EVALUATION OF THE SIDI BEL ABBÈS ATMOSPHERIC POLLUTION GRADE AND ITS RISKS OVER HEALTH

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This study has been realized on the agglomeration of Sidi Bel Abbès, north western Algeria in North Africa. Its main goal is the determination of the atmosphere pollution intensity and the noxious probability risk (at short term) over the exposed populations.
Nevertheless, this very huge 200,000 inhabitants city is deprived from any air quality surveying organ or structure.
The atmospheric pollutants metrology achieved in this paper, from 2005 to 2006 showed very elevated episodic concentrations of principals' urban pollutants.
Comparing with international guide values, these concentrations are susceptible to cause respiratory alterations on the exposed populations.
This study aims to sensitize decision makers, researchers as well as the civil society on the real existence of a noxious risk upon the city, and the necessity of taking in account the atmospheric pollution question in quality of public health problem.

Keywords: atmospheric pollution, metrology, risk evaluation, respiratory illnesses

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Introduction

Former several scientific papers have shown the intimate relation between atmospheric pollution and public health [1]. Since this, pollution researches and studies have been diversified, and the question becomes a multidisciplinary problem [2].

Currently it is well-known and proven that with determined contents, the pollutants in the air, water and the food, human health can be seriously deteriorated and these can even lead to death. This report is very confirmed by all the publications, which gives, with precision, thresholds and amounts presenting health risks, in particular those published by the specialized agencies (NCEA, the EPA-US and the ATSRD) [3].

Our work is based on the method validated by these organizations, and is interested by the evaluation of the risks of the air pollution of Sidi Bel Abbès which is an agglomeration of average density, located in a forest area and of agricultural vocation with a weak industrial activity.

The problems is that several years later, the area were recommended to the suffering people of respiratory insufficiencies, because of the purity of its air, but currently there appears a prevalence of the asthmatic cases close to the national average which is about 9 %, and the frequency to hospitalization due to respiratory deficiencies has grown increasingly.

More, the area is deprived of structures of air-quality monitoring, from where follow the ignorance and the absence of data to evaluate the exposure of the population to the air pollution.

The study was carried out over a period of two years, from January 1, 2005 to December 31, 2006 and comprises two aspects; the metrology of the atmospheric pollutants, and in parallel analysis of the frequency of the hospital admissions for respiratory causes.

The expected objectives of the study are multiple, where the most important would be:

− The metrology of the pollutants present in the atmosphere of Sidi Bel Abbès.

− The impact risk evaluation of the air pollution by comparison between the variation of the concentration of the pollutants and the frequency of hospitalization for a respiratory cause.

− To exhort the decision makers to set up measurements centres and monitoring for the forecast and the risk managing.

− The responsibility assumption of this public health problem by the constitution of a data base on the exposure of the population and the impact risks.

Description of the studied zone and the factors acting on the pollutants

For the evaluation of the medical risk the study of the zone is very important for the estimation of the exposure. In our case, one considers that the population concerned is residential, then with an occupation of time of 100 % in urban environment. In an arbitrary way, one estimates that the urban air pollution is identical inside, and then the exposure of the population can be regarded as homogeneous and suitably estimated.

A very brief study of the zone is necessary, because the environmental factors influence the pollutants, the latter are not stationary and undergo variations of the climate factors (humidity, precipitations, temperatures and winds) [4, 5].

In addition an outline on the population, its characteristics and distribution makes it possible to determine the most exposed populations.

The department of Sidi Bel Abbès located at the North-West of Algeria, is distant approximately fifty kilometres of the Mediterranean. It extends on 15 % of the north western Algeria, being stretched in the plain of Mekerra and remaining under the screen of the Tessala mounts in the north and Dhaya in the south. Its geographical site makes it a crossroads, crossed by the principal road axes of the west Algerian, thus constituting a transit centre of the western area with the south of the country.

The climatic factors are important for the study of the air pollution, because they interact with the it to act on human health. They have an action on the transport and the dispersion of the pollutants [5].

Our studied zone belongs to the semi-arid bioclimatic stage characterized by the rain concentration in autumn and winter and of dryness during the summer. The seasonal mode is of the HAPE type (see Fig. 1 and 2). These last show the maximum of the rains in winter followed by the autumn, spring and finally the summer. However the number of days of rain per period remains weak.

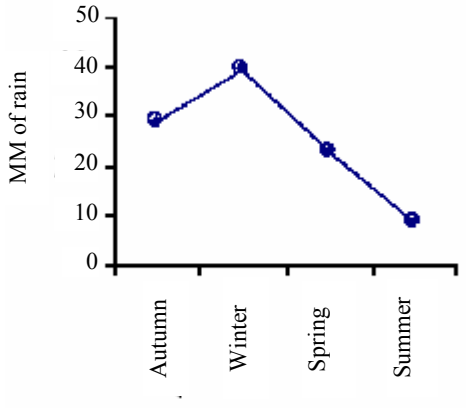


Fig. 1. *Importance of rain/season*

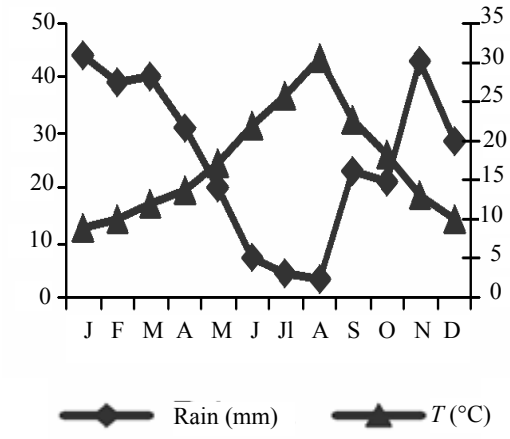


Fig. 2. *Ombrometric curve of Sidi Bel Abbès*

The wind is a dominating factor in the transport and the space concentration of the pollutants. It acts on the dispersion of the pollutants, such as more the wind is strong; more the levels of pollution are lowered. On the other hand, a low speed wind favours the accumulation of the pollutants [4]. In the Sidi Bel Abbès district, the winds are of the North-West or North-East, weak to

moderated during the day and calm during the night (National office of Meteorology, 2005). The weakness of precipitations and winds permit pollutants to accumulate and persist in the atmosphere of the city.

The topography of Sidi Bel Abbès district is appreciably plane allowing a certain liberty of air movement. The only obstacles are the buildings, where which the average height is about 15 to 20 meters. Ground surface is at the origin of atmospheric turbulences on the level of the rough underlayer. These turbulences can be due to the thermal instability of air masses, or have mechanical origin, due to the surface obstacles [4]. It is the size, the form, the density of the obstacle and its environment which condition the air flow on the surface of the ground, the time of residence and the exchanges with the bordering layer; thus, in an insulated and ventilated street, the time of residence of an air mass is, perhaps, of a few seconds only [5]. The short outline on the characteristics of the city enables us to draw three conclusions:

1. From its geographical situation, the city is a crossroads crossed by a dense road traffic, composed mainly of heavy vehicles of the diesel functioning type functioning.
2. The weakness and the absence of precipitations and humidity during the dry season allow the persistence and the concentration of the pollutants in the atmosphere of the agglomeration.
3. Despite of the flatness of the city, the weakness of the winds make that the pollutants circulate more slowly and are thus maintained longer in the urban atmosphere.

Finally, according to the National Office of Statistics data, the district population is estimated of 537,276 inhabitants, where 187,042 are living in the town, with a rate of 34.81 % of town resident, representing the urban atmospheric pollution most exposed population.

Materials and methods

The evaluation methodology of the medical risk followed is that validated by the US-EPA (United States Environmental Protection Agency) [3], which follows four standardized stages:

1. Identification of the danger (metrology of the pollutants in the atmosphere). The pollutants are measured uninterruptedly and in real time, directly by fixed sensors analysers installed in precise points of the agglomeration. The measured substances, are the nitrogen dioxides (NO_2), ozone (O_3), carbon dioxide CO_2 and the sulphur dioxide (SO_2) [6]. The levels of NO_2, CO_2 and SO_2 are evaluated by an average concentration during 24 h and expressed in mg/m^3. The level of O_3 is evaluated by 8 consecutive hours averages per day and expressed in µg/m^3. The identification of the dangerous potential of these substances and the determination of the risk probability are done according to the method validated by the National Institute of Research and Safety (NIRS), the Agency for Toxic Substances and Diseases Registry (ATSDR), the US-EPA, and the WHO international agencies [7, 8, 9].
2. Toxicological characterization which is a comparison between the concentrations measured and the guides' values. The characterization of the danger is established by comparison between the concentrations measured (estimated like values of exposure) and the recommendations or guides' values based on observations on human or by extrapolation of the animal experiments [8]. The estimation of the exposure on the populations is rated with the amount Daily Estimated Ratio (DER).
3. Determination of the exposed populations. It is estimated that the population exposed to the pollutants is equal to the total population of the town of Sidi Bel Abbès and its periphery. In the same way, this exposure is supposed to be homogeneous for the whole of the population. Since the lung is the air pollution directly exposed organ, the medical impact selected is the individuals' hospitalized total number for a non-infectious respiratory pathology during the period of the study [4]. We recorded the frequency of the respiratory due hospitalizations, during the period going of January 1, 2005 to December 31, 2006 to the pneumological service of the Sidi Bel Abbès University Hospital Centre.
4. Estimation of the risk. For a defined geographical area, the populations are subjected to the same level of exposure [10]. Evaluation of the air pollution impact risk on health in the area have been done by the study of the connection between the variations of the measured pollutants and the frequency of hospitalization for a respiratory cause [11, 12].

The measurement of the air pollution was carried out by sensors fixed on four selected stations according to well-defined criteria, in order to cover various spaces of the city [7]. The sensors are connected by Intranet network to a measuring apparatus connected to a computer, and the unit is managed by software allowing the recording of gases concentrations in the atmosphere, hour per hour continuously.

The measuring apparatus used is an IMR 1400-Compact type combustion gas analyser, able to measure and analyse, uninterruptedly, the following atmospheric parameters: temperature of the air and concentration of gases such as oxygen, carbon oxides, nitrogen oxides, and the sulphur dioxide. It displays, simultaneously, eight measured variables on LCD in the set of units: ppm, mg, µg/k., and a minimal resolution of 1 ppm. It is provided with a memory for 220 measurements, and appropriate for connection with a computer.

Four stations were selected according to two criteria: the pollutants zone exposure and the importance of the population circulating there. A third requirement of a sedentary and technical nature (connection by Intranet of the equipment) was taken into account in the choice of the site of the sensors. The sensors were installed on

university buildings with heights of 3 and 4 meters over the ground, covering great sectors of the city:
1. Station 1 in downtown, to measure the importance of pollution resulting from the road traffic and the density of the exposed population which circulates there the day long.
2. Station 2 on the periphery of the city (by-pass) to measure the road traffic pollution risk which crosses the area.
3. Station 3 close to the industrial area to measure possible risks of industrial pollution.
4. Station 4 in a zone apparently with a weak risk, since located in a residential environment, around the UHC, where there remain gardens and agricultural farms.
The study have regarded exclusively four urban pollution indicator gases, like ozone O_3, the nitrogen dioxide NO_2, the sulphur dioxide SO_2 and carbon dioxide CO_2.

Results and discussion

The Sidi Bel Abbès department is of an agricultural vocation. The industrial activities present in the periphery of the city are very low polluting the atmosphere; put aside a complex of electronic instruments manufacture and a factory of farm equipment assembly. The remainder is composed by small and average agro-alimentary units, cosmetic, and clothing.
The most important sources of urban pollution would be the solid wastes incinerators in open air and the road traffic.
An analysis of the cars park reveals that this latter doubled in the last 10 years. Currently, it is estimated to 90571 vehicles, whereas the road infrastructures only evolved very little. This situation is worsened by a degraded state of the roads and strewn with speed reducers. It results from this frequent congestions and obstructions which slow down circulation, while remembering that the idling engines produce more pollution.

In addition the analysis of the components of the automobile set of the area shows that:
a) 84.55 % of the vehicles are of 11 years old and more (see Fig. 3), in consequence that this amount of vehicles is aged. The old vehicles are generally badly regulated and consume up to 10 % additional fuel, leading to a significant increase in the pollutants emissions in the air.
b) 51 % of the vehicles of the district function are diesel type, while knowing that this kind of engine strongly emits nitrogen oxide, sulphur oxides and fine particles (from 30 to 100 times more emitted particles than those running on the gasoline) [13, 14, 15].

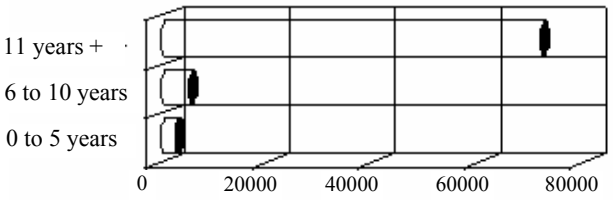


Fig. 3. *Cars' repartition by age*

To these factors is added all the west Algerian road traffic which crosses Sidi Bel Abbès, while waiting for the finalization of the by-pass of the town avoidance.
By what precedes we estimate that automobile transport constitutes the principal source of air pollution.
The studied zone measurements homogeneity and the good agreement of measuring sites provided data were controlled by the calculation of the correlation coefficients for each pollutant.
Thus, one notes for the two years that the measurements of the stations are very well correlated. The correlation coefficients of the stations vary from 0.68 to 0.99 for Ozone and from 0.83 to 0.99 for other pollutants (Table 1). The monthly averages measured of gases are variable with peaks in January, March, June and September of the principal atmospheric pollutants NO_2, SO_2 and O_3 (Fig. 4).

Table 1

Correlation coefficients between gases measuring stations

	Station 1				**Station 2**				**Station 3**				**Station 4**			
	NO_2	**SO_2**	**CO_2**	**O_3**	**NO_2**	**SO_2**	**CO_2**	**O_3**	**NO_2**	**SO_2**	**CO_2**	**O_3**	**NO_2**	**SO_2**	**CO_2**	**O_3**
Station 1	1.00	1.00	1.00	1.00	0.96	0.96	0.83	0.99	0.83	0.83	0.99	0.88	0.97	0.97	0.81	0.79
Station 2	0.96	0.96	0.83	0.99	1.00	1.00	1.00	1.00	0.86	0.86	0.83	0.87	0.97	0.97	0.99	0.80
Station 3	0.83	0.83	0.99	0.88	0.86	0.86	0.83	0.87	1.00	1.00	1.00	1.00	0.81	0.81	0.82	0.68
Station 4	0.97	0.97	0.81	0.79	0.97	0.97	0.99	0.80	0.81	0.81	0.82	0.68	1.00	1.00	1.00	1.00

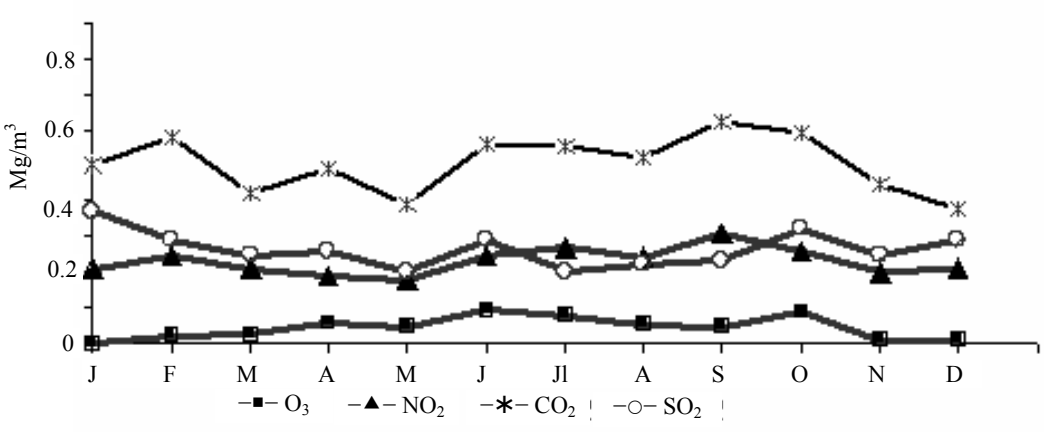


Fig. 4. *Pollutants monthly average variation in 2006*

The amplitude of the variations of the gas concentrations versus time is very important (see Table 2). One notes important peaks, as SO_2 varies from 0.16 mg/m^3 in April to 0.29 mg/m^3 in September (see Fig. 4 also). Ozone oscillates from 00 µg/m^3 in January to 0.96 µg/m^3 in June. The high level of the latter at this period is justified by the fact that it is secondary photochemical pollutant.

The recorded variations can be explained by the action of the climatic factors. One observes, thus, that the pollutant averages remain high during the dry season, without precipitations and with strong heats (Fig. 4 and Table 2).

The quantitative differences between the measuring sites are negligible, cause of the flatness of the city and the weakness and even the absence of winds. Pollution disperses more slowly and in a homogeneous way in all the urban area.

SO_2 is always present in the atmosphere and with important concentrations. This is explained by the concentration of the heavy road traffic all the year.

The quantities of CO_2 and NO_2 vary from 0.30 mg/m^3 to 0.62 mg/m^3 and 0.19 mg/m^3 to 0.37 mg/m^3, respectively (see Table 2).

It is noted that the annual average is in progression in 2006 compared to that of 2005 (see Table 2 always).

Table 2

Monthly averages of the pollutants measured in the four stations (unit: µg/m^3 for Ozone and mg/m^3 for other gases)

Month average	O_3		NO_2		SO_2		CO_2	
	2004	2005	2004	2005	2004	2005	2004	2005
January	0.02	0.00	0.205	0.210	0.290	0.376	0.40	0.50
February	0.17	0.22	0.208	0.251	0.220	0.295	0.50	0.58
March	0.25	0.25	0.225	0.212	0.570	0.251	0.32	0.42
April	0.60	0.60	0.160	0.194	0.220	0.263	0.47	0.49
May	0.52	0.45	0.167	0.187	0.200	0.203	0.43	0.39
June	0.84	0.96	0.232	0.251	0.370	0.297	0.60	0.56
July	0.76	0.80	0.252	0.272	0.220	0.209	0.45	0.55
August	0.45	0.55	0.228	0.241	0.250	0.223	0.62	0.52
September	0.32	0.42	0.290	0.310	0.100	0.237	0.60	0.62
October	0.10	0.09	0.222	0.267	0.100	0.320	0.62	0.59
November	0.10	0.10	0.185	0.198	0.120	0.256	0.35	0.45
December	0.12	0.02	0.209	0.214	0.350	0.294	0.30	0.38
Annual average	0.35	0.37	0.215	0.233	0.250	0.268	0.471	0.504

The characterization of the danger is highlighted by the identification of the dangerous potential of the measured substances in the atmosphere of Sidi Bel Abbots using the bibliography which recognizes the referenced toxicological values (see Table 3). The guides' values used in this study are those validated by the US-EPA, and the WHO recommendations.

Table 3

Guides' values for current pollutants. Source: WHO (2003)

Pollutant	Guide's value ($\mu g/m^3$)	Concentration where effects on the health could be observed in $\mu g/m^3$	Exposure duration
CO_2	10,000 60,000 30,000 10,000	No object	15 min 30 min 1 hour 8 hours
O_3	160 110	No object	1 hour 8 hours
SO_2	500 350 125 50	1000 700 250 100	10 min 1 hour 24 hours 1 year
NO_2	200 40	400 80	1 hour 1 year

The determination of the danger occurrence probability has been established by the relation between the exposure for a certain amount of pollutant and an effect or the occurrence probability of an effect. The risk is calculated by the relationship between the measured values and the referred guides' values

A proportion, equal or higher than 1, of a contaminant present in the environment indicates the probability of a noxious effect on health [16].

Concerning the exposure, one considers that the total air pollutant exposure index is the same one for the whole of the population (inside and outside) dwelling in the urban environment [17, 11].

It should be noticed that for this type of study it is very difficult to measure duration that the population in an environment passes, which represents the exposure time [18].

Moreover, one took into account the fact that the urban environmental exposures, other than all other exposures of professional nature (pollen, pesticides and solvents used by industry), can probably have an action on public health or a synergistic effect.

The atmospheric pollutants emissions measured inside the town of Sidi Bel Abbès approach strong values. Average concentrations of measured gases, exceed in, all cases, amounts recognized by the various specialized organizations as presenting a toxic health risk [19, 20, 21]. All hospitalized for a respiratory cause in the UHC pneumological service are listed in Table 4.

Table 4

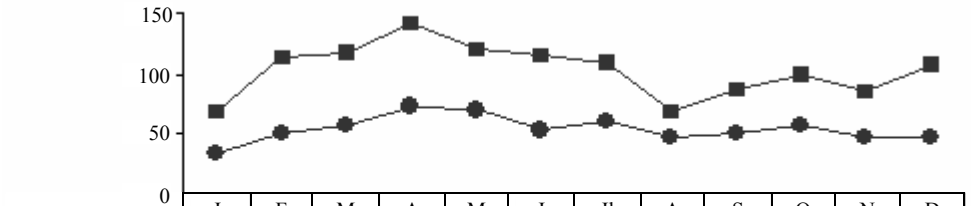
Monthly distribution of the hospitalizations for a respiratory cause (2005-2006)

Hospitalisation for a respiratory cause	J	F	M	A	M	J	Jl	A	S	O	N	D
2005 year	33	51	58	73	65	57	60	27	46	51	43	57
2006 year	36	62	60	69	51	62	49	21	37	42	38	61

One notes that there are small monthly variations, except for February, May and July when an important variation is distinguished. However the respective fluctuations vary in the same direction (see Fig. 5).

The patients distribution by residence zone, shows that the frequency of hospitalization among the urban population, resident with Sidi Bel Abbots and its periphery, presents a rate of 74,78 % of the total population of the department. The quality of the air have, probably, a part of responsibility in this important variation.

The morbidity nature analysis shows that the asthma and asthma crisis are the most frequent hospitalizations with a rate of 45.76 %. Various pathologies such dry coughs, pleurisies, bronchitises, laryngitides account for 28.24 %. Infectious diseases (tuberculosis, infectious pneumopathies,..) 7.90 %, and finally cancers 3.95 %.



	J	F	M	A	M	J	Jl	A	S	O	N	D
−■−Morbidities	36	62	60	69	51	62	49	21	37	42	38	61
−●−Morbidity	33	51	58	73	70	53	60	47	50	57	48	47

Fig. 5. *Hospitalization variations for respiratory cause in 2006*

Analysis of the asthma distribution (Fig. 6) indicates that the peaks appear during the winter and spring seasons.
The pollution level varies according to seasons and climatic hazards, such as scrubbing by precipitations in the winter and a strong concentration in dry period. Ozone, him, increases from April to September, period of strong luminosity.
The Sidi Bel Abbès atmosphere pollutants metrology and the hospitalizations frequency for a respiratory cause for the risk situation evaluation, led to study the intensity of the existing connection between their variations in the year.
This relation is measured by the population exposures to the atmospheric pollutants and the hospitalization (medical impact).
Thus, graphs (in Fig. 7) illustrate the existence of a correlation between the curves variations, while this statistical relation between pollutants and morbidities does not, inevitably, mean the existence of direct causality bond, since other factors could influence each of both first and explain the correlation observed.

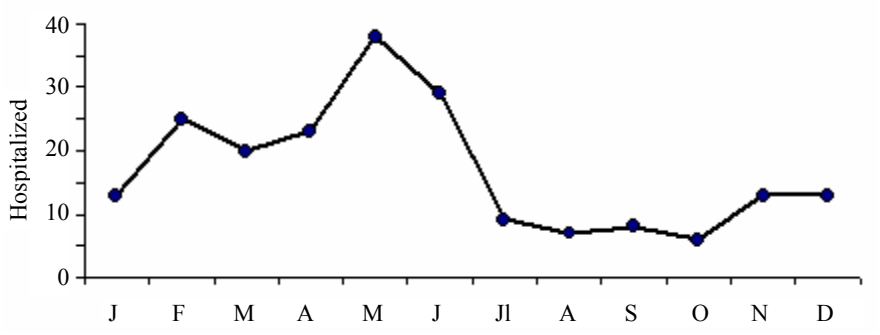


Fig. 6. *Asthma variation in 2006*

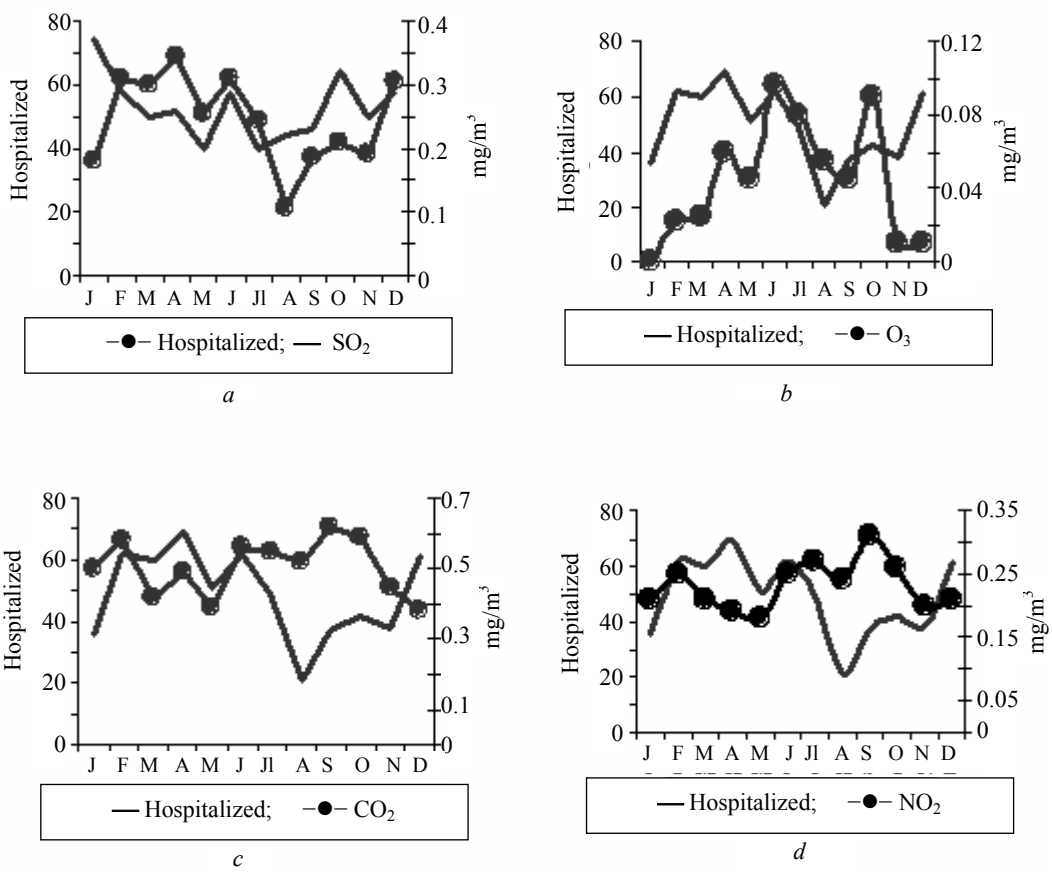


Fig. 7. *Hospitalization variations for respiratory cause versus pollutants:*
a − SO_2, b − O_3, c − CO_2 and d −NO_2

As we can see on the graph (Fig. 4), the pollutants variations are, themselves, well correlated, which makes difficult the understanding of their respective influences.
However, and being based on the literature, their convergences indicate an influence of the air pollution on the breathing apparatus.
One can, therefore, admit that there is an effective impact even if the epidemiologic analysis does not make possible to identify with precision which components of pollution is the true determinant of this impact [22, 23, 24, 25, 26].
Moreover, to certain asthmatics, the air pollution is over added to other factors such as nervous tiredness, anguish, efforts, passive nicotinism, allergy, climate, etc. [26]. Let us notice that certain irritants are natural, like the cold, moisture or pollen.
The results obtained show that there are strong increases in the hospitalizations for respiratory causes during the cold winter period and of pollen in spring (Fig. 5 and 6).
According to the expertise organizations published recommendations which are founded on human observations or by extrapolation of animals experiments, the relationship between the pollutants concentrations found in the atmosphere of Sidi Bel Abbès and the guides' values, show the probability of possible impact on resident public health who is permanently exposed [10, 19, 20, 22, 23].
It is noted that the pollutants concentrations (SO_2 and O_3) reach raised levels in comparison with the noxious found thresholds, being able to cause or worsen respiratory morbidities.
In addition recent results in epidemiologic research led to think that even on levels of concentrations usually observed, there is a measurable impact of pollution on human health [23].
Thus, it has been demonstrated, by many research and scientific studies, in particular in the industrialized countries that at the asthmatic or respiratory deficient people, the air pollution can have consequences, sometimes tough, at certain periods (heat wave, anticyclone, stormy heat), hence a certain pathology indicating the presence of an allergen factor which could be polluting [9, 10, 24].
The phenomenon of these pathologies is in a constant rise for few years in Algeria and in the area of Sidi Bel Abbès, particularly. By this fact, it has been deduced that the factor pollution is not foreign with this increase in the prevalence of asthmatics in the region.

Conclusion

The noxious effects on health of the air pollution are currently well-known and the epidemiologic and experimental studies highlighted the role of the air pollution in the appearance or the aggravation of respiratory and cardiovascular pathologies. Because of the absence of threshold, the medical effects of the air pollution can be observed for levels of exposure lower than the legal guides' values.
The question is a problem of public health, and currently, many research tasks are carried out in order to better understand dispersion and the become of pollutants in the urban environments and to establish with precision the existing correlation between the presence of these substances in the air and health for better risks preventing, health preserving and the environment.
To be unaware of the level of pollution of our atmosphere is not equivalent to the absence of risks for the population. Our evaluation of the air pollution in Sidi Bel Abbès has given concentrations, often, higher than the recommended guides' values as limiting thresholds for health protection of health. Thus the risk probability of short-term public health harmfulness exists, particularly the exposure of the people presenting a cardiovascular and/or a respiratory insufficiency.
In conclusion, our risk evaluation is of an interest at the decisional plan to deal with this problem of public health by:
1. The creation of inspection networks of the quality of the air, determining element for better apprehending the importance of the problem.
2. To better know the quality of the air than we breathe and thus the possibility of intervening by reducing the rejections and the pollutants emissions in the atmosphere within non-noxious recognized limits for health.
3. The approach can be developed and generalized to envisage medical and environmental impacts on the urban environments before setting up new projects and activities.

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