

The capital of Afghanistan and the smoke caused by coal in the winter season, the use of solar energy on a small scale to solve this big challenge

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Abstract

One of the most important problems in big cities is air pollution, which can be harmful to human health and the environment. Kabul, the capital of Afghanistan, is also one of the most polluted cities in Afghanistan and the world. Its geographical location, low wind speed, excessive use of coal in industrial factories and the of buildings and apartments, old and non-standard cars, dirt roads and alleys increase the amount of air pollution in this city. Carbon monoxide is one of the most important air pollutants. Therefore, this study was conducted with the aim of measuring CO concentration in the open air of Kabul city and comparing it with the air quality standard. In this descriptive-analytical study, the concentration of carbon monoxide during the four seasons of urban open air in 2018 was conducted. In order to check the changes of air pollutant (CO), the data available on the website of the National Environmental Protection Agency of Afghanistan was used. According to the results of the study, the concentration of carbon monoxide has reached its maximum during the second six months of 2018. There are different solutions to solve this challenge. Considering the increasing needs of the citizens of Kabul for thermal energy in the winter season to heat their houses and also to end the crisis caused by fossil fuels in the future of Kabul, the existence of solar energy and its use in small scales such as houses, apartments, etc, can be an effective step to reduce air pollution caused by coal smoke. Also, in this research, using reliable books and articles in order to use more solar energy for heating houses, apartments and providing hot water by solar water heaters and how they work in order to minimize the air pollution of Kabul city.

Keywords:Air pollution, Air quality, Carbon monoxide, Concentration,Solar energy, Solar water heaters,Solution

1. Introduction

Every year, with the arrival of winter, coal smoke darkens the sky of Kabul city. Due to the non-imposition of restrictions on the import of coal to Kabul city and its excessive use by the citizens of Kabul city, the amount of air pollution in this city is increasing. The lack of electricity, the high price of petroleum products and the low quality of petroleum products have added to this problem. Since most of the citizens of Kabul are economically at a low level and do not have access to other facilities, coal is the most available option for the people of Kabul to heat their houses. Therefore, with the increase of coldness, day by day the amount of air pollution increases by burning coal, all kinds of plastic, rubber, car tires, etc., whose smoke is completely toxic and causes various diseases in humans and eventually causes death. Meanwhile, children and adults are more at risk [1]. The air in the city of Kabul becomes very unhealthy in the nights of the winter season, and for this reason, Kabul was among the most polluted cities in the world in 2018 [2]. According to the statistics announced by the Ministry of Public Health, in 2020, about 5000 people died due to air pollution [3]. According to the statistics of the Ministry of Public Health, 10% of those who died as a result of diseases related to air pollution were in Kabul. Many factors play a role in polluting the air, in this article, carbon monoxide, which plays the biggest role in polluting the air, is examined.

In order to reduce air pollution in Kabul city, in heating houses, offices, etc., energy that pollutes the air should not be used and new energy should be used instead. New energy or alternative energy are those types of energy that are used for their production from carbon-free sources; Such as solar energy, wind energy, etc. In addition to the fact that this type of energy does not cause air pollution, their production is inexhaustible and unlimited. Therefore, it is necessary to use clean energy in small scales such as residential houses in order to achieve pollution-free air. Air pollution in Kabul city has many factors. The key factors of air pollution in Kabul city can be attributed to population density, Non-standard cars, dirt roads and alleys and most importantly, residential houses, heating centers of apartments, industrial plants, factories and clay kilns are activities that always use coal. Poverty is the most important reason for air pollution in Kabul city. Poverty makes people unable to use new and renewable energies or clean energy such as liquid gas, and this makes them look for fossil fuels such as coal, whose smoke is an important cause of air pollution in Kabul city.

2. The importance and necessity of conducting research

Just as humans need water, air, food, housing and other basic necessities of life for their survival, it is also necessary to use different sources of natural energy to produce energy for their consumption. Considering the limited reserves of fossil energy that pollutes the air and the increase in the level of energy consumption in the current world, it is no longer possible to rely on the existing energy reserves. In the last few decades, examples of solar houses have been built

in industrialized and advanced countries, which use natural energy (solar, wind, etc.) to heat and cool buildings. Of course, the use of this technology on a large scale has rarely happened. Private homes are one of the major energy-consuming sectors, and for this reason, it is necessary to pay special attention to the optimization of thermal energy production in apartments and houses. In our dear country of Afghanistan, due to the increasing needs for electrical energy sources and the amount of electricity imported from neighboring countries, the necessity of keeping the environment healthy, reducing air pollution, limiting the supply of electricity to remote villages, using energy- New technologies such as solar energy, wind energy, etc. have a special place. Therefore, it is necessary and to use new energy sources instead of electricity imported from neighboring countries and not to use air polluting sources for the citizens of Kabul to heat their homes.

Solar energy is a cheap, abundant energy that has been used by mankind for many years; But after obtaining fossil fuel resources, it abandoned past experiences and increased the use of these resources day by day, So that after such unbridled consumption and waste of these resources, a dark future is ahead in which fossil fuel resources are running out. This perspective has caused the possibility of using solar energy and its application in heating and cooling residential houses to be considered once again in all corners of the world. Now, considering the increasing trend of residential complexes in the country, especially in big cities like Kabul, if solar energy is not used and coal smoke increases in winters, the health problems and even the lives of Kabul citizens will be threatened.

3. Air pollution

The presence of any foreign substances other than the composition of air are called pollutants and when the amount of these pollutants exceeds the permissible limit and the presence of that opinion at the time causes disturbance in the normal life process of humans, animals and plants or harms human objects and belongings, then it is said that the air is polluted. On the other hand, air is one of the basic elements of human life and all living beings and in case of breathing polluted air, people will face various diseases. Its effects are different in people of different ages, and in the meantime, children, elderly people, pregnant women and heart patients are more at risk of air pollution [8].

In general, there are two main sources of air pollution; Natural and artificial resources. When pollutants enter the earth's air system without human intervention - as an obvious factor that changes air quality - they are called natural pollutants. This section includes volcanic gases, methane, carbon monoxide, carbon dioxide. These pollutants have a short period and are part of the nature period. Kabul is not very active from the point of view of geological activities and there are no signs of volcanic activity. Therefore, the air of this city is very little polluted from this source. But besides natural sources of air pollution, pollutants may also originate from artificial sources. Artificial sources of air pollution are those that humans directly contribute to their production. These sources in Kabul city are divided into different sections considering the stationary or moving state, which are listed below.

4. Air pollutants

Different pollutants (hydrocarbons, nitrogen oxides, sulfur dioxide, carbon monoxide, lead, mercury, particulate matter, ozone, radioactive substances, dioxides) can exist in the air [3]. In this research, the harmfulness of air pollutant caused by coal smoke is discussed.

4.1. carbon monoxide

Usually, as a result of good combustion of carbonaceous materials, such as wood, non-hazardous carbon dioxide (CO_2) gas is released. But if complete combustion is not done and oxygen is low, poisonous gas carbon monoxide (CO) is formed. In terms of physical properties, carbon monoxide is an odorless, colorless, tasteless gas that is slightly lighter than air [6]. The natural concentration of this gas in the air is around 0.2ppm (Part Per Million), which is not harmful to humans [4&9]. If the concentration of this gas exceeds 0.2ppm, it becomes toxic and harms the health of humans, animals and plants. This gas is produced in small amounts mainly as a result of the combustion of chemical substances, such as the natural metabolism of animals, and it is believed that it plays a role in some biological activities. Natural sources of this gas include volcanoes and fires. Other main sources of this gas are engine exhaust of cars and some industrial activities such as steel making, brick kilns, etc. Tobacco smoke is one of the main domestic sources of carbon monoxide [4&9]. This gas is considered as one of the most widespread air pollutants and it is produced due to reasons such as the lack of sufficient oxygen in the environment, low temperature, the length of time the mixed gas remains in the air and the burned materials at high temperature, and the insufficiency in the combustion environment. This gas in homes usually endangers human lives due to improper use of incomplete and non-standard heaters or their incorrect use. Carbon monoxide is slightly lighter than normal air. For this reason, this gas, in any combustion, goes out of the building with the flow of smoke through the heater pipe and chimney. But the air in the room becomes dangerous when the heater chimney is damaged or not working properly. For example, a bird has built a nest in it or is stuck in it or is blocked by tree leaves, snow or something else. Improper use of the ventilation device can also cause the carbon monoxide gas produced in the heater to be absorbed into the room instead of going outside.

Since carbon monoxide gas is an odorless, colorless and tasteless gas, the existence of this gas cannot be felt in a closed room. When this gas enters the human respiratory system, it immediately enters the hemoglobin of the blood, which is responsible for transporting oxygen to the body tissues. Hemoglobin is a protein present in red blood cells and its role is to transport oxygen in the blood. Carbon monoxide gas causes the transfer of oxygen in the blood to be interrupted. This reaction causes a person to become unconscious in a very short time. Most of the people who are poisoned by this gas do not realize it in time. They first feel very tired and sleepy, then they lose consciousness and suffocate. One of the first effects of this dangerous gas is a burning sensation in the eyes. If the poisoned person tries to stand up, she will feel dizzy and nauseous and her eyes will turn black. Of course, the speed of this process depends on the concentration of this gas inside the room.

5. Air quality index and comparing the air quality of Kabul city with it

Based on this index, air quality is divided into six different categories, each category indicating the impact of air pollution on human health. The air quality is said to be good when the air quality index changes in the interval of 0-50. In this case, the air quality is satisfactory and the air is safe or low risk from the point of view of pollution. The quality of air is average, if its quality index is around 51-100. The air quality in this state is acceptable, while some pollutants may cause diseases in some people. Air is considered unhealthy when its quality index is between 101 and 150. The air is said to be unhealthy in terms of quality, if AQI changes between 151 and 200. People who are sensitive to pollution are more exposed to the dangers of unhealthy air than others. Air is considered very unhealthy when the AQI ranges between 201 and 300.

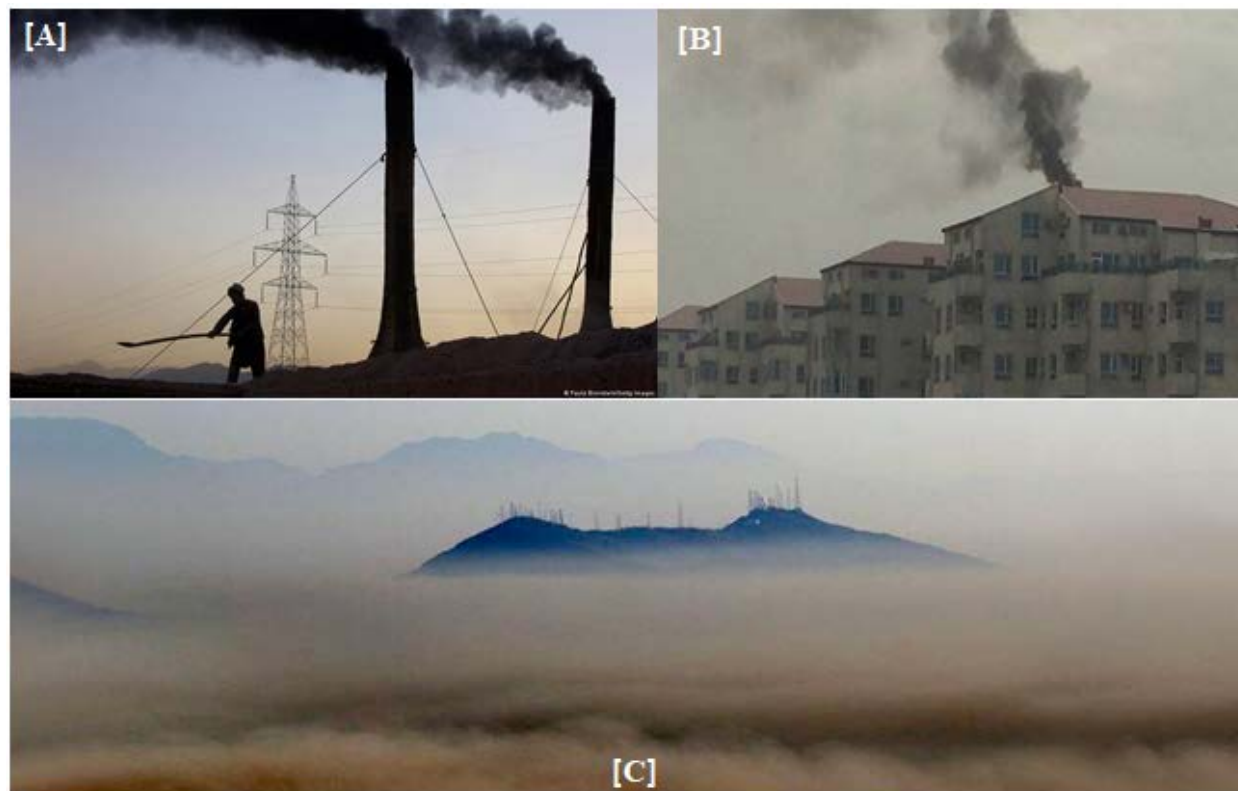
If the AQI of the air is more than 300, it indicates the danger of the air and gives a serious warning to humans. In this situation, most governments declare a state of emergency because in this situation, all members of the society are affected by air pollution. The concentration of carbon monoxide inside buildings usually does not exceed 30 ppm under conditions with natural ventilation and adequate air evacuation rates [7].

Air Quality Index		
AQI Category and Color	Index Value	Description of Air Quality
Good Green	0 to 50	Air quality is satisfactory, and air pollution poses little or no risk.
Moderate Yellow	51 to 100	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups Orange	101 to 150	Members of sensitive groups may experience health effects. The general public is less likely to be affected.
Unhealthy Red	151 to 200	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy Purple	201 to 300	Health alert: The risk of health effects is increased for everyone.
Hazardous Maroon	301 and higher	Health warning of emergency conditions: everyone is more likely to be affected.

Table1. The Air Quality Index includes AQI categories and colors, corresponding index values and cautionary statements for different levels of health concern [13].

There are no accurate statistics of the population of Kabul city. Various sources have estimated the population of Kabul between four and five million [5]. In this study, if the population of Kabul city is considered to be approximately 5 million and the average number of members per family is 5 people, then one million residential houses are necessary for the population of 5 million in Kabul city. As it is known, in the winter season, the people of Kabul city use coal to

heat their homes. Whenever the diameter of each of the heating pipes of residential houses in Kabul city, which emits smoke in the winter season, is 0.1 meters or 10 centimeters; In general, smoke is exported to Kabul city from a 100 meter diameter pipe during the winter season.

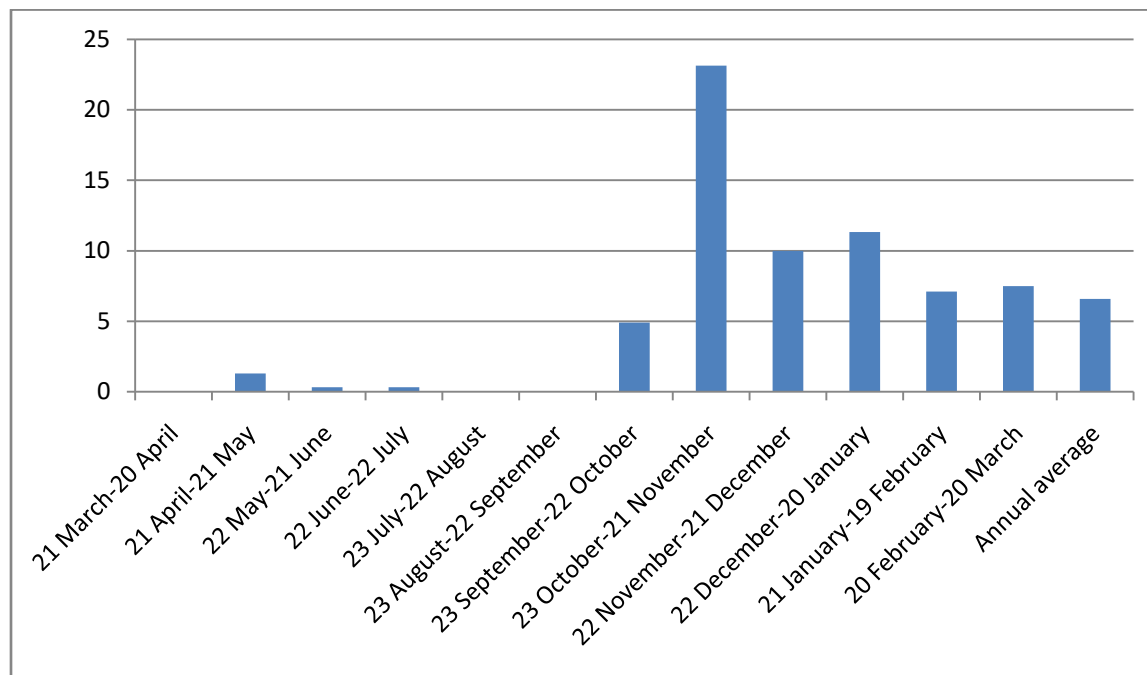


A: Rising smoke caused by coal from a brick kiln in Kabul [10]. **B:** Rising smoke caused by coal from the heating activity of an apartment in Kabul [11]. **C:** A view of Kabul city [12].

Table2. The average volume of carbon monoxide particles (mg/m^3) during the twelve months of 2018 [6].

سنبله (23 August-22 September)	اسد (23 July-22 August)	سرطان (22 June-22 July)	جوزا (22 May-21 June)	ثور (21 April-21 May)	حمل (21 March- 20 April) mg/m^3
		0.31	0.31	1.3	0
حوت (20 February- 20 March)	دلو (21 January-19 February) mg/m^3	جدي (22 December- 20 January) mg/m^3	قوس (22 November-21 December)	عقرب (23 October- 21 November)	ميزان (23 September- 22 October)
7.49	7.113	11.34	9.981	23.129	4.9
Annual average: 6.5873					
Afghanistan's national air quality standard: $30mg/m^3$ per hour					

These figures were obtained intermittently by mobile air quality stabilization devices in different parts of Kabul city in 2018.



The average volume of carbon monoxide during the year 2018 [6].

6. Analyze

Keeping in mind the figures presented in the above table which show the amount of air pollution in Kabul city, it can be seen that the amount of air pollution (carbon monoxide particles) from the month of Scorpio 2018 onwards compared to the figures of the national air quality standard at different times was mostly higher than the standard [6].

It should be noted that the mentioned figures do not indicate the exact situation of air quality in Kabul city, because the existing system and equipment have only obtained the presented figures in a temporary and cross-sectional form from different parts of Kabul city. In order to have accurate figures in accordance with national and international standards about air quality every 24 hours regularly, there is a need to install fixed devices (stations) in different parts of the city and provide regular figures in seconds during 24 hours. It is worth mentioning that, as can be seen, in the last two months, the amount of air pollution has decreased significantly compared to other months according to the national standard of air quality. This decrease in air pollution was due to rains.

7. Environmental actions of two big cities in the world

7.1. London

In the 19th and 20th century, when coal fuel was used to heat homes and continue industrial activities, the sky of the English capital was often covered with thick smoke and dust. One of the worst weather conditions in this city dates back to 1952. As the weather got colder, people had to use coal, which was often of poor quality. In 1952, thick smoke and dust severely reduced horizontal visibility and resulted in the deaths of more than 10,000 people in four days. In 1956, the Clean Air Act was passed in England. In 1956, the law on smoke caused by domestic and

industrial activities was considered and applied in cities and villages (smoke control areas), where only the use of smokeless fuels was required. Also, families were given a subsidy to use clean fuels. This law was extended in 1968 and in the following decades air quality in London improved [8].

7.2. Beijing

Rapid growth, industrialization in China has been accompanied by a sharp increase in air pollution in this country. Coal-fired power plants, along with an increase in the number of automobiles in the 1980s, had polluted Beijing's air with dangerous chemical compounds. In 2014, the Shanghai Academy of Social Sciences reported in a report that the city is almost uninhabitable due to air pollution. The 2020 report of the United Nations shows that in the four-year period from 2013 to 2017, the level of fine particles in Beijing's air decreased by 35%, while the level of this pollutant in nearby areas decreased by about 25%. This reduction was the result of measures that began over two decades in 1998. Since then, the Chinese government has imposed stricter emission standards and established advanced air quality control systems. At present, the problem of air pollution in Beijing has not been completely solved. This city is involved in the phenomenon of emission of polluting particles, which are mostly known as suspended particles less than 2.5 microns. Also, in a number of Chinese cities, the amount of pollutants exceeds international standards [8].

8. Proposed solutions to solve this great challenge

There are different solutions to solve this challenge; But in general, these solutions can be divided into two parts. On a large level and on a small level.

8.1. Solution on a large scale

The solution on a large scale requires more money from an economic point of view and is beyond the capacity of a village, a district and even a province. If we want to solve this challenge on a large scale, we will refer to the article published in September 2023 under the title The amount of solar energy radiation in Afghanistan and the methods of using modern technologies in electricity production for large-scale exploitation which has been published in one of the prestigious journals of India, should be implemented.

8.2. Solution on a small scale

8.2.1. Application of solar energy in small scales

The purpose of using solar energy in small scales is to use the sun's energy as best as possible to meet heating and cooling needs and also to provide electricity to houses and residential buildings if needed. Key points that is effective in the formation and implementation of solar energy technologies in the first stage, the economy of the residents of Kabul city is discussed. In the second stage, by applying the design of solar buildings to meet the heating and cooling needs of buildings and reduce air pollution, a law should be enacted, which has not been done in the past

20 years. In this design, issues such as: direction of buildings, thermal insulation, determining the level of windows, double-layering of windows and other matters should be considered by building experts. The use of solar energy in small scales can be done in different ways.

8.2.2. Solar water heater

In active solar systems, domestic hot water is provided by solar water heaters. Solar water heaters are the most basic technology used in non-solar power plant applications. As its name suggests, it is used to heat water. The produced hot water can be used in the kitchen, bathroom, washroom, building space heating, etc. Solar water heaters can be divided into 4 general categories based on performance. Thermosyphon solar water heater, pump solar water heater, gravity solar water heater and closed loop system in solar water heater.

8.2.3. How the solar water heater works

Water heaters usually consist of three main parts: collector (absorber), piping circuit and thermal tank. The design of collectors in the form of a flat and cylindrical plate is more common. In most of today's water heaters, water and antifreeze solution are used and it flows in a closed circuit between the tank and the collector through the piped circuit. The collector absorbs the sun's thermal energy and transfers it to the water and antifreeze solution. This solution is heated moves to the water storage source, where after passing through a heat exchanger, it transfers its heat to the water inside the tank and after cooling, it returns to the collector, thus it is constantly moving in a closed circuit without mixing with the water used.

Solar water heaters are divided into open circuit and closed circuit water heaters, each of which can work in two ways: thermosiphon (natural flow) and pump (forced). In open circuit systems, the water that is used to supply hot water is pumped directly from the storage tank of the collectors. We have two types of open circuit: a: forced circulation (pump) b: thermosiphon (natural)

When the temperature of the water and antifreeze solution inside the collectors is higher than the temperature of the storage tank, the heated water is directed to the storage tank. The bottom drain system includes a valve that drains the water inside the collectors when it reaches 38 degrees Celsius. When the temperature is below 38 degrees Celsius, the system automatically pumps water from the storage tank to the collectors. The closed circuit system is very efficient and reliable and requires less maintenance. For example, the antifreeze used in the system needs to be inspected every 2 years. In this system, due to the use of antifreeze liquid, there is no possibility of rapid cooling and freezing, and it is very reliable and can be used in a wide range. Of course, in this system, the collectors must be installed above the heat transfer tank. In open systems, the power of the pump is equal to the sum of the friction inside the pipes and the height difference between the collector and the storage tank. If in closed systems, the power of the pump is only equal to the sum of the internal friction of the pipes. The use of solar water heaters is suitable for areas with high radiation and far from the national network.



Pictures of flat plate solar water heater and parabolic cylindrical solar water heater

9. Conclusion

In this research, the amount, factors and solutions to reduce air pollution caused by coal smoke in the air of Kabul city in 2018 were investigated. The results of the study show that the temporal changes of air pollutants in Kabul city are sequences of low concentration in the seasons (spring and summer) and high concentration in the seasons (autumn and winter). Air pollution in Kabul is one of the biggest environmental challenges facing the people of Kabul city. The amount of air pollution multiplies with the arrival of autumn and winter. This significant increase is related to the continuous lack of electricity and people's widespread use of coal and various materials such as plastic, car tires, paper, etc., in order to heat houses and apartments. The use of coal in a non-standard way and without purification is related to the economic weakness of the people of Kabul city. According to the results obtained from this research, the air quality of Kabul city is not acceptable in terms of carbon monoxide index and the level of pollution is increasing in autumn and winter. According to the obtained statistics, we conclude that the use of renewable energy, the construction of secondary roads and their concreting, public awareness of the dangers of an unhealthy environment, controlling the activity of old means of transportation, establishing urban discipline for means of transportation, Monitoring the oil import market in the country, preventing the import of low-quality oil, making liquid gas cheaper, and controlling fossil resources such as coal, gas, and gasoline play an effective role in reducing air pollution.

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