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Contribution To The Study Of Air Pollution Nearby Algiers By Polluting Gases Using A New Sampling Technique

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ABSTRACT/RESUME

Abstract: *The study presents the level of air pollution by eleven polluting gases measured during six months in Draria (Algiers), a location influenced by the traffic emissions. The sampling of this pollution was done by a 24 hours and 7 days a week sampling station that we ourselves built based on an Arduino programmable board and a series of MQ-type sensors. During this study we have shown the interest of using such type of programmation in order to have an instantaneous evaluation of the air quality to allow making decisions about this pollution and take preventive measures and actions.*
The rate of benzene is on average lower than the international norms of $10\mu g/m^3$. The exploitation of the results has permitted to put into evidence the daily, weekly and monthly distribution of these polluting gases. The study of the compassrose and pollution rose has permitted to surround the most affected zones by the pollution.
Various interrelationships between these polluting gases that have been established show that the benzene is a good indicator of the pollution by cars.

I. Introduction

The air pollutants in the largecities and their impacts on human health in recent years is become a topical topic is ambient[1-21]. In fact, with the advent of the industrial age and technological advances, the growing demand for energy has forced the use of coal as the main source of energy, and as a result, air pollution has increased [22]. However, the combustion of coal mainly generates NOx, SO_2, mercury and dust, etc [23, 24] which is one of the main causes of environmental disasters such as acid rain, haze and photochemical smog [25]. Over the last thirty years, the notion of atmospheric pollution has become much more complex, with a population of more than six billion people on Earth and a growing consumption of natural and energy resources [26, 27]. Air today has taken an unprecedented scale. Apart from this wide wave of industrialization, the growing interest in the various aspects of pollution is also explained by the dramatic events of the Donora(Pennsylvania) disaster in 1948 and London in 1952 [28], which caused the deaths of thousands of people [29, 30].
Recent studies further confirm that these pollutants are probably public health risk factors associated mainly with chronic respiratory problems (asthma, chronic obstructive pulmonary disease and lung cancer) and allergic symptoms causing long-term permanent scarring of lung tissue [4, 17, 31, 32]. Several studies carried out in various parts of the world, such as Algeria, have shown that road traffic is one of the main causes of ambient air pollution [33, 34].
In Algeria, in this context recent work has shown that Greater Algiers is subject to intense atmospheric pollution [35]. Several studies carried out in various parts of the world, such as in Algeria, have shown that road traffic is one of the main causes of ambient air pollution [36, 37]. Moreover, these follow-up studies, carried out in particular in Algiers, are very insufficient to illustrate clear and indisputable conclusions on air quality.
To this end, initiatives to predict the deterioration of air quality have been taken. First, the researchers

developed physicochemical analysis methods based on a direct analysis of pollutants emitted through physicochemical sensors.

This method, although it provides quantified data, is quickly proven to beeconomically expensive, and not indicative of changes on biological levels and on the environmental level. As part of our study, we will focus on air pollution by a certain range of the most predominant polluting gases. It is clear today that these gases have a relationship with the presence of toxic metals in the air, particularly in urban areas and near industrial zones [33] these pollutants, which are very dangerous because of their stability, constitute an important health risk for man as well as the various ecosystems of his environment [3].

II. Data collection and methods

II.1. Site location and description

The objective of this study is the sampling of air pollution by polluting gases and then study this pollution distribution. To do this, the choice of the sampling site is essential and must meet the following requirements:

- Continuous air intake
- Absence of constraints (obstacles) between the air and the sampling device.

The study site is located within the suburb of Drarïa [34], wilaya of Algiers, populated by 44,141 inhabitants and which is 10 kilometers south-west of the center of the capital . The study area is located at the following geographic coordinates: 36°43'32.18"North and 3°00'29.15"Est as shown in figure 1.

The sampling system was installed on the roof of a three-storey building, approximately 17,5 meters above ground level and 10 meters away from the nearest road with a traffic of approximately 30,000 vehicles per day. Adding that the nearest domestic incinerator is 7 km to the east

Traffic is a major source of air pollution in this region, mainly because of the abrasion of brake linings and tires followed by the resuspension of road dust generated by relatively strong winds generally marking this region.

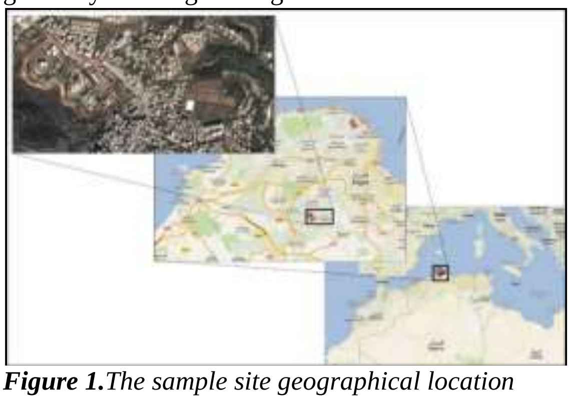

Figure 1.*The sample site geographical location [34]*

II.2. Sampling system design

It is a station based on Arduino module which is a platform works on a simple input / output interface. An Arduino module is usually built around an Atmel AVR microcontroller and additional components that facilitate programming and interfacing with other circuits [38, 39]. Each module has at least one 5 Volt linear regulator and a 16 MHz crystal oscillator (or a ceramic resonator in some models). The microcontroller is preprogrammed with a bootloader so that a dedicated programmer is not needed.

In order to design a smart gas sampling station, we used:

- Arduino board of type UNO R3 ;
- Four gas sensors (MQ_2, MQ_3, MQ_7 and MQ_{135}) [40-43];
- Temperature and humidity sensor (DHT_{11}) ;
- RTC module (Real Time Clock) to memorize sampling date and time ;
- Module for micro SD memory card ;
- NPN transistor ;
- LED lamp.

Through this station we were able to capture eleven (11) polluting gases, each sensor was programmed to analyze a specific gas based on its affinity for it, the sensors were used as fellow :

- MQ_2: LPG, Propane, CH_4
- MQ_3: Alcohol, Benzene
- MQ_7: H_2, CO
- MQ_{135}: Toluene, Alcohol, NH_4, Acetone, CO_2

The large number of wires connecting the different components and ensuring the transmission of different signals has led us to think how to reduce and organize them, the answer to this problem was to opt for a double layer printed circuits. In the PCB (Printed Circuit Board) shown on figure 3 we have created a positive (+) and a ground (-) tap denoted $V_{i\ (i\ =\ 0,\ ...\ 6)}$ and $G_{i\ (i\ =\ 0,\ ...\ 6)}$ simultaneously. These jacks serve as a power and ground pins for each module and sensor.

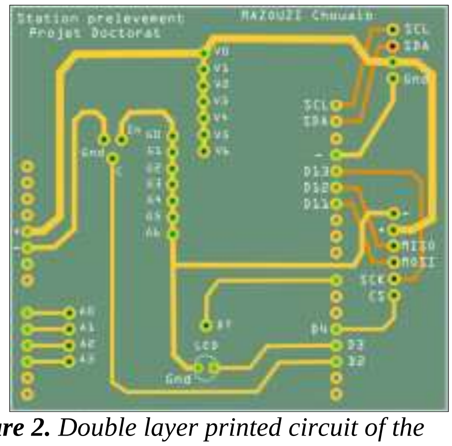

Figure 2. *Double layer printed circuit of the sampling station; Yellow: upper face wires, orange: down face wires*

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Figure 3 illustrates the electronic part of our pollutant sampling station, the PCB was manufactured in China by PCBWAY company [44] and the different electronics and modules were assembled and welded by ourselves.

Figure 3.*Assembling the arduino board with the RTC and SD modules on the PCB*

II.3. Sampling station algorithm

We set a sampling interval equivalent to one sampling every 3 hours. The Arduino board is connected to a current transformer that delivers +12V which ensures its continuous power supply by electricity, the first step is to turn on all the sensors and modules for a determined time of 25 minutes to heat the sensors, to do this we send an electrical signal to the digital pin D_2 which is connected to the transistor base, this load will activate the transistor of the blow to pass the collector current to the transmitter.

After heating, we proceed to the data acquisition picked up by the different sensors and then save the obtained values on the SD memory card. If all the modules and the sensors work according to the desired algorithm, the LED flashes once, as the last step, all the modules and sensors are switched off by cutting off the electrical signal from the digital pin D_2.

After the extinction stage, the different recorded concentrations are calculated, to do this, the electrical signal is converted into a usable numerical value according to the technical data sheet of each sensor. The standard deviation is calculated to detectany anomaly and then is investigated to find out if the problem is coming from the sensor or the sample itself [45,46]. If an anomaly is recorded (sudden change in concentration), a new sampling time equal to one-tenth (1/10) of the previous period is imposed. Once the anomaly is resolved we reuse the old deadline fixed to a levy every 3 hours.

II.4. Sensors positioning

In order to ensure the correct operation of the station and to have the best sampling in terms of precision we simulated the assembly of the station by the software SolidWorks 2018 [47], we applied a wind speed constraint and different directions for analyzing the direction and direction of the flow of air through the sensors (figure 5), the purpose of this simulation is to optimize the sensors location to allow each sensor to receive fresh air and so that the flow of the latter is not impeded by other sensors.

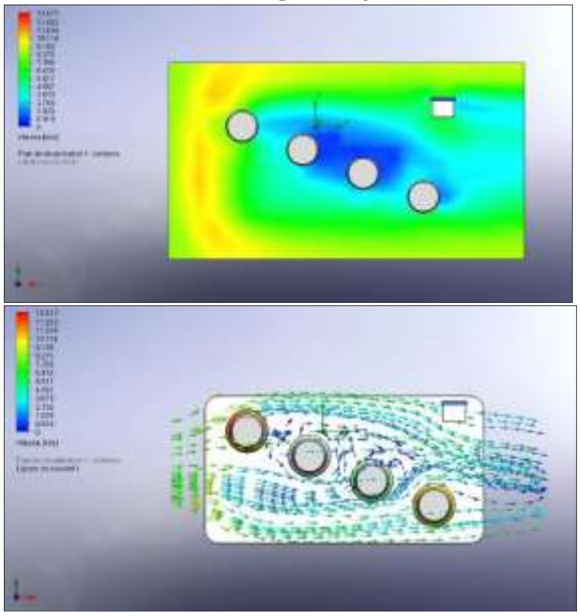

Figure 5.*Simulation of velocity profile and direction of air around the sampling sensors*

We note that a free flow of air is provided around the sensors, the air passes freely between them by bringing each passage of fresh air (no redundancy).

Figure 6.*Positioning of the sensors in the holder*

II.5. Data analysis

The method of analysis by the sensors type MQ series is a graphical method (projection) based on the technical sheet of each sensor [40-43]; Since we have more than 1.400 analyses to compute we have opted for the numerical method instead of the classic one, to do this, we have converted the reading graphs of each sensor into a fiting equation in order to inject only the ratio R_0/R_s [40- 43] already calculated to have the corresponding concentration in ppm. The fiting equations corresponding to each sensor for each gas are as follows :

MQ$_2$ sensor

$$GPL = 625{,}68\,.\,(\frac{R_0}{R_s})^{-2{,}113} \quad (1)$$

$$Propane = 685{,}74\,.\,(\frac{R_0}{R_s})^{-2{,}104} \quad (2)$$

$$CH_4 = 4380{,}8\,.\,(\frac{R_0}{R_s})^{-2{,}628} \quad (3)$$

MQ$_3$ sensor

$$Alcohol = 0{,}4275\,.\,(\frac{R_0}{R_s})^{-1{,}501} \quad (4)$$

$$Benzene = 4{,}9767\,.\,(\frac{R_0}{R_s})^{-2{,}691} \quad (5)$$

MQ$_7$ sensor

$$H_2 = 72{,}978\,.\,(\frac{R_0}{R_s})^{-1{,}348} \quad (6)$$

$$CO = 103{,}88\,.\,(\frac{R_0}{R_s})^{-1{,}5} \quad (7)$$

MQ$_{135}$ sensor

$$Toluene = 47{,}697\,.\,(\frac{R_0}{R_s})^{-3{,}325} \quad (8)$$

$$NH_4 = 103{,}3\,.\,(\frac{R_0}{R_s})^{-2{,}556} \quad (9)$$

$$CO_2 = 115{,}26\,.\,(\frac{R_0}{R_s})^{-2{,}887} \quad (10)$$

$$Acetone = 38{,}043\,.\,(\frac{R_0}{R_s})^{-3{,}282} \quad (11)$$

III. Results and discussion

III.1. Data cleaning

Frequently, errors slip into the master data and denature the content completely. This can occur during the measurement, transmission, coding, storage or decoding of observations, or because of built-in values after filling gaps [48].

It is therefore important, before any treatment, to detect such gross errors, so that a finer analysis can be made to decide whether this dubious data is out of the ordinary and must be eliminated, or if it is exceptional, which must therefore be preciously conserved, we have been based on three tests [45]:

- Grubbs and Beck test
- Homogeneity test
- Independence test

III.2. Data acquisition

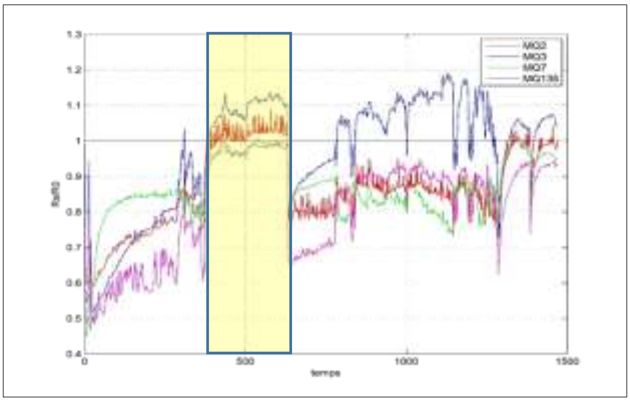

Figure 7. *Ratio R_s/R_0 recorded by the sensors*

Figure 7 shows the recorded signals by the sensors during the sampling period from June 3rd, 2018 to November 28th, 2018. The elaborated computer program, the algorithm of which is presented above, enabled us to present directly the graph Rs/R_0 ratio, this ratio is used to convert the signal recorded by each sensor in a concentration expressed in ppm, these values are summarized in table 1.

We notice that in the table below there is an Algerian limit value only for NH_4 and CO because the Algerian law has not defined a limit value for all polluting gases in the air [54-57].

Note that as of June, 20th to July 10th, 2018 there is an abnormal deflection (represented by the yellow frame) in the measurement range, this deflection will be interpreted and discussed later.

Table 1. *Statistical data of the detected pollutants gaseous concentration at our study area expressed on ppm, benzene on mg/l*

	Min	Average	Max	Standard deviation	Algerian limit value [54]
LPG	522,826	908,376	1919,954	267,275	/
Propane	573,451	993,822	2094,228	291,069	/
Toluene	46,308	124,992	536,597	2447,364	/
Alcohol	71,376	164,899	300,000	97,276	/
NH_4	100,979	185,689	300,000	86,895	135,830
CO_2	112,340	258,786	942,687	74,513	/

Acetone	36,949	98,154	414,799	171,127	/
CO	103,173	131,976	345,296	75,248	141,058
H_2	72,531	90,350	214,778	27,259	/
CH_4	5000	7238,551	17667,422	16,307	/
Benzene	3,117	6,700	28,874	4,953	/

Compared to the international standards governing benzene, we note that the air quality objective of 2 µg/m^3 in force in France is largely exceeded in Draria. The limit threshold of 10µg/m^3 in annual average is however respected.

Table 2. *Benzene and toluene levels in mg/l in certain cities [36]*

Cities an type of site	**Benzene**	**Toluene**
Algiers, 2002		
- urban	9,6	15,2
- peri-urban	4,2	23,6
Paris (France), 2001		
- traffic station	9,8	34,9
- Urban station	4,0	15,0
Sao Paulo (brésil), 2002		
Urban et traffic station	4,6	44,8
Santiago (chili), 2000		
urban	19,5	83,5
Izmir (Turquie), 2001		
Urban	56,9	106,5

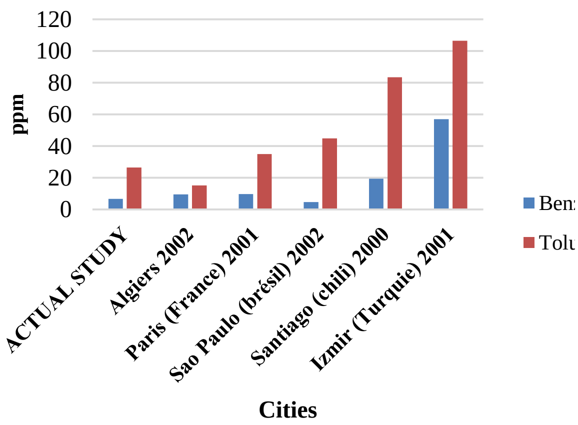

Figure 8. *Benzene levels in mg/l in certain cities compared to our actual study*

The benzene contents measured at Draria are also just above the limit of the 5 µg/m^3 threshold prescribed by the European directive of 16 November 2000.

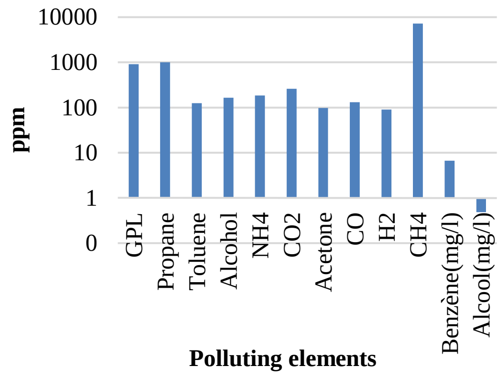

Figure 9. *Average gaseous pollutants concentration analyzed at our study site in ppm*

According to the figure 9, we can clearly see that LPG and CH_4 are the most polluting elements and the most present in the Draira's air, this strong presence is due to their use in the majority of petrol cars that are in circulation [49]. The other gases analyzed are gases that result from the combustion of fossil fuels so their presence in the air of Draria is mainly due to road traffic [50,51].
The different pollutants concentration variation analyzed at our study site are presented on the figures 9, 10, 11 and 12.

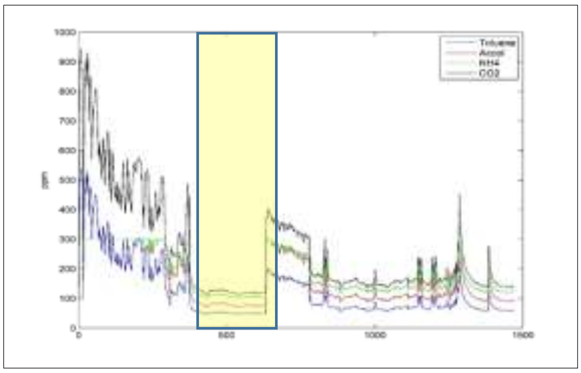

Figure 10.*Variation in the concentration of toluene, alcohol, NH_4, CO_2 during the sampling period*

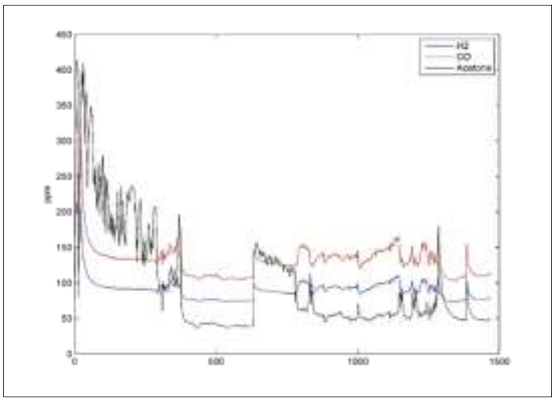

Figure 12.*Variation in the concentration of acetone, CO and H2 during the sampling period*

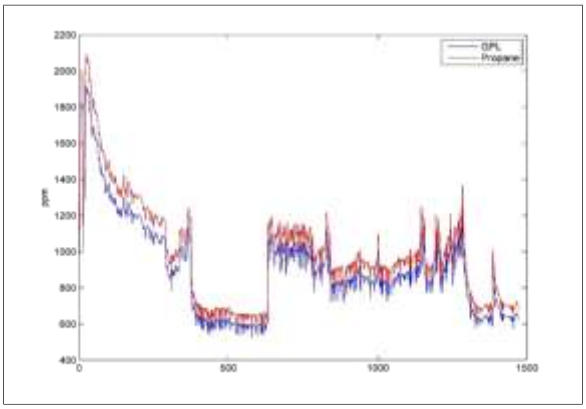

Figure 11.*Variation in the concentration of propane and LPG during the sampling period*

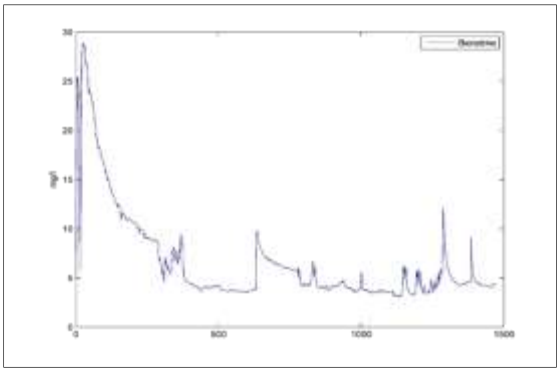

Figure 13.*Variation in benzene concentration during the sampling period*

Table 3.*Pearson correlation matrix of gas pollutants analyzed at the level of our study site*

	LPG	Propane	CH_4	Toluene	Alcohol	NH_4	CO_2	Acetone	CO	H_2	Benzene
LPG	1	1	0,988	0,919	0,830	0,832	0,922	0,920	0,715	0,723	0,889
Propane		1	0,988	0,919	0,830	0,832	0,922	0,920	0,715	0,723	0,889
CH_4			1	0,943	0,811	0,810	0,941	0,943	0,708	0,713	0,934
Toluene				1	0,877	0,872	0,999	1	0,600	0,602	0,947
Alcohol					1	1,000	0,896	0,879	**0,410**	**0,416**	0,760
NH_4						1	0,892	0,874	**0,415**	**0,421**	0,754
CO_2							1	0,999	**0,590**	**0,592**	0,940
Acetone								1	0,599	0,601	0,946
CO									1	1	0,599
H_2										1	0,600
Benzene											1

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There is a strong correlation between pollutants (the majority of cases r> 0.8) because they are all generated by the burning of fossil fuels, note that there is relatively little correlation between benzene and alcohol , NH and CO, adding to this a low correlation also between the couple (alcohol-CO), (alcohol-H_2), (NH-CO), (NH-H_2). For a better understanding of these correlation pairs a detailed study of the air pollution by the exhaust gases is necessary.
In order to better interpret the measurement results, several meteorological parameters were taken into consideration during the sampling campaigns. These meteorological parameters can have a great influence on the distribution of the pollutant gases detected. The average daily relative humidity, wind speed, cumulative precipitation, and collected temperatures are shown in Figures 13, 14 and 15
From these diagrams, we can draw the following information :

- Southeast winds are the prevailing winds
- In the South-East direction, wind speed frequencies are about 10% for speed class 1 to 2 m/s, 19% for class 2 at 3 m/s and about 20% for speeds ranging from 3 to 4 m/s.
- The winds of the North are, with a frequency of the order of 5%, less frequent than the easterly winds are distributed equally on the classes of 1 to 2 and 2 to 3m/s.
- West sector winds appear at frequencies of more than 10% with moderate speeds in 1 and 3m/s.
- South winds are very rare and constitute less than 1% of all observed wind directions.

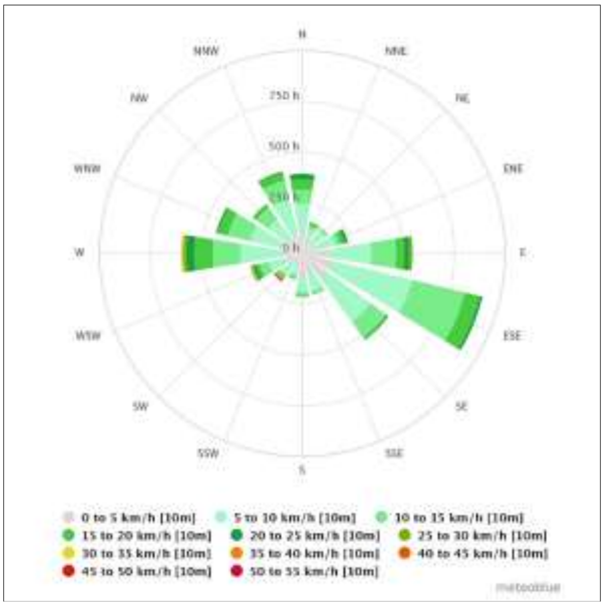

Figure 14.*Wind rose recorded at the Dar el Beida station during the study period*

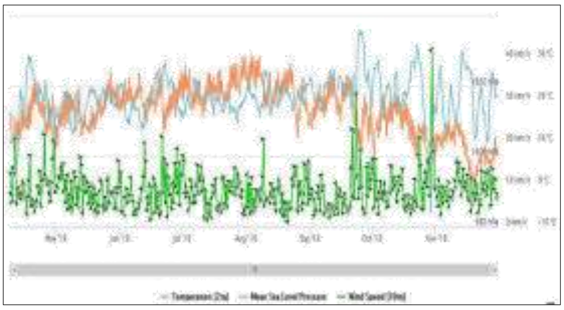

Figure 15.*Variation in temperature, atmospheric pressure and wind speed during the study period*

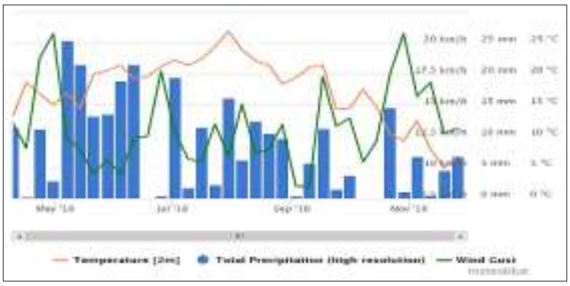

Figure 16.*Variation in temperature, precipitation and gusts of wind during the study period*

The disruption of the analyzed results represented by the yellow frame (figure 7) that covers the period from June 20th to July 10th can be explained by gusts of violent winds that have reached a speed of almost 20 km/h and the change in wind direction (East to the West), adding to that the recording of 20mm rainfall as well as a sharp decrease in atmospheric pressure and air density.
From a total point of view, the high concentrations recorded at the beginning of the collection period are due mainly to road traffic, we notice that there is a gradual decrease in concentration which can be explained by the beginning of the holiday period and the end of the academic year, these two parameters have only reduced the road traffic contrary to the last two months of the period of the collection of samples where the pollution by the gases has known a progressive increase due to the end of the summer period, the end of the holidays and the return back to universities and schools.

III.3. Daily distribution

We present in figures 16 the evolution of the daily concentrations of polluting gases detected at the study site during the period from June 3rd, 2018 to November 28th, 2018.

Table 4. *Daily distribution of gaseous pollutants concentration on ppm at the study site*

	06h-10h	10h-14h	14h-18h	18h-22h	22h-02h	02h-06h
LPG	1528,168	1309,095	1324,553	950,563	460,765	482,506
Propane	1818,625	1490,688	1520,389	983,167	456,217	731,986
Toluene	463,561	495,066	467,777	264,020	153,556	142,168
Alcohol	327,586	176,288	260,290	263,534	160,000	80,000
NH_4	252,794	299,776	270,050	251,883	148,529	108,423
CO_2	549,655	561,552	538,213	501,129	204,149	129,236
Acetone	228,743	240,172	196,877	224,252	53,819	50,774
CO	242,223	259,596	255,204	220,066	135,837	111,595
H_2	170,187	192,297	180,352	128,606	35,895	75,618
CH_4	15002,128	14893,608	14835,608	7317,345	6396,569	6384,551

The examination of the average daily profile (Figure 17) shows that in Draria all the detected gases show two important peaks, one at the beginning of the morning around 8 o'clock and the other at the end of the day around 18 o'clock. There is also sometimes a slight peak in the middle of the day. These peaks can be explained by the influence of neighboring road traffic emissions [52].

The intense road traffic observed during peak hours generates very high levels at the measuring site, which are close to twice the daily average levels. During the afternoon, the intensification of road traffic begins at 4'pm and persists, especially in summer, beyond 4'pm (the return of summer vacationers from the beaches of western Algiers) which explains the wide peak observed in the daily evolution. We also noted that all pollutants evolve during the day in the same direction; the maxima and minima matched the same schedule. This result suggests that these compounds have the same polluting source, in this case road traffic, and suffer the same effects of dispersion. In terms of scale of pollution, the levels recorded at this peri-urban site, which is influenced by road traffic emissions, are very high, but much lower than those observed in the center of Algiers [36]. A comparison with the data collected in the literature on cities in developed and emerging countries also shows that the rates measured at Draria are relatively alarming. However, the situation would be different if the study was conducted in a purely urban site where cold starts and idling are more frequent, as well as in canyon-type streets where natural ventilation is reduced. Such conditions cause more intense pollution of gaseous pollutants. Remember in this context that for the W.H.O., benzene and carcinogens have no preciselimits where they can be with no noticeable risks on human health.

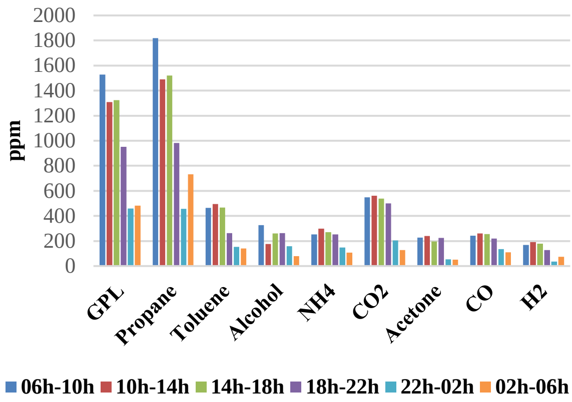

Figure 17.*Daily distribution of gaseous pollutants concentration on ppm at the study site*

III.4. Weekly distribution

In order to verify whether the reduction in traffic intensity during the weekend days has an effect on the levels of air pollution by gases, we used the data collected according to the days of the week. table 5 summarizes the average daily levels of this pollution by days of the week.

Figure 18 shows that whatever the pollutant considered, Friday is the lowest pollution rate. On this day of rest, the pollution is reduced compared to the most polluted day of about 15 to 20%. As several administrations and services (bank etc.) are closed or do not receive public on Saturday, this day of the beginning of the week comes, in terms of pollution, just after the holiday of Friday. Thursday is paradoxically among the days of the week that shows a high rate of pollution. Indeed, it is not a real holiday because some public administrations are open, the private and informal sector is also active today and the sectors of national education and higher education are also active. These results come outduring a certain effervescence of the

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socio-economic life which then affects the levels of pollution.

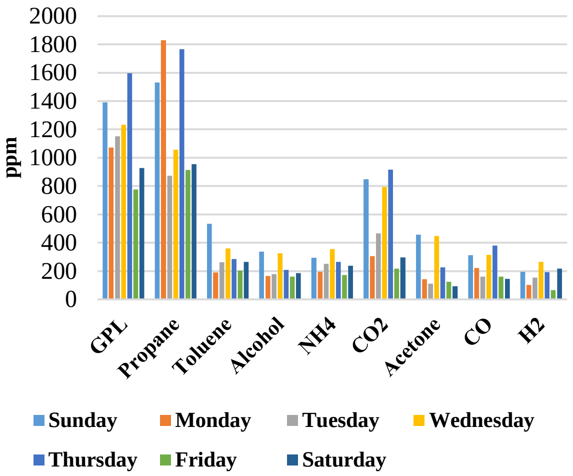

Figure 18.*weekly distribution of gaseous pollutants concentration on ppm at the study site*

Figure 18 shows that whatever the pollutant considered, Friday is the lowest pollution rate. On this day of rest, the pollution is reduced compared to the most polluted day of about 15 to 20%. As several administrations and services (bank etc.) are closed or do not receive public on Saturday, this day of the beginning of the week comes, in terms of pollution, just after the holiday of Friday. Thursday is paradoxically among the days of the week that shows a high rate of pollution. Indeed, it is not a real holiday because some public administrations are open, the private and informal sector is also active today and the sectors of national education and higher education are also active. These results come outduring a certain effervescence of the socio-economic life which then affects the levels of pollution.

III.5. Monthly distribution

Several studies carried out in Europe, in Asia and in the USA have shown that there is a more or less important difference between the winter contents and the summer contents of the gaseous pollutants in the air. The speed of the wind and especially the precipitation are at the origin of this variation. The concentrations recorded at our study site are shown in table 6.

Table 6.*Monthly distribution of gaseous pollutants concentration on ppm at the study site*

	June	July	August	September	October	November
LPG	1359,866	821,079	758,596	884,109	870,370	755,436
Propane	1485,393	898,744	830,609	967,533	952,566	827,214
Toluene	301,509	112,714	100,559	88,140	70,626	76,851
Alcool	297,987	167,611	157,315	137,566	109,702	119,283
NH_4	298,350	187,900	177,029	163,869	139,381	147,653
CO_2	568,554	238,854	215,609	195,095	161,839	173,510
Acetone	234,681	88,729	79,249	69,691	56,037	60,884
CO	157,776	125,513	116,140	135,141	138,531	118,645
H_2	105,856	86,441	80,637	92,425	94,498	82,176

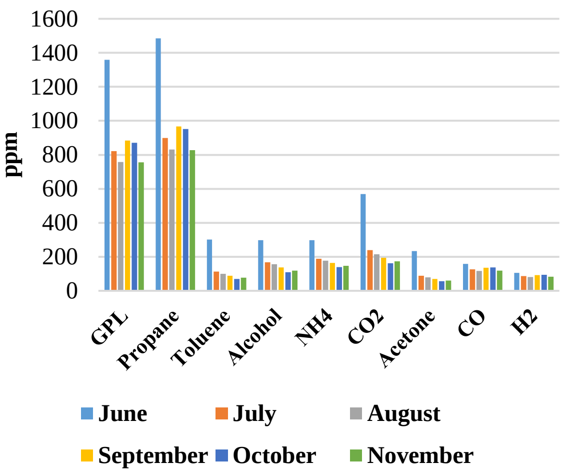

Figure 19. *Monthly distribution of the ppm concentration of gaseous pollutants at the study site*

During our study, which ran from June to November, the winter season was not covered. However, we found it useful to check if there was a difference between two periods:

- Average temperature period: (Tmw = 19°C) corresponding to the period of October and November.
- Period with strong sunshine and high temperature: (average = 25.2°C) and corresponding to the months of June, July, August and September

The examination of these evolutions shows that the month of August accuses, whatever the pollutant considered, the lowest contents. The months of September and October show comparable evolutions and levels of pollution. There is therefore a seasonal effect.
These results show that for all pollutants there is a significant difference between the two seasons (summer / autumn) [53]. This seasonal variation which is characterized by a temperature difference of the order of 7 °C is about 36% for benzene.

IV. Conclusion

During this study, we presented the levels of ambient air pollution at the level of the suburbs of Draria, a commune in the wilaya of Algiers, we presented the results obtained from our own pollutants gas sampling station, this station allowed us to analyze eleven (11) gaseous pollutants that are mainly from road traffic following the combustion of fossil fuels.
The monitoring of the contents of the eleven polluting gases over the period from June 3rd, 2018 to November 28th, 2018 allowed us to trace the daily, weekly and monthly evolutions and to highlight peaks of pollution that are linked to the intensification of traffic road that passes a hundred meters away from the measurement site. The study of weekly evolution showed that Friday (public holiday) has the lowest pollution rate. The monthly evolution of this pollution has shown that the month of August is the least polluted month. A seasonal variation is thus highlighted and one notes during the summer season a decrease of the rate of pollution of the order of 15 to 25%. This decrease is related to the intensification of atmospheric photochemistry that takes place in summer.
In terms of pollution levels, the levels measured for benzene are relatively high but generally remain below the standards in force in Western countries. Similarly, we have shown that, just like CO, benzene, LPG, Toluene, CO_2 are good indicators of automobile pollution, to better understand these correlations, a study on vehicle exhaust fumes is needed.
Overall, the various studies that we conducted yield interesting and promising results that testify to the feasibility and validity of our approach; the results of gas pollution from our own sampling station have a strong similarity in size and profile with other approved studies in Algiers and across other countries of the world.
Our perspective aims firstly to integrate an internet module into our smart sampling station in order to have permanent data acquisition and reading in real time, to receive an alarm in the event of displacement of a predefined limit value and to benefit from a remote control in the event of a malfunction of the station. Not only this, our perspective also aims to set up several smart sampling stations across the municipalities of the wilaya of Algiers in order to develop a map of the pollution by pollutiong gases and to contribute to the definition of a limit value for each pollutant gas to better protect the human health of residents.

V. References

1. Bi, C.; Chen, Y.; Zhao, Z.; *Characteristics, sources and health risks of toxicspecies (PCDD/fs, PAHs and heavy metals) in PM2.5during fall and winter in anindustrial area*. Chemosphere 238 (2020), 124620-124620.
2. Brauer, M.; Freedman, G.; Frostad, J.; *Ambient air pollution exposureestimation for the Global Burden of Disease 2013*. Environ. Sci. Technol. 50 (2016),79e88.
3. Chen, H.; Li , L.; Lei, Y.; Wu, S.; Yan, D.; Dong, Z.; *Public health effect and its economics loss of PM2.5 pollution from coal consumption in China*. Science of the Total Environment 732 (2020), 138973.
4. Chan, K.H.; Kurmi, O.P.; Bennett, D.A.; Yang, L.; Chen, Y.; Tan, Y.; *Solid fuel use and risks of respiratory diseases. A cohort study of 280,000 Chinese neversmokers*. Am. J. Respir. Crit. Care Med. 199 (2019), 352e361.
5. Cohen, A.J.; Brauer, M.; Burnett, R.; *Estimates and 25-year trends of theglobal burden of disease attributable to ambient air pollution: an analysis ofdata from the global burden of diseases study 2015*. Lancet 389, (2017) 1907e1918.
6. Fuertes, E.; Sunyer, J.; Gehring, U.; *Associations between air pollutionand pediatric eczema, rhinoconjunctivitis and asthma: a meta-analysis of*

Eu-ropean birth cohorts. Environ. Int. 136 (2020), 105474
7. Gu, X.; Liu, Q.; Deng, F.; *Association between particulate matter airpollution and risk of depression and suicide: systematic review and meta-analysis*. Br. J. Psychiatr. 215 (2019), 456e467
8. Guo, H.; Sahu, S.K.; Kota, S.H.; *Characterization and health risks ofcriteria air pollutants in Delhi*. Chemosphere 225 (2019), 27e34, 2017.
9. He, T.; Zhu, J.; Wang, J.; *Ambient air pollution, h19/DMR methylation incord blood and newborn size: a pilot study in Zhengzhou city, China*. Chemo-sphere 212 (2018), 863e871.
10. Hoek, G.; Pattenden, S.; Willers, S., *PM_{10} and children's respiratorysymptoms and lung function in the PATY study*. Eur. Respir. J. 40 (3) (2012), 538e547
11. Kan, H.D.; Shi, X.M.; *Research progress of ambient air pollution and humanhealth in China*. Zhonghua Yu Fang Yi Xue Za Zhi [Chinese journal of preventivemedicine 53 (2019), 4e9.
12. Kim, H.J.; Seo, Y.S.; Sung, J., *Interactions of cdh13 gene polymorphismsand ambient PM10air pollution exposure with blood pressure and hypertensionin Korean men*. Chemosphere 218 (2019), 292-298
13. Li, T.; Yan, M.; Sun, Q., *Mortality risks from a spectrum of cause's asso-ciated with wide-ranging exposure tofine particulate matter: a case-crossoverstudy in Beijing, China*. Environ. Int. 111 (2018), 52-59
14. Li, J.; Liu, C.; Cheng, Y., *Association between ambient particulate matterair pollution and ST-elevation myocardial infarction: a case-crossover study in a Chinese city*. Chemosphere 219 (2019), 724-729.
15. Li, S.; Zhou, G.; Liu, Z., *Synthesis and performance characteristics of anew ecofriendly crust-dust suppressant extracted from waste paper for surfacemine*. J. Clean. Prod. 258 (2020), 120620.
16. Lin, Z.; Meng, X.; Chen, R., *Ambient air pollution, temperature and Ka-wasaki disease in Shanghai, China*. Chemosphere 186 (2017), 817e822
17. Liu, C.; Chen, R.; Sera, F., *Ambient particulate air pollution and dailymortality in 652 cities*. N. Engl. J. Med. 381 (2019), 705e715.
18. Lu, C.; Zhang, W.; Zheng, X., *Combined effects of ambient air pollutionand home environmental factors on low birth weight*. Chemosphere 240 (2020), 124836.
19. Sun, J.; Liang, M.; Shi, Z., *Investigating the PM2.5mass concentrationgrowth processes during 2013-2016 in Beijing and Shanghai*. Chemosphere 221 (2019), 452e463.
20. Yan, B.; Liu, S.; Zhao, B., *China'sfight for clean air and human health*.Environ. Sci. Technol. 52 (2018), 8063e8064.
21. Xiu, Z.; Nie, W.; Yan, J., *Numerical simulation study on dust pollution char-acteristics and optimal dust control air flow rates during coal mine production*.J. Clean. Prod. 248 (2020), 119197.
22. Kaygusuz, K., *Energy for sustainable development: A case of developing countries*. Renewable & Sustainable Energy Reviews 16 (2012), 1116–1126.
23. Wang, N.; Wu, D.; Yang, Y., *Exergy evaluation of a 600MWe supercritical coal- fi red power plant considering pollution emissions*. Energy Procedia 61 (2014), 1860- 1863.
24. Sui, Z.; Zhang, Y.; Wang, T., *Full-scale demonstration of enzyme-treated coal combustion for improved energy ef fi ciency and reduced air pollution,* Energy Fuels 32 (6) (2018), 6584e6594.
25. Atkinson, R.; Lloyd, A.C., *Evaluation of kinetic and mechanistic data for modeling of photochemical smog*. J. Phys. Chem. Ref. Data 13 (2) (1984), 315.
26. Yin, J.; Harrison, R.M., *Pragmatic mass closure study for PM1.0, PM2.5 and PM10 at roadside, urban background and rural sites*.Atmospheric Environment 42 (2008), 980–988
27. Nguyen, T. H.; Byeong-Kyu, L., *Characteristics of particulate matter and metals in the ambient air from aresidential area in the largest industrial city in Korea*. Atmospheric Research 98 (2010), 526–537.
28. Nemery, B.; Hoet, P.H.M.; Nemmar, A., *The Meuse Valley fog of 1930: an air pollution disaster*. The lancet • (2001) Vol 357: 704–08
29. Bell, M.L.; Davis, D.L.; 2001. *Reassessment of the lethal London fog of novel indicators of acute and chronic consequences of acute exposure to air pollution*. Environmental Health Perspectives 109 (Supplement 3), (1952) 389–394.
30. National Public Radio, 2002. *The killer fog of '52*. Text and audio files at http://discover.npr.org/features/feature.jhtml?wfId=873954 (accessed June 2006).
31. Seow, W. J.; Hu, W.; Vermeulen, R.; Hosgood Iii, H.D., Downward, G.S., Chapman, R.S., *Household air pollution and lung cancer in China: a review of studies in xuanwei*. Chin. J. Canc. 33 (2014), 471-475.
32. Zhang, G.; Sun, B.; Song, S.; Wang, H.; Zhou, G; *CFD comparative analysis on the pollution characteristics of coal dustunder turbulent airflow from coal cutting in the fully mechanizedmining face*. Process Safety and Environmental Protection. 146 (2021) 515–530.
33. Boughedaoui, M. ; Kerbachi, R. ; Joumard, R. ; *Mesure de la pollution plombifère dans l'air ambiant d'Alger*, Poll. Atm., N°121, (2004) pp.105-111
34. Bouhila, Z. ; Mouzai, M. ; Azli, T. ; Nedjar, A. ; Mazouzi, C. ; Zergoug, Z. ; Boukhadra, D. ; Chegrouche, S. ; Lounici, H.; *Investigation of aerosol trace element concentrations nearby Algiers for environmental monitoring using instrumental neutron activation analysis.* Atmos Res 166 (2015), 49–59
35. Oucher, N., *Contribution a l'étude, par classe granulométrique, des aérosols particulaires et des métaux lourds qui leurs sont associées à Alger*, Mémoire de Magister, ENP. (2006)
36. Kerbachi, R. ; Boughedaoui, M. ; Koutai, N. ; Lakki, T. ; *La pollution par les oxydes d'azote et l'ozone dans la ville d'Alger*. Poll. Atm., (1998) pp 89-101.
37. Aghaei, A.; Khademi, H., *Evaluating and Determining of heavy metals in the atmospheric dust by using statistical methods (PCA and CA)*, Algerian J. Env. Sc. Technology, 2:3 (2016), 224-234
38. Hooyberghs, J.; Mensink, C.; Dumont, G.; Fierens, F.; Brasseur, O., *A neural network forecast for daily average PM10 concentrations in Belgium*. Atmospheric Environment 39 (2005), 32793289.
39. Papanastasiou, D.K.; Melas, D.; Kioutsioukis, I., *Development and assessment of neural network and multiple regression models in order to predict PM10 levels in a medium-sized Mediterranean city*. Water, Air and Soil Pollution 182 (2007), 325e334
40. https://www.pololu.com/file/0J309/MQ2.pdf
41. https://www.sparkfun.com/datasheets/Sensors/MQ-3.pdf
42. https://www.sparkfun.com/datasheets/Sensors/Biometric/MQ-7.pdf
43. https://www.olimex.com/Products/Components/Sensors/Gas/SNS-MQ135/resources/SNS-MQ135.pdf
44. https://www.pcbway.com/

45. Ahn, K.; Rakha, H., *A field evaluation case study of the environmental and energy impacts of traffic calming*. Transp Res Part D Transp Environ 14 (2009), 411–424.
46. Arbilla, G.; Bauerfeldt, G.F.; De Paula, M., *Atmospheric levels of aldehydes and BTEX and their relationship with vehicular fleet changes in Rio de Janiero urban area*. Chemosphere, 67 (2007), pp 2096-2103
47. https://www.solidworks.com/fr
48. Trigo, R.; Palutikof, J. *Simulation of daily temperatures for climate change scenarios over Portugal: a neural network model approach*. Climate Research 13 (1999), 4559.
49. Joumard, R.; Jost, P.; Hickman, J.; Hassel, D., *Hot passenger car emissions modelling as a function of instantaneous speed and acceleration*. Sci Total Environ 169 (1995):167–174.
50. Franco, V.; Kousoulidou, M.; Muntean, M., *Road vehicle emission factors development: a review*. Atmos Environ 70 (2013), 84–97
51. Mansouri, A.; Lebsir, F.; Hamou, A., *Control of air quality in Oran city, Algeria*, Algerian J. Env. Sc. Technology, 2:3 (2019), 190-195
52. Wilson, W.S.T.; Tze, W.W., Andromeda, H.S.W., *Association between air pollution and daily mortality and hospital admission due to ischaemic heart diseases in Hong Kong.* Atmospheric Environment, 120 (2015), 360-368.
53. Yang, J.; Kang, S.; Jib, Z.; Yin, X., Tripathee L., *Investigating air pollutant concentrations, impact factors, andemission control strategies in western China by using a regionalclimate-chemistry model*. Chemosphere 246 (2020) – 125767.
54. http://extwprlegs1.fao.org/docs/pdf/alg64227.pdf
55. https://and.dz/site/wp-content/uploads/D%C3%A9cret-executif-n%C2%B006-02.pdf
56. https://and.dz/site/wp-content/uploads/Decret-executif-%C2%B003-410.pdf
57. http://www.cntppdz.com/uploads/legisla/decret%2007-299.PDF

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