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Study and Investigation of Natural Gas as Fuel for Vehicles and their Environmental Impacts

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ABSTRACT

This research is dedicated for studying and investigation of how to use natural LPG and CNG gases and its superiority over other fuels such as petroleum, diesel and coal in vehicles, cooking and its environmental impacts. Currently, more than 80% of air and environmental pollution in Kabul and other major cities of the country are due to cars fume and the use of low-quality diesel and petroleum fuels. Liquefied petroleum gas (LPG) consists of heavy gas hydrocarbons such as propane and butane, which are liquefied under pressure. If we use liquefied natural gas (LPG) and compressed gas (CNG) are used in vehicles, it will not pollute the environment. On the other hand, it saves a lot of economic costs. This scientific-research is considering the causes of air and environmental pollution from vehicles fume by low quality diesel and petroleum fuels in Kabul and other big cities of the country. Specific suggestions have been made for replacing petroleum and diesel engines with dual fuel oil and gas engines. Also, as a result of this scientific-research, the economic comparison of gas and liquid fuels in internal combustion engines has been evaluated. In addition, the environmental impact and economic benefits of gas related liquid hydrocarbons have been studied based on the field data, laboratory research, and library scientific references.

1. Introduction

Natural gas: Methane gas results from native rocks of the earth crust by the deformation of animal and plant organs under the influence of heat and pressure. Due to the change in collector properties, the inlet pressure of groundwater, it migrates from a permeable formation to reservoirs rocks which are safe from tectonic activities, severe groundwater intrusion, metamorphism and magmatism operations. Large and small oil and gas mines are formed under the less permeable rocks. Natural gas has a combination of methane, ethane, propane and butane. Table (1) shows the chemical composition of these gases and its weight percentage.[3]

Table (1) Chemical composition and weight percentage of natural gas

The chemical formula of natural gases		Percent weigh
Methane	CH_4	88
Ethane	C_2H_6	5
Propane	C_3H_8	2
Butane	C_4H_{10}	1

In this research, an attempt is made to study the superiority of natural liquefied gas (LPG) and compressed natural gas (CNG) as fuels in vehicles, and its environmental impacts have been evaluated.

Research goal: the purpose of this scientific-research work is to study and investigate the use of natural gases in internal combustion engines and vehicles and to evaluate their environmental impacts. In addition, the effects of air, water and soil pollutants by low quality fuels (petrol and diesel) in cities and industrial centers of the country have been evaluated and useful suggestions have been provided to reduce environmental pollution in industrial, manufacturing and transportation centers of major cities.

2. Research Methods

Research method of this scientific-research work consists of collecting field data, analyzing and its evaluating under theoretical foundations and valid library references, which includes the following steps.

- Taking air samples from Kabul and evaluating the presence of carbon dioxide, carbon monoxide, lead and other materials that enter the air from low quality fuel materials
- Frequent visits from gas stations in Kabul
- Comparison of diesel and petroleum pollution with hydrocarbon gases
- Providing clear suggestions about the effectiveness of using natural gases instead of low quality liquid fuels under valid scientific sources.

3. Subject background

Dual fuel vehicles have been used for many years in the region and developed countries of the world and good results have been obtained from it. The main environment pollutants in the world is the use of low-quality fuels in vehicles, so the most populous countries and regions have to pay attention to alternative ways. The economic advantage of using natural gas in vehicles is that natural gas prices are likely to remain stable for the next 200 years. As the second-largest producer of natural gas in the world, Iran has started using LPG for the first

time in 1984, and after more research in this regard, finally, in 1990, the first car started service with dual use of LPG and oil. In 1994, the use of LPG and CNG gas was studied. In 2008, this gas was practically used in vehicles in which 80% of CNG and 20% of diesel gas were burned, and after a while, this figure reached to 91% gas and 9% diesel. For the first time in Afghanistan the LPG was used in vehicles in 1994 by a workshop called Humble Gas in Kabul. Currently, there are 10 gas distribution agencies and hundreds of workshops for converting oil to gas engines in Kabul city and other provinces. The Ministry of Mines and Petroleum of the Islamic Republic of Afghanistan established the first compressed natural gas system in May 2012 in Jawzjan province, which is a major achievement in the use of domestic gas in transportation.[4]

Study and investigation of natural gas as a fuel for vehicles and their environmental impact: The air and environment in the world and our dear country is hardly polluted by smoke of vehicles with low-quality diesel and petroleum fuels.If LPG and CNG are used in vehicles, environments will pollute less and its price is also cheaper than petroleum and diesel.

Hydrocarbons are in the following states in reservoir and surface conditions:

1) Oil with non-associated gas
2) Dissolved gas: It is a gas that is dissolved in the oil in the reservoir conditions, but after extraction from the it, it separates from oil and form a gas phase due to the reduction of pressure and temperature.
3) Associated gas: Natural gas that is in the form of a gas cap above the crude oil in the reservoir.
4) Condensate gas: It is hydrocarbons that have a gaseous state in the reservoir conditions and with the reduction of pressure and temperature; it forms a liquid phase in the wellhead and mainly has a pentanes composition.
5) Free gas: Hydrocarbon gas is a gas that remains in the form of a gas phase in the reservoir and on the surface and is mostly composed of methane (CH4).[1]

Transportation and efficient use of natural gas:

1) Compressed Natural gas CNG:This gas is transported by gas pipelines, mostly methane gas.
2) Liquated petroleum gas LPG: It is a heavy gaseous hydrocarbon such as propane and butane that take on a liquid state under pressure.[7]

Compressed Natural gas:

This gas is mostly composed of methane (CH4) and has low amounts of ethane (C2H6), propane (C3H8), butane (C4H10), and pentane (C5H12). The smoke coming out of the cylinder of gas-fired vehicles consists of water vapor and carbon dioxide (CO2). The effects of environmental pollution by the above-mentioned flue gases are less; therefore, CNG is used more in Iran and Pakistan.

The first CNG gas station in Afghanistan was inaugurated by a Singaporean company in 2012 with a grant of $ 3 million from the United States government with a processing capacity of 18,000 M^3 of gas per day. This gas is mostly composed of methane (CH4) and has low amounts of ethane (C2H6), propane (C3H8), butane (C4H10), and pentane (C5H12). The CNG gas station covers only the city of Sheberghan. The establishment of this station in the city of Sheberghan represents a new industry in the supply of cheap fuel materials in order to grow the country's economy and people. This industry can be effective in creating jobs, preventing environmental pollution, and strengthening infrastructure. (5)

The National Bureau of Standards also states that CNG can be a good, cheap, and clean alternative to low-quality imported petroleum products, which have returned 1.5 million liters of low-quality fuel in the last six months alone. More than this amount, low-quality oil may have been smuggled into the country. The presidency of Petroleum and Liquefied Gas of the Ministry of Commerce states that Afghanistan receives 30 million metric tons of petroleum products annually.

According to the officials of the National Standards Office, the oil is mainly imported from Turkmenistan, Iran, Syria, and Iraq. This fuel is not checked properly due to the lack of advanced equipment to determine the quality of fuel and the existence of corruption in the country's customs.[4]

Table (2) Fuel materials are sold in Afghan markets at the following prices.

Fuel prices in Afghanistan			
Price per liter of fuel	Date	AFN	USD
Petrol	2020-4-20	35	0.46
Diesel	2020-4-20	38	0.5
LPG liquefied natural gas (Kg)	2020-4-20	19	0.25

These are the Retail prices of the mentioned materials, which include all taxes and expenses.

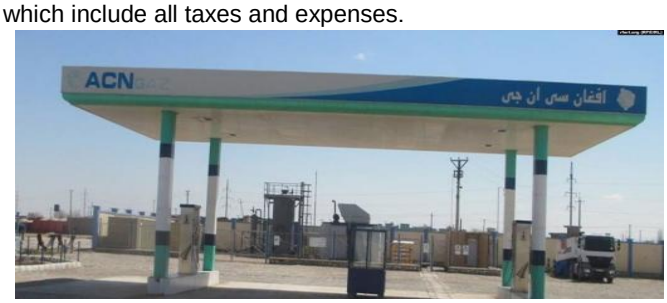


Fig.1 Gas distribution station for vehicles in Sheberghan provided by the Afghanistan Ministry of Mines and Industry

Liquefied petroleum gas (LPG): This gas is one of the side-product of oil, which includes propane, butane in different proportions, although most LPG is composed of propane and butane in approximately equal proportions.Sometimes 30% of propane gas is 70% of butane gas, but the difference is in summer and winter, which is sometimes the opposite.

Use of LPG gas in vehicles: This gas has a key role in reducing air pollution and the environment. LPG tanks with capacities of 30, 33, 40, 45, 60, 66, 80 and 116 liters, of which 60 liters are the most used.

And has a net weight of 26 kg. A gas tank does not explode due to a collision, because it has gas fuses such as boiler fuses. Liquefied gas tanks are made of two very strong floors.

Therefore, natural gas is the best alternative to low- quality liquid fuels in vehicles and pollutes the environment less.[6]

Figure (2). Gas tanks for vehicles [6,3]

Diseases caused by air pollution

Air pollution is one of the most important issues and problems facing the world today.Diseases caused by air pollution include shortness of breath, various respiratory allergies, lung cancer, cardiovascular disease, a threat to pregnant women and infants

4. To fight air pollution, we must observe the following points.

- Wear a filter mask when leaving the house
- Staying home on days when the air is polluted.
- Purchase and install air purifiers to clean indoor or office air [8]

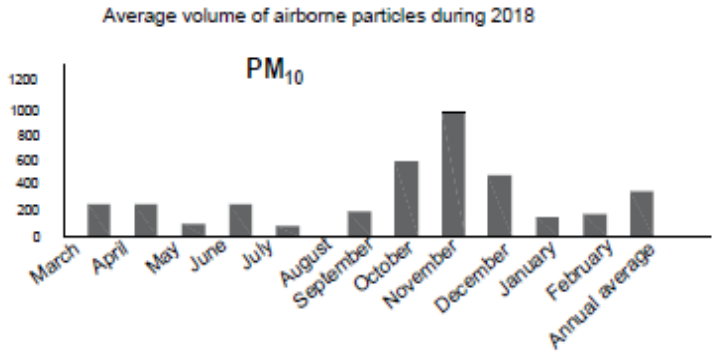
The composition of polluted air

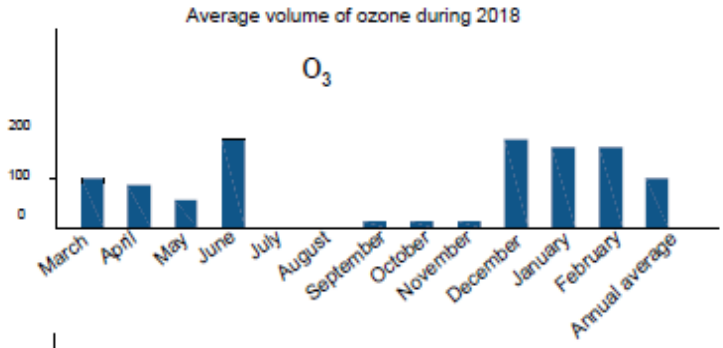
The main causes of air pollution are small particles that are less than 2.5 micrometers or microns in size.Particles 2.5 microns or less (100 times smaller than the diameter of a human hair) are so small that they can penetrate even the smallest airways in the lungs.These suspended particles are lifted into the air from fuel oil, gas, coal, forest fires, and their amount in air is measured in micrograms per cubic meter of air in 24 hours.Suspended particles of 2.5 to 10 microns that are released into the air from the smoke and dust of factories, agricultural activities, un-asphalted roads, plant pollen, and other similar activities are also harmful to the health of living beings.

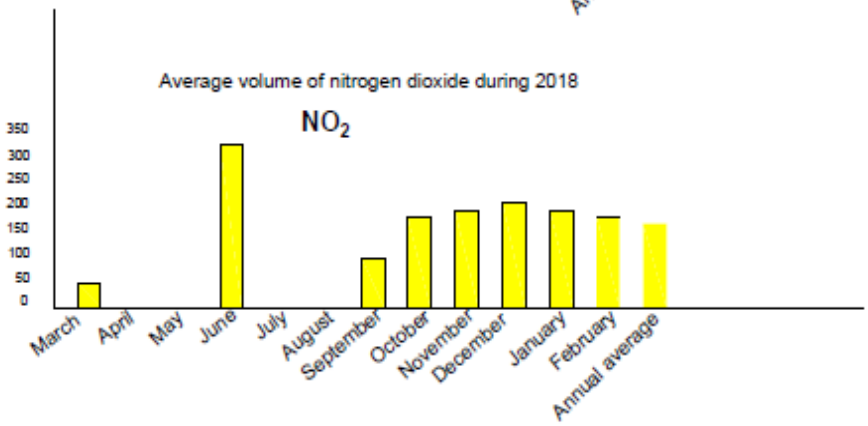
Table (3) Stabilization of air quality in different parts of Kabul city in 2018

These figures were obtained intermittently in 2018 by mobile air quality stabilization devices in different parts of Kabul city.															
NO	Average figures of airborne particles in 2018	March	April	May	June	July	August	September	October	November	December	January	February	average	Afghanistan National Air Quality Standard
		µg/m³	µg/m³	mg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	annual	
1	Average volume of suspended particles 10 microns in diameter (PM10 µg / m³) in one month	259.2	267.3	129.26	254.3	68.88		208.383	620.7	1002	511.44	163.08	177.12	332.87	150 µg / m³ PM 10 (in 24 hours)
2	Average volume of suspended particles 2.5 microns in diameter (PM 2.5 µg / m³) in one month	191.93	255.2	180.36	179.2	73.55		198.974	282.04	361.77	194.19	88.198	65.21	195.04	75 µg / m³ PM 2.5 (in 24 hours)
3	Average volume of carbon monoxide (mg / m³ CO) in one month		1.3	0.31	0.31			4.9	23.129	9.981	11.34	7.113	7.49	6.5873	CO mg / m³ 30 (per hour)
4	Average volume of nitrogen	61.37			320.7			98.46	185.067	193.61	212.063	193.99	185.44	181.333	NO2 µg / m³ 80 (in 24 hours)

	dioxide (µg / m³ NO2) in one month														
5	Average volume of sulfur oxide (µg / m³ SO2) in one month	242.67	564.3	44.57				82.586	88.974	102.27	168.6	106.091	86.11	165.131	SO2 50 µg / m³(in 24 hours)
6	Average volume of ozone (µg / m³ O3) in one month	103.84	84.97	57.93	156.9			8.622	3.341	5.69	153.2	131.35	132.35	83.8153	O3 100 µg / m³ (in 8 hours)
7	Average volume of carbon dioxide (µg / m³ CO2) in one month	2.3	3.31	3.31				4.9	5.9	6.9	8.9	91.129	100.129	88.1312	CO2 50 µg / m³(in 24 hours)







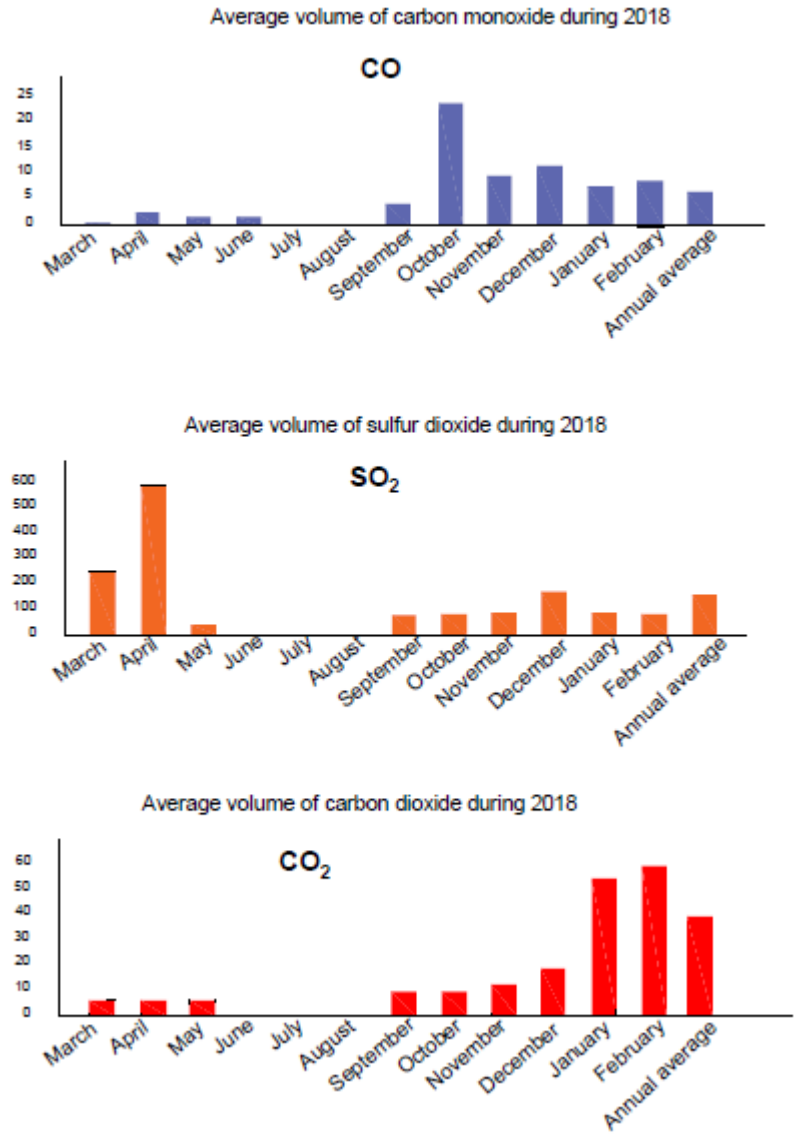


Fig.3. Average figures of airborne particles 2018 provided by the Afghanistan National Environmental Protection Agency [9]

Table (4)**Air quality index based on PM 2.5 and their level of concern**

Air quality index level of concern	Level	Meaning
Good	0 to 50	Air quality is satisfactory and air pollution is safe or low risk.
Medium	51 to 100	Air quality is acceptable although some pollutants may be associated with special health considerations for a very small number of people who are sensitive to air pollution.
Unhealthy for sensitive groups	101 to 150	Some people in sensitive groups may experience certain health effects. When air pollution is at this level, the general public is not affected.
Unhealthy	151 to 200	Anyone can experience high health effects. Members of sensitive groups experience more serious health effects than others.
Very Unhealthy	201 to 300	It is a serious warning for human health and declaring a state of emergency. The situation is likely to affect everyone in the community.
Dangerous	301 to 500	It is a health warning, which means that anyone can experience more serious effects on their health.

An air quality monitor installed at the US Embassy in Kabul,Measures the number of airborne particles in the embassy. These particles are usually 2.5 microns in diameter and smaller, and the information collected from this monitor, which is a relatively small area (US Embassy), may differ from the information of other monitors installed in Kabul.

Stabilization of air quality in different parts of Kabul city intermittently in 2020

Table (5)**These figures are obtained by the Air force monitor at the US Embassy from various points in the city of Kabul as an interval of 2020**

No	Average figures of airborne particles in the last four months of 2019-2020	April	March	February	January	Afghanistan National air quality standard
		µg/m³	µg/m³	µg/m³	µg/m³	
1	Average volume of suspended particles to 2.5 micron diameter (PM 2.5 µg/m³) during a month.	66.15	60.36	45.19	40.93	75 µg/m³ PM 2.5 (to 24 hours)
2	Average volume of suspended particles to 10 micron diameter (PM 10 µg/m³) during a month	70.27	65.26	54.29	50.2	150 µg/m³ PM 10 (to 24 hours)
3	The average volume of ozone (µg/m³ O3) during a month	46.86	42.93	35.97	30.84	100 µg/m³ O3 (to 8 hours)

5. Analyze

From the figures in the table above, it can be seen that the amount of air pollution in Kabul city from September 2018 onwards has been higher than the national standard quality figures. The number of suspended particles (PM2.5, PM10) according to the standard within 24 hours should be 150 and 75 micrograms per cubic meter of air, respectively, But field figures show the amount of this gas in the air of Kabul city at different times and areas is much higher These figures for sulfur dioxide clearly show that the use of coal in high-rise buildings, bathrooms, and residential homes has increased. And its particles are suspended in the ambient air due to the natural practice of Thermal Inversion and are easily breathed by humans. It should be noted that these figures do not indicate the exact situation of air quality in Kabul, because the existing system and equipment of the figures provided only *temporary* and *Cross*-sectionally taken from limited points. In order to have accurate figures in accordance with national and international standards on air quality on a regular basis every 24 hours, it is necessary to install stationary devices (stations) in different parts of the city and to have regular figures within 24 hours to present. It should be noted that in the last four months of 2020, the amount of air pollution compared to other months of the year according to the national air quality standard has decreased significantly.

Comparison of CNG, LPG with petroleum products

1) CNG burns better than petroleum products and has less harmful gases.
2) Propane and butane (LPG) fuels are less polluting than petroleum products and are easy to transport and can be stored in tanks.
3) Advantages of CNG, LPG natural gas fuel in vehicles
4) Natural gas is much cheaper than petrol and diesel fuels.
5) Pollutes the environment less than petrol and diesel fuels
6) Gas vehicles turn on easily in cold weather
7) Natural gas is safer because, unlike gasoline, natural gas is released into the air during accidents, but gasoline poses a fire hazard on the ground.
8) The life of gas-burning vehicles is long and less need to be repaired. Replacing spark plugs in gasoline vehicles lasts up to 32,000 km and in gas-burning vehicles up to 120,000 km. Natural gas has fewer greenhouse gases (sulfur, nitrogen, and carbon dioxide) than oil and coal, so natural gas is the cleanest
9) Natural gas does not produce a strong odor, which is quite common in petrol or diesel generators.

6. Comparison in terms of environment and economy

In recent years, global demand is increased for using clean energy (with less carbon content) that pollutes the environment less. During this period, the energy required by humans has changed from wood to coal, then to oil, and now to natural gas, solar, wind and geothermal, and in this regard, the share of natural gas as fuel is increasing. Natural gas is a relatively clean, abundant, and cheap source of energy that is now widely used for vehicle, industrial and domestic use and will expand over the coming decades. Natural gas per unit of energy produces 24% less polluting gases than oil and 42% less than coal. In terms of natural gas composition, it is much cleaner than liquid combustible materials (petroleum, diesel), and the amount of pollutants emitted by gas-fired cylinder engines is much healthier than liquid fuel materials. Usage of natural gas is very useful than which kill many people in big cities due to its pollution. In Belgium, for example, in 1930, 40 people lost their lives in one day and 4,000 in one year due to the accumulation of greenhouse gas emissions from factories.

And these factors led the world to pay attention to environmental protection, reducing air pollution Set special rules and regulations for vehicles. This year, according to the United Nations, about 8% less carbon dioxide will release into space due to reduced fuel consumption of the Coronavirus (COVID-19).But this is not enough. In the future, more investment should be made in energy that pollutes the environment less, such as natural gas, solar, and geothermal energy to make the environment less polluted. USGS estimates gas fields in northern Afghanistan at 400 billion cubic meters based on aerial geophysical research. Comparison of natural gas and fuel prices (petroleum, diesel) in world markets shows that the price of a liter of gasoline is 47 cents and the price of natural gas is equivalent to 10 cents, which indicates a cheaper price of natural gas than gasoline.[2]

Fig.4.Emissions of smoke from oil, diesel and gas exhaust pipes [3]

7. Conclusions and Recommendations

1) Natural gas is known around the world as a clean fuel and therefore it is predicted that from 2020 to 2025 we will see the production of the largest amount of natural gas in the world.
2) Natural gas has 28% less carbon than diesel, so it has less environmental pollution.
3) LPG and CNG cost about half of the diesel and petrolprice.
4) In cold weather gas vehicles switch on faster than diesel vehicles.
5) Natural gas is a good Alternative to low-quality petroleum products for transportation, heavy industry, and other production activities.
6) The use of natural gas in vehicles Causes reduces diseases.
7) Diesel vehicles are first converted to petroleum and then replaced with dual systems (gas and petroleum).
8) Smoking , welding, and lighting fires must be avoided around the gas stations
9) Employees of gas stations must be equipped with fire-fighting equipment and clothing.
10) Private workshops and owners of such vehicles must obtain a permit from the Office of Norms and Standards and the High Department of Environment to carry out activities, repair, and excellent skills in replacing the oil-to-gas system to prevent accidents.
11) In the future, investments should be made in the production of energy that pollutes the environment less, such as gas production, solar energy, wind, and geothermal energy, so that air, water, and land are safe for the normal activity of living beings.
12) To have accurate figures on air quality we must follow national international standards regularly every 24 hours, it is necessary to install stationary devices in different parts of large cities, especially in Kabul, and regular figures during Register and submit in 24 hours.

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