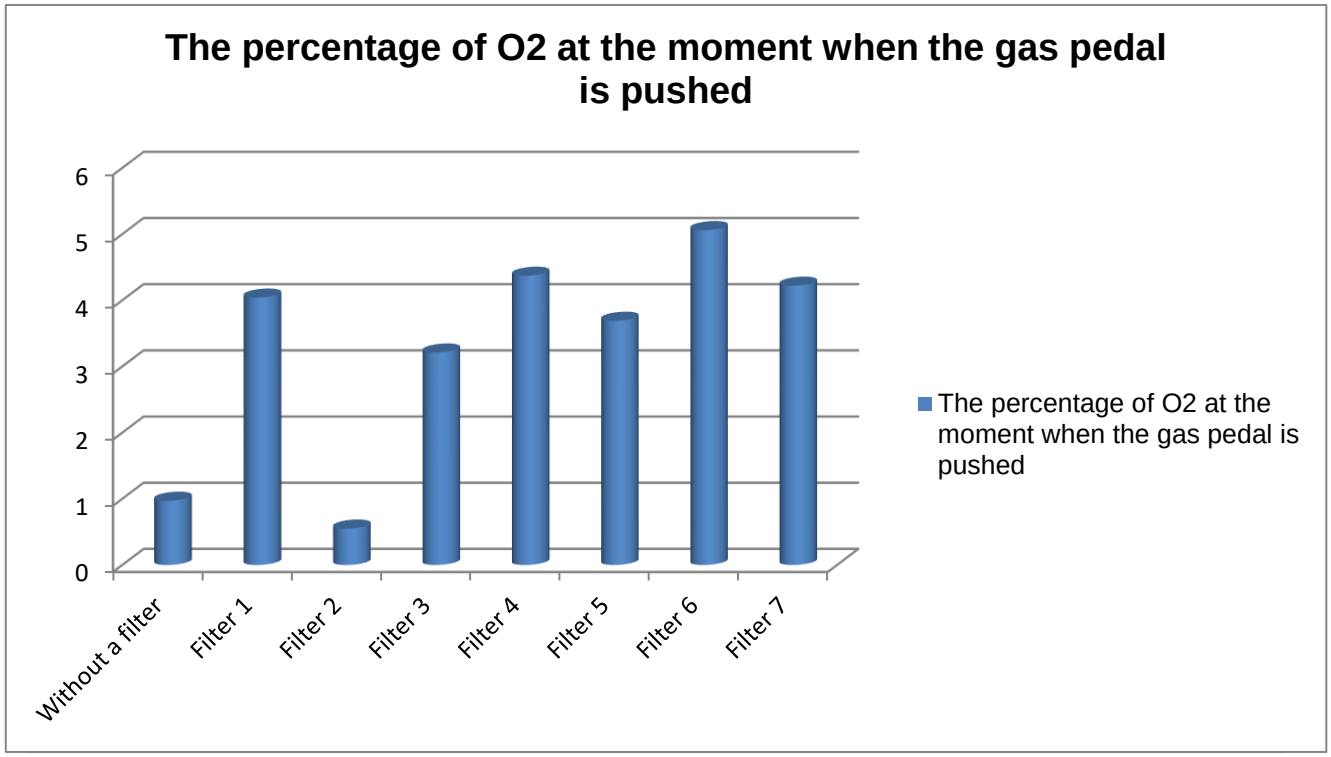
6.2.4.7.

By using **the 7th filter (used tea bags)** it rapidly increased to 5.03% when the car was working constantly and 4.22% when the gas pedal was pushed.



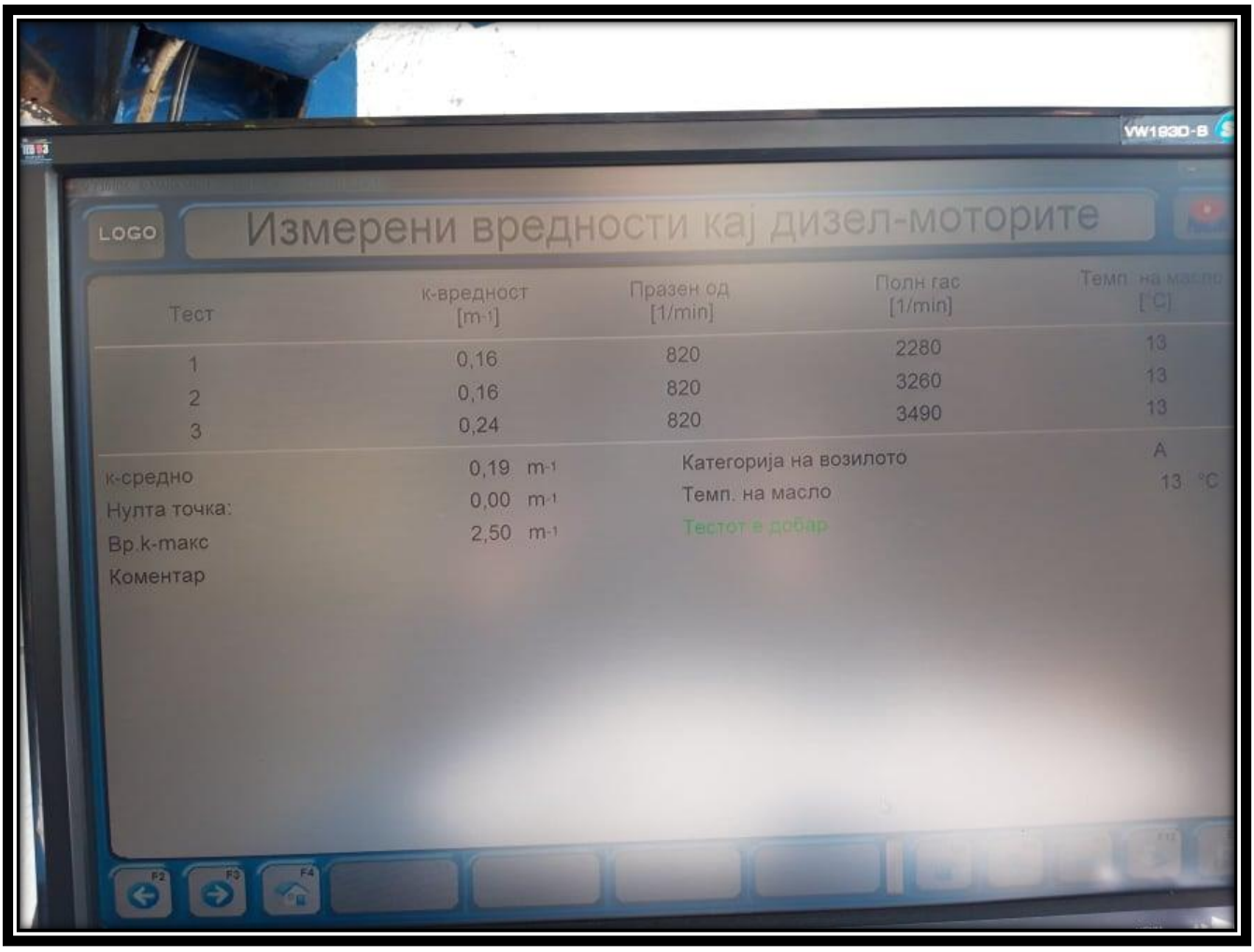
6.2.4.8.


The percentage of O2 when the car is working constantly
7
6
5
4
3
2
1
0
Without a filter
Filter 1
Filter 2
Filter 3
Filter 4
Filter 5
Filter 6
Filter 7
The percentage of O2 when the car is working constantly


The percentage of O2 at the moment when the gas pedal is pushed
6
5
4
3
2
1
0
Without a filter
Filter 1
Filter 2
Filter 3
Filter 4
Filter 5
Filter 6
Filter 7
The percentage of O2 at the moment when the gas pedal is pushed

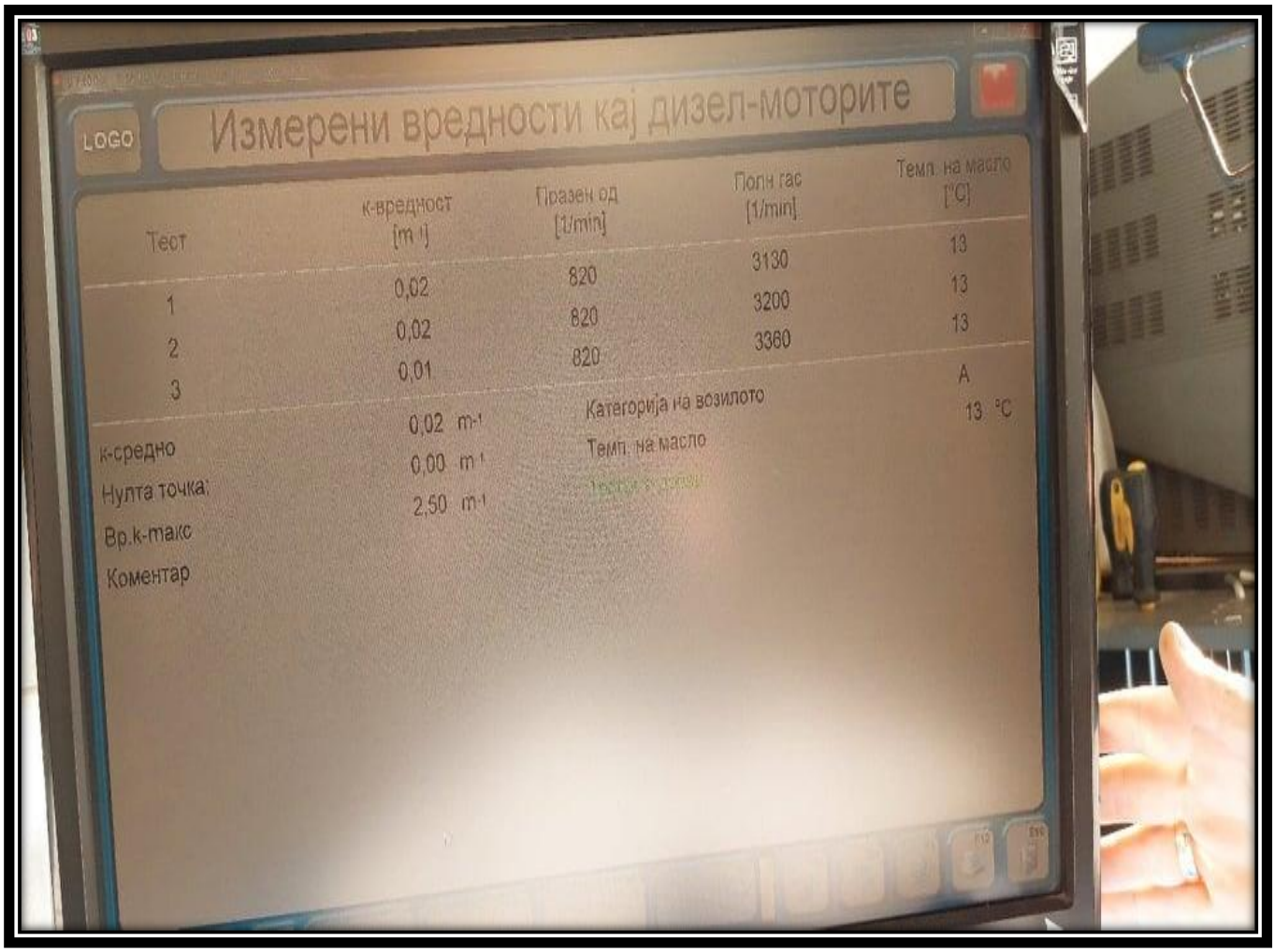
6.3. The third part of the experiment tested the filters on a car which uses diesel as a fuel

For the diesel car, we did not get measurements with these standard values. Therefore, in addition I will only post pictures of the results which prove that the filters work on this type of cars as well.



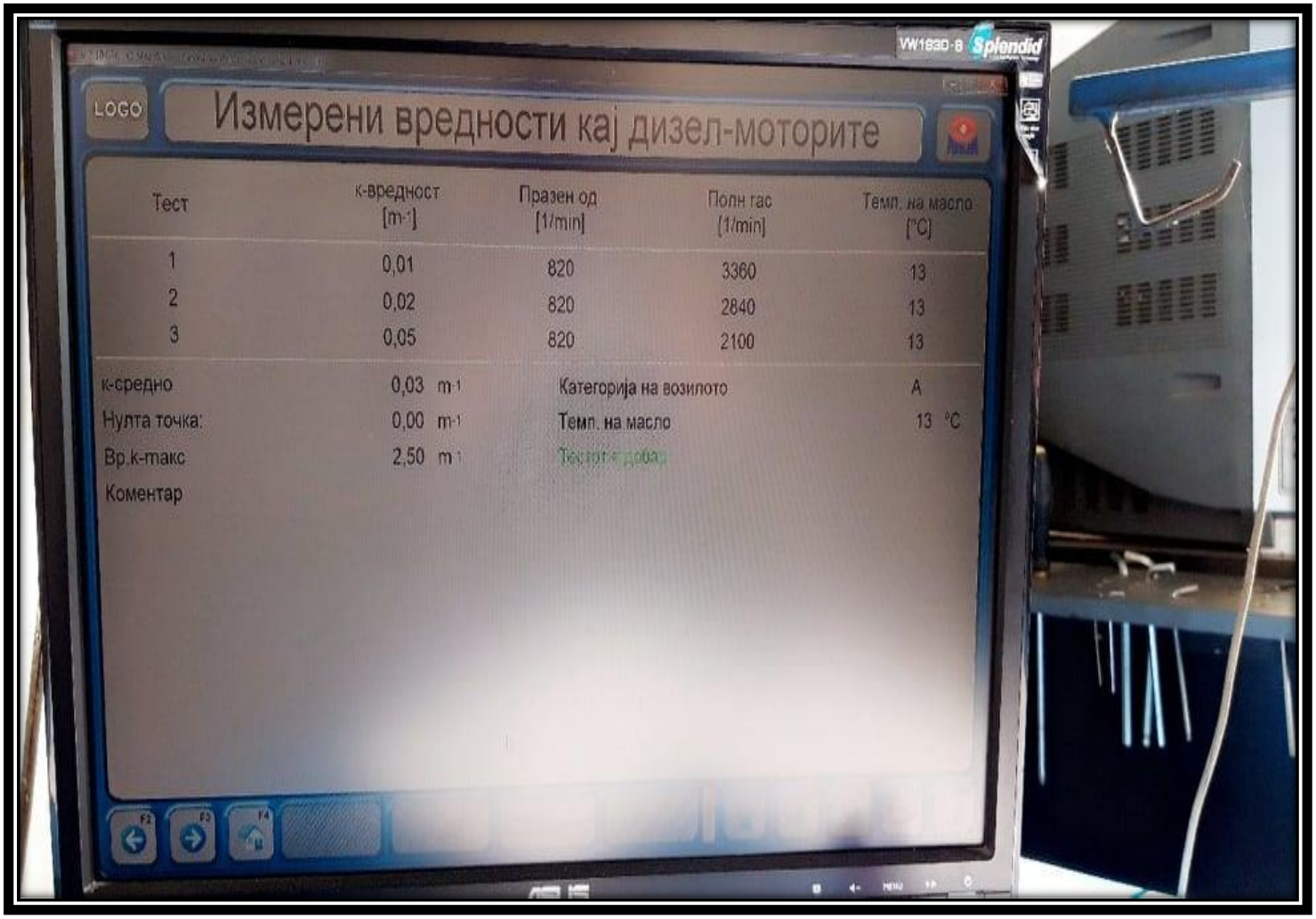
28.Results without a filter

6.3.1.



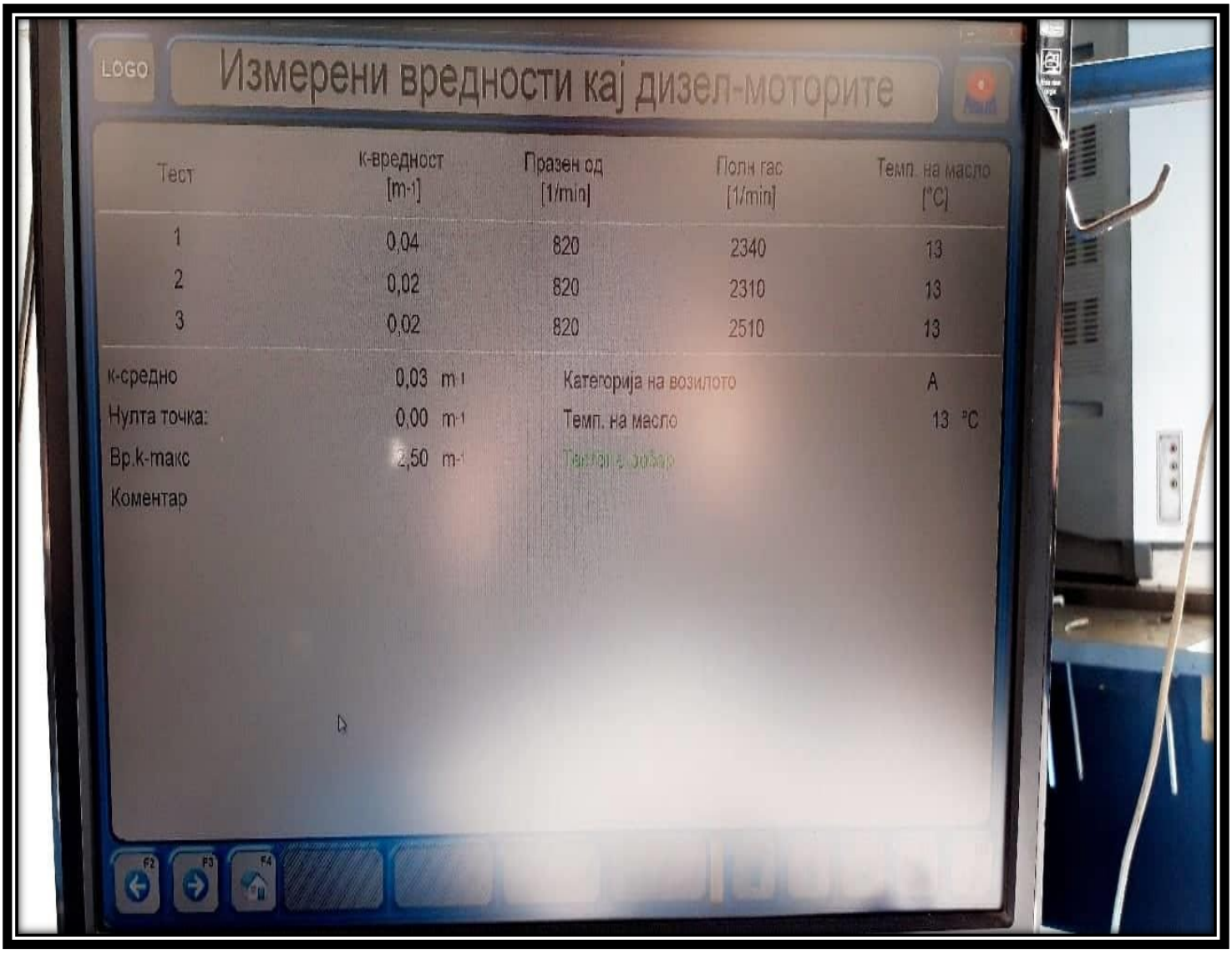
29.Results we obtained by using the first filter (cotton)

6.3.2



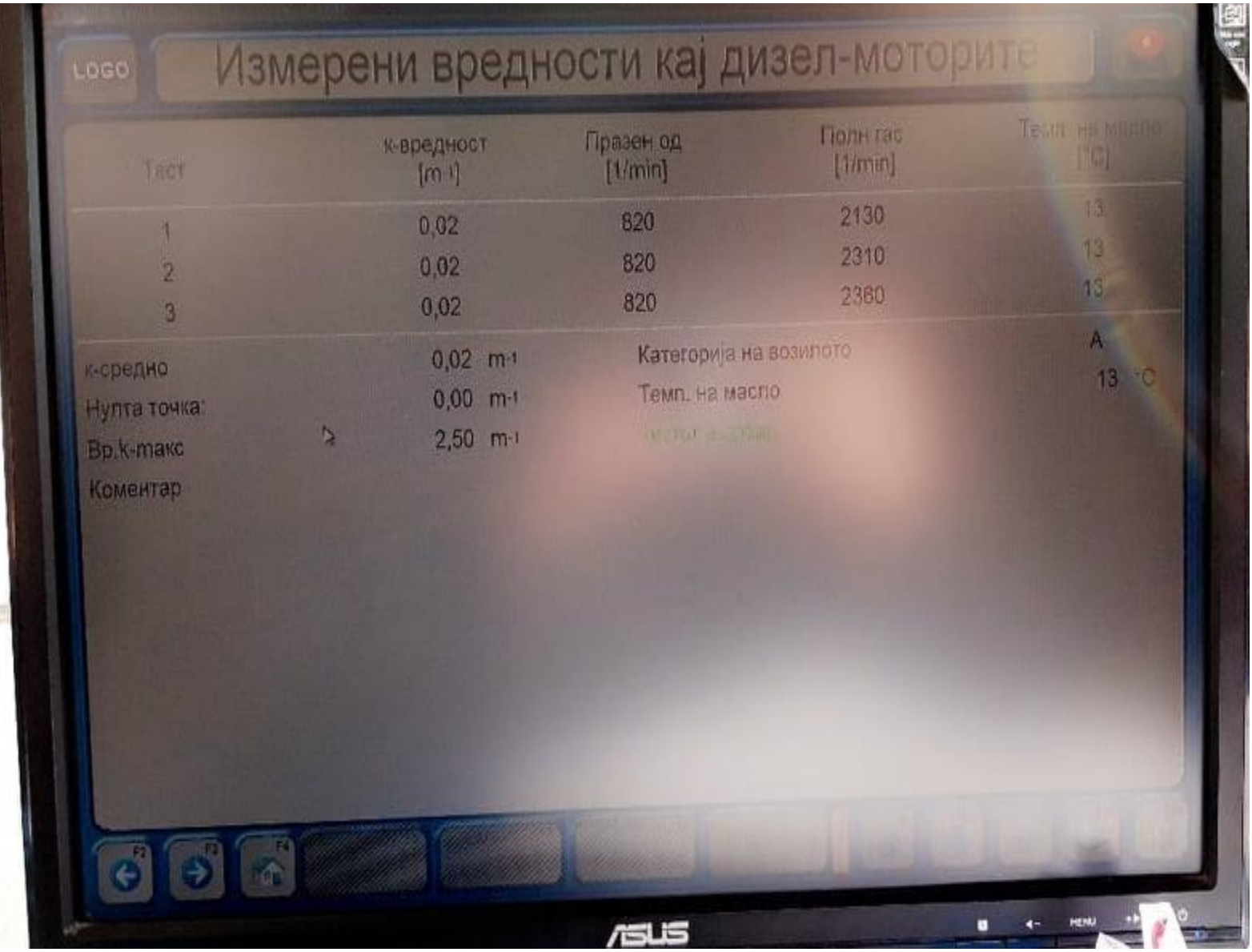
30.Results we obtained using the second filter (synthetic material)

6.3.3.



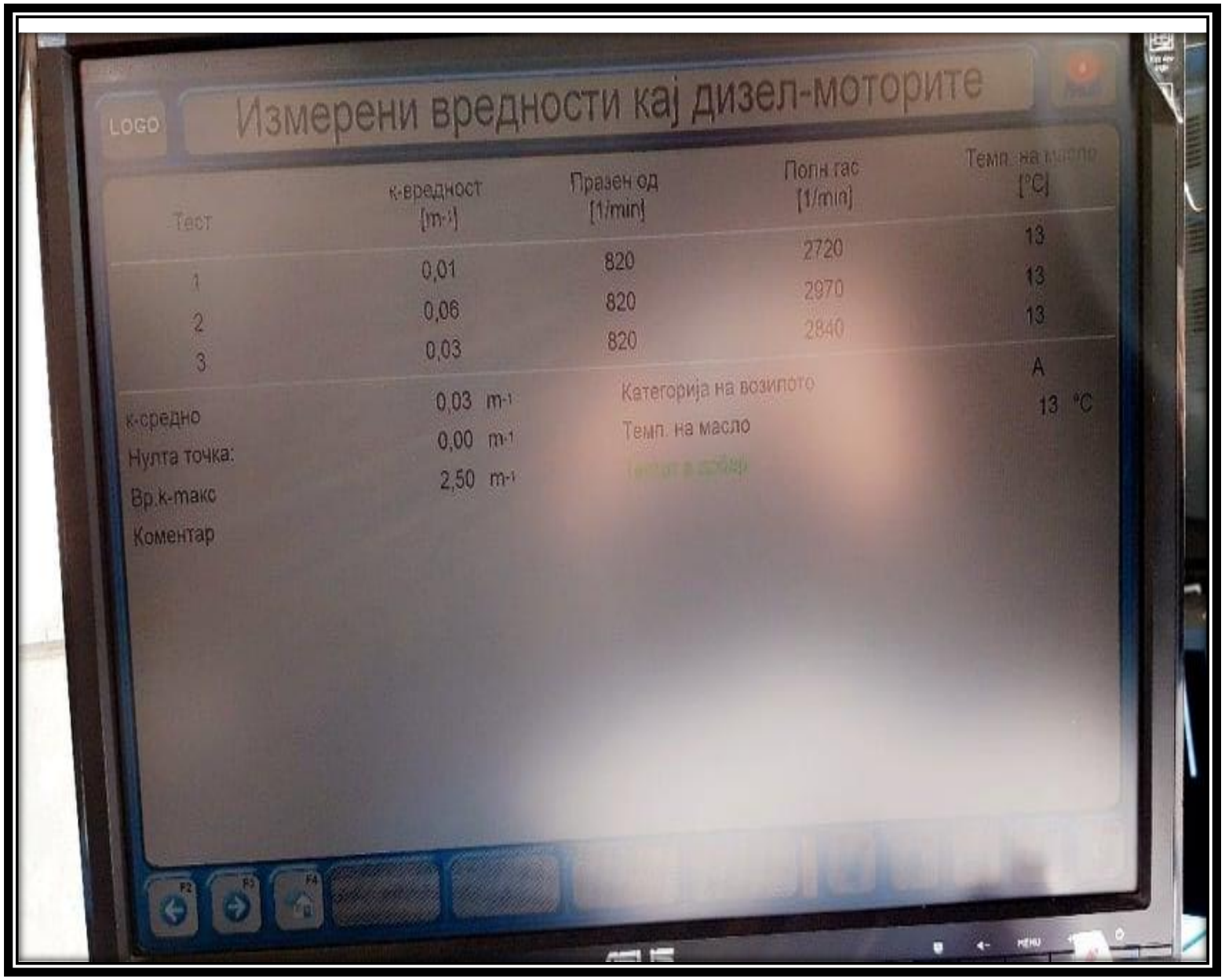
31.Results we obtained using the third filter (georgette)

6.3.4.



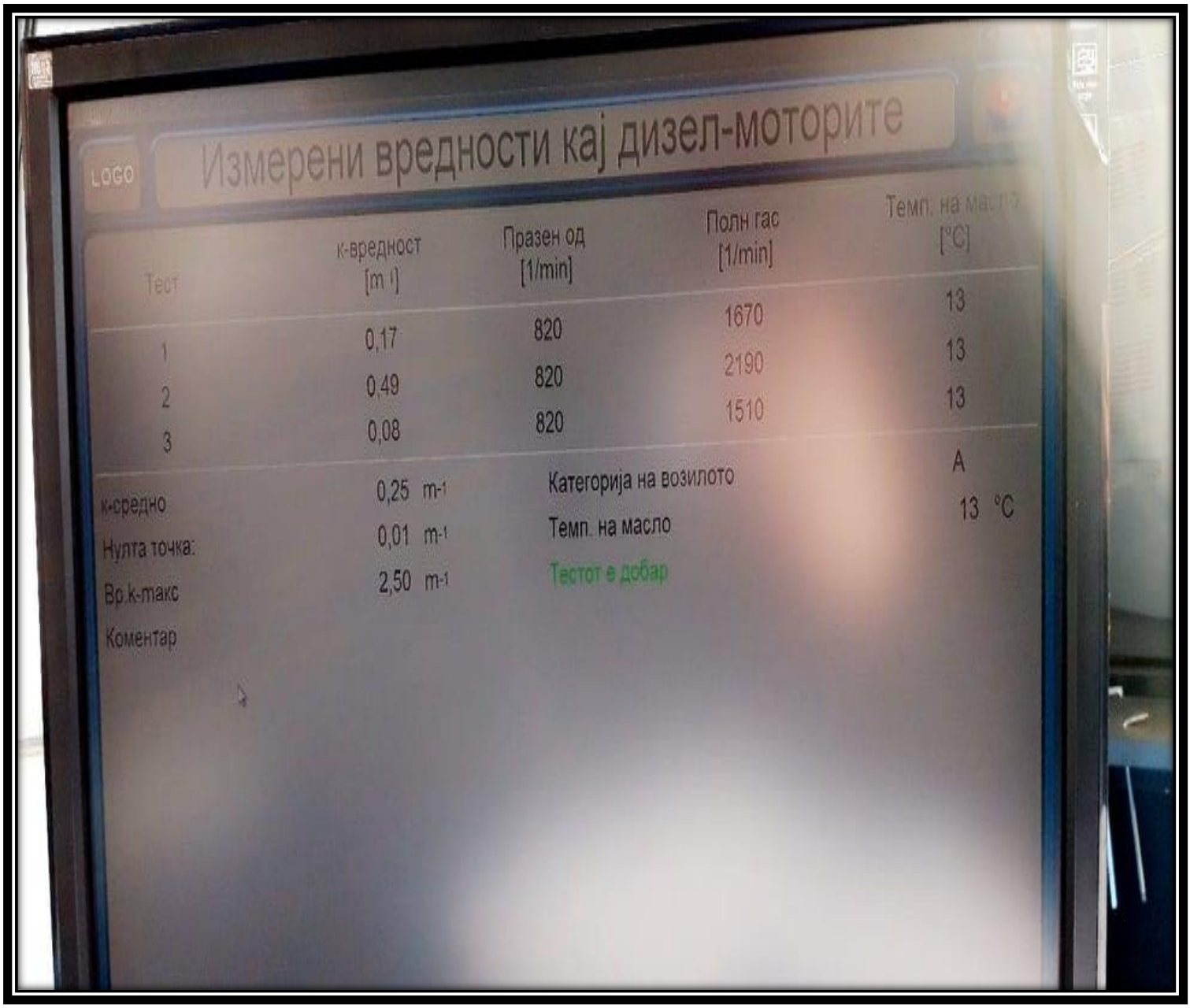
32.Results we obtained using the fourth filter ("Porhet" –cotton)

6.3.5.



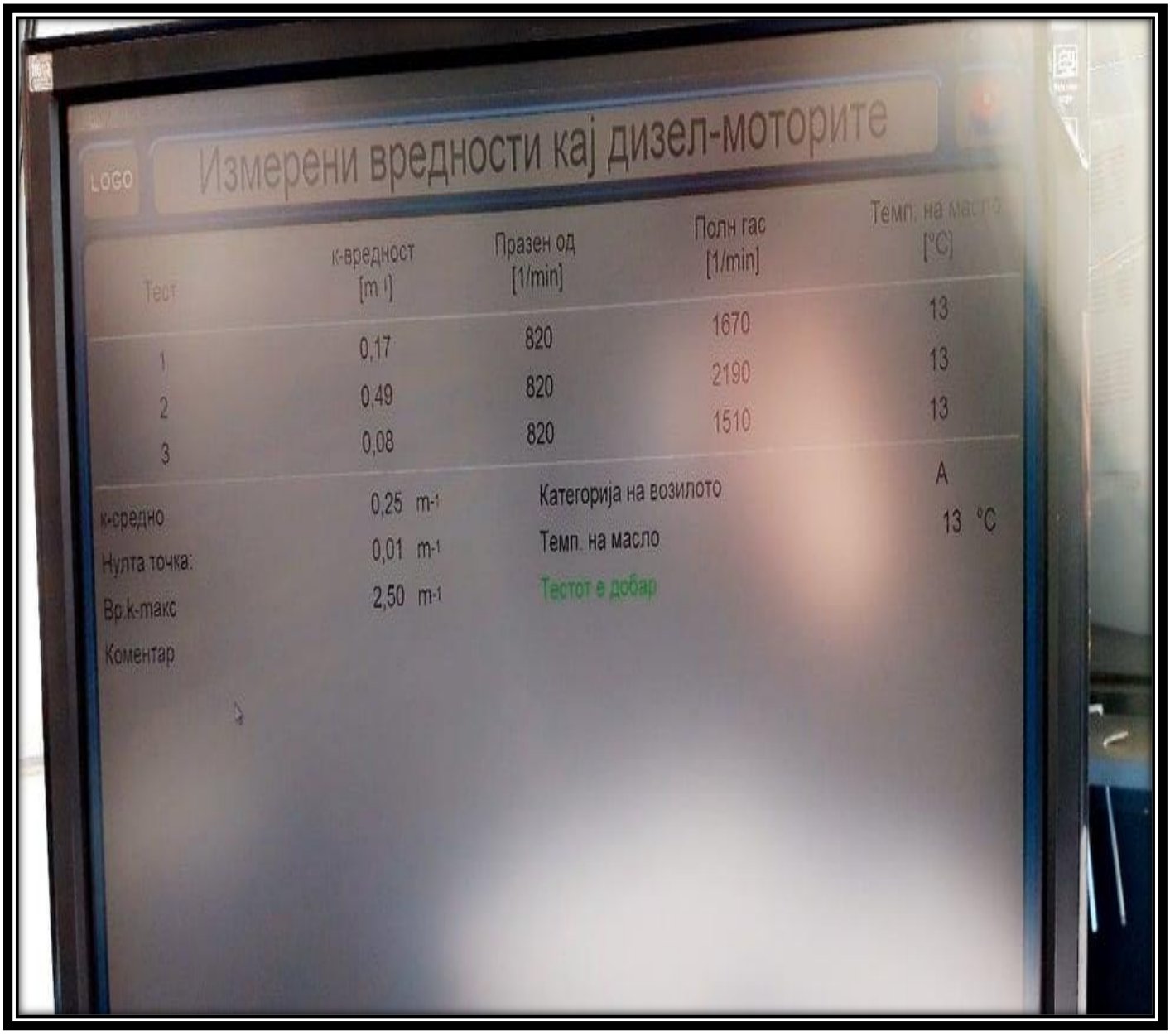
33.Results we obtained using the fifth filter (cord)

6.3.6.



34.Results we obtained using the sixth filter (inedible biomass)

6.3.7.



35.Results we obtained using the seventh filter (used tea bags)

7. *DISCUSSION*

After comparing all the results, we got we are able to say that

(percents are circled to the nearest whole number)

a) For a car that uses gasoline while it is **working constantly**:
   - Best absorbers of CO are the filters number 3 (georgette), 4 (“Porhet”-cotton), 5 (cord),6 (inedible biomass) and 7 (used tea bags) with efficiency of 100%, there was not emission at all. The filter number 1 (cotton) absorbed the amount of CO with efficiency of 75% and the filter number 2 (synthetic material) absorbed it with efficiency of 25%.
   - For CO_2 the efficiency of the 3rd (georgette) filter was even 79%, of the 4th filter (“Porhet”-cotton) 76%, of the 5th filter (cord) 61%, of the 1st filter (cotton) 41%, of the 2nd filter (synthetic material) 32%, of the 7th filter (used tea bags) 11% and of the 6th filter (inedible biomass) 5%.
   - For HC the efficiency of the 3rd filter (georgette) was surprisingly 96%, of the 1st filter (cotton) 92%, of the 4th filter (“Porhet”-cotton) 80%, of the 7th filter (used tea bags) 76%, of the 6th filter (inedible biomass) 72%, of the 5th filter (cord) 64% and of the 2nd filter (synthetic material) 12%.
   - For the amount of oxygen, I am going to show You the percentage of the increase in its amount. The efficiency of the 5th filter (cord) was surprisingly 3953%-approximately 43 times more, of the 4th filter (“Porhet”-cotton) 3367%-approximately 35 times more, of the 3rd filter (georgette) 3334%-approximately 37 times, of the 2nd filter (synthetic material) 2789%-approximately 29 times, of the 1st filter (cotton) 2116%-approximately 22 times more, of the 7th filter (used tea bags) 945%-approximately 10 times more and of the 6th filter (inedible biomass) 271%-approximately 4 times.

b) For a car that uses gasoline **when the gas pedal is pushed**:
   - Best absorbers of CO are the filters 1 (cotton), 3 (georgette) ,4 (“Porhet”-cotton) ,5 (cord) and 7 (used tea bags) with efficiency of 100%, there was not emission at all. The filter number 6 (inedible biomass) absorbed the amount of CO with efficiency of 75% and the filter number 2 (synthetic material) increased the amount of CO for 92%.
   - For CO2, the efficiency of the 1st filter (cotton) was even 43%, of the 7th filter (used tea bags) 26%, of the 3rd (georgette) and the 4th filter (“Porhet”-cotton) 25%, of the 5th filter (cord) 21%, of the 2nd filter (synthetic material) 6% and of the 6th filter (inedible biomass) 5%.
   - For HC, the efficiency of the 1st filter (cotton) was surprisingly 93%, of the 5th filter (cord) 87%, of the 6th (inedible biomass) and the 7th filter (used tea bags) 80%, of

the 4th filter ("Porhet"-cotton) 80%, of the 3rd filter (georgette) 70% and the 2nd filter (synthetic material) increased the amount of HC for 43%.

- For the amount of oxygen, I am going to show You the percentage of the increase in its amount. The efficiency of the 3rd filter (georgette) was surprisingly 3137%-approximately 32 times more, of the 1st filter (cotton) 3034%-approximately 31 times more, of the 4th filter ("Porhet"-cotton) 2278%-approximately 24 times, of the 5th filter (cord) 1073%-approximately 12 times, of the 7th filter (used tea bags) 890%-approximately 10 times more, of the 6th filter (inedible biomass) 222%-approximately 3 times more and of the 2nd filter (synthetic material) 195%-approximately 3 times.

c) For a car that uses LPG while it **is working constantly:**

- With the filters 1 (cotton) ,2 (synthetic material),3 (georgette) ,4("Porhet"-cotton) and 7 the amount of CO which was already low remained the same, with the filters 5 (cord) and 6(inedible biomass) it increased twice the amount it was before.
- For CO2 the efficiency of the 1st filter(cotton) was even 24%, of the 6th filter (inedible biomass) 21%, of the 7th filter(used tea bags) 17%, of the 5th filter (cord) 10%, of the 4th filter ("Porhet"-cotton) 8%, of the 3rd filter(georgette) 2% and with the 2nd filter (synthetic material) it remained the same.
- For HC the efficiency of the 7th filter (used tea bags)was surprisingly 81%, of the 6th filter(inedible biomass) 80%, of the 3rd filter (georgette) 77%, of the 1st filter (cotton) 69%, of the 5th filter (cord) 67%, of the 4th filter ("Porhet"-cotton) 62% and of the 2nd filter (synthetic material) 43%.
- For the amount of oxygen, I am going to show You the percentage of the increase in its amount. The efficiency of the 1st filter (cotton) was surprisingly 660%-approximately 8 times more, of the 6th filter (inedible biomass) 544%-approximately 6 times more, of the 7th filter (used tea bags)513%-approximately 6 times more, of the 5th filter (cord) 309%-approximately 4 times more, of the 4th filter ("Porhet"-cotton) 230%-approximately 3 times more, of the 3rd filter (georgette) 170%-approximately 3 times more and of the 2nd filter (synthetic material) 1%.

d) For a car that uses PG when the gas pedal is pushed:

- Best absorbers of CO is the filter number 4 ("Porhet"-cotton) with efficiency of 100%, there was not emission at all. The filters number 2 (synthetic material) , 5 (cord), 6 (inedible biomass) and 7(used tea bags) absorbed the amount of CO with efficiency of 98%, the filter number 1(cotton) absorbed the amount of CO with efficiency of 92% and the filter number 3(georgette) absorbed its amount with efficiency of 58%.
- For CO2, the efficiency of the 6th filter (inedible biomass) was even 16%, of the 7th filter (used tea bags)12%, of the 5th (cord) and the 3rd filter (georgette) 10%, of the 1st filter (cotton) 9%, of the 4th filter("Porhet"-cotton) 3% and the 2nd filter (synthetic material) increased its amount for 6%.

- For HC, the efficiency of the 7th filter(used tea bags) was surprisingly 98%, of the 6th (inedible biomass) , of the 3rd (georgette) and of the 1st filter (cotton) was

approximately 97%, of the 5th filter (cord) 96%, of the 4th filter ("Porhet"-cotton) 95% and of the 2nd filter (synthetic material) 93%.

- For the amount of oxygen, I am going to show You the percentage of the increase in its amount. The efficiency of the 6th filter (inedible biomass) was even 422% - approximately 5 times more, of the 4th filter ("Porhet"-cotton) 351%-approximately 5 times more, of the 7th filter (used tea bags)335%-approximately 4 times, of the 1st filter (cotton) 316%-approximately 4 times more, of the 5th filter (cord) 280%-approximately 4 times more, of the 3rd filter (georgette) 231%-approximately 3 times more and the 2nd filter(synthetic material) decreased the amount of oxygen for approximately 44%.

This project in details shows that waste clothes can be used to construct filters which will reduce the amount of toxic gases in the exhaust fumes from vehicles, as well as using peels mandarin and the inner part of a cabbage which can to be used and otherwise would end up in a landfill. The main purpose was to use the clothes waste in order not to be burnt and pollute the air and to reduce the exhaust fumes from cars (one of the biggest air pollutants) at the same time. That is the win-win solution we managed to achieve.

8. FUTURE IMPLEMENTATION

From the results we conducted, it is obvious that this project was successful. Therefore, I hope that engineers and scientists will consider this idea and will make filters that can be used every day as well as on professional level. Based on the car they design the filter for, the amount of each toxic gas the specific car releases and their goal, they can choose and mix among the materials that were proven to be the most successful. In this way, they will stop burning tons of clothes waste and in the same time will decrease the toxic gases that would be released in the atmosphere. If car companies consider this proposal and construct cars using these filters, air pollution will drastically decrease and millions of people will live longer and healthier.

9. CONCLUSION

The hypothesis of this scientific project was that "***If we use waste cotton and other waste clothes materials as well as tea bags and inedible biomass, we will be able to reduce the amount of CO, CO_2, HC and increase the amount of Oxygen in the exhaust fumes from cars."*** With a specific research for each of those materials on different types of cars we showed how to make filters using all stated materials, we shown how they decreased the amount of toxic gases and we gave ideas how to use them in our every-day lives.

Although different filters have different effect on specific gases, I do not recommend the 2nd filter because its results were not good enough for this very successful project.
For a car that uses gasoline, I strongly recommend the 3rd filter (georgette) as well as the 1st (cotton), 4th ("Prohet"-cotton), 5th (cord),6th (inedible biomass) and 7th (used tea bags) considering the fact that they all have showed amazing results in absorbing different types of gases.
For a car that uses LPG, I strongly recommend the 4th filter ("Prohet"- cotton) as well as the 1st (cotton),3rd (georgette) and the 7th (used tea bags) filter which showed great results.
This project solves two big and world -wide important problems with one efficient and in the same time cheap solution.

10. ACKNOWLEDGMENTS

I would like to express my thankfulness to the ones who helped me conduct my ideas and ambitions. Big "Thanks" to the chemistry teacher and in the same time Vice Principal in my school Ms Emel Sherif Miftar for supporting my ideas, believing in my abilities and her opinions that made me think more critically , my school for the great facilities that helped for conducting the project, to "AMCM"-Tetovo for helping me to get the final measurements and also to my family who helped me to find all the materials and contacted "AMCM"-Tetovo.

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