Moroccan Journal of Chemistry
ISSN: 2351-812X
http://revues.imist.ma/?journal=morjchem&page=login
BACHIR BOUIADJRA & al./ Mor. J. Chem. 5 N°4 (2017) 740-747

Air quality in the metropolitan area of Sidi Bel Abbes (Algeria) through the lichens species as bio-indicators

BACHIR BOUIADJRA Salah Eddine (a), RAMDANI. Mohamed(b), DJELLOULI. Riad(a), ELKHIATI. Najat(c), EL ZEREY. Wael(a), BOUTERFAS. Karim(a), BOUHDJILA. Sofiane(d), ELMSELEM. Hicham(e)* and Roger. FLOWER(f)

(a). Laboratory of Eco-développement des espaces. Faculty of sciences of nature and life Djillali Liabes University. SBA, Algeria
(b). Laboratory of Water, Environment and Sustainable Development, Faculty of Sciences, Mohammed Premier University, Oujda, Morocco
(c). Faculty of sciences Ain Chock, University Hassan 2, Casablanca, Morocco,
(d). Environnement Directorat, SBA, Algeria ;
(e). Laboratory of Applied Chemistry and Environment (LCAE-URAC18), Faculty of Sciences, Mohammed Premier University,
Oujda, Morocco.
(f). Department of Geography, University College London, UK

* Corresponding author:
h.elmsellem@gmail.com
Received 04 May 2017,
Revised 22 May 2017,
Accepted 22 Sept 2017

Abstract

The air quality in towns and cities is increasingly deteriorating as human activities increase but no actions have been taken in Algeria to limit air pollution. There are no regulations for controlling pollutant emissions and no specialist treatment center for treating diseases and allergies caused by air pollution. To access urban air quality lichens species were used for bio-monitoring 12 stations spread across Sidi Bel Abbés city (Western Algeria). The use of living organisms, in this case lichens, for evaluating the quality of air is a preferred method. European lichenologists developed a new environmental quality assessment protocol using mapping lichen diversity and lichens are very often used as bio- accumulators. The selected species are generally those growing on tree trunks, and having a broad geographic distribution. The lichen species most often used are thallus foliaceus or fruticose forms such as Parmelia caperata, P. sulcata, Hypogymnia physodes, Xanthoria parietina, Evernia prunastri, Pseudevernia furfuracea. These lichens species have large adsorption surfaces for major pollutants. In this work we evaluate the air quality by applying lichen index based on German environmental engineers to map air pollution in the city of Sidi Bel Abbes.

Keywords: *pollution, lichens, Air quality index, Sidi Bel Abbes Algeria.*

1. Introduction

Sidi Bel Abbés Province is a wilaya of Algeria in North Africa with 604 744 inhabitants in an area of 9328 km². The population density is 64.8 inhabitants per km². Sidi Bel Abbes and Sfisef Telagh are the largest agglomerations in this province among the 52 agglomerations that compose the wilaya. The climate is semi-arid dry in summer and cold in winter. With a total area of 9150.63 km2, only an area of 3 660 km2 (40%) is covered with steppe, 2 250.37 km2 (ie 24.59 %) are composed of mountainous landscape and 3239 km2 (34.40 %) of plains. During the last decade, the urban fabric of this city has undergone a dramatic extension. The population census in 2000 was approximately 224,000 inhabitants. The forecasts for 2017 estimate the population of Sidi Bel Abbes to be 305.000 inhabitants, assuming an average annual growth rate of around 2.5 %. The region of Sidi Bel Abbes has favorable climatic conditions for the development of lichen vegetation which can grow abundantly on local trees.

2. Methodological approach : ecologists German Engineers Method (Kirschbaum and Wirth)

The method uses lichens as bio-indicators of air pollution in order to calculate the index of the air quality and subsequently to deduce the class of pollution [1], [2], [3], [4] [5], [6]. Air pollution index classes used are shown in Figure 1.

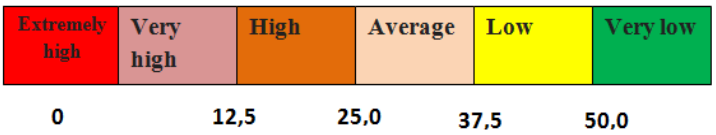


Figure 1: Air Quality Index

To collect data, we used a map of the Sidi Bel Abbes area and trees were measured to make the diameter of the bark of the tree, A magnification hand lens 8x to 16, necessary for the determination of different lichen species, a camera, a calculator and plastic boxes to collect the lichen species. The Statement Listing noted in pencil on the field observations [8], [9].

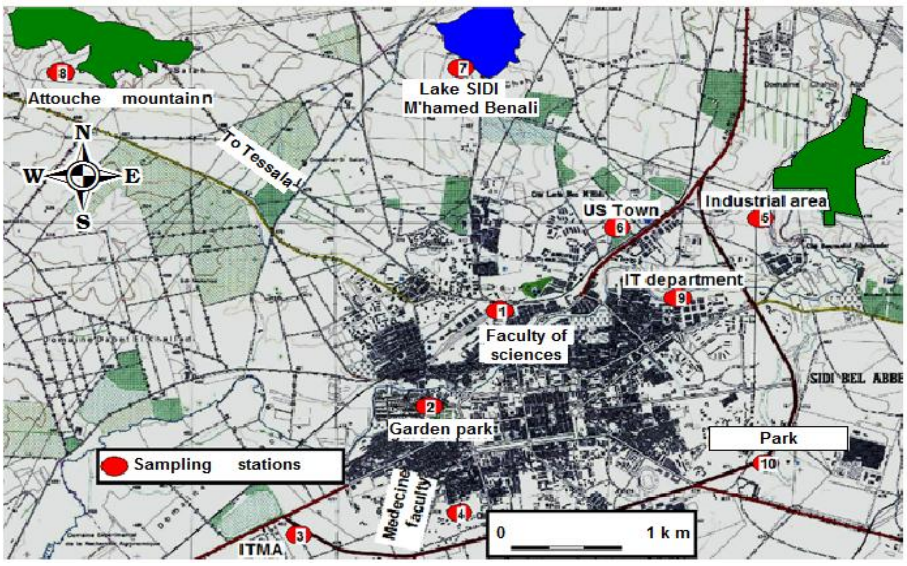


Figure 2: Sampling stations

Selection of trees bearing lichens species: The criteria used to select the sampling stations are: presence of a minimum of 6 trees in a station; trees should be subject to the same conditions for light humidity and exposure to wind; the diameter of the trees must be more than 20 cm [11], [12], |13].

Lichen surveys : These were undertaken by placing a counting grid on a support shaft about 100 cm from the ground; then identifying the species in each square and completing the survey grid. This is done for each of the 6 trees (figure 3). After calculating local air quality indices in the ten sampling stations , we evaluated the mapping results by using MapInfo Professional 7.5 and 3.5 Surfer software . This phase involves several steps: 1-Scanning a background urban area (1/5000) of the city of Sidi Bel Abbes; 2- georeferencing of this fund is using the MapInfo 7.5 software, and applying a 0 pixel timing error. 3- Use the Surfer software to produce results as curves or isovalues . 4- The superposition of layers isovalues indices of air quality in the city of Sidi Bel Abbes.

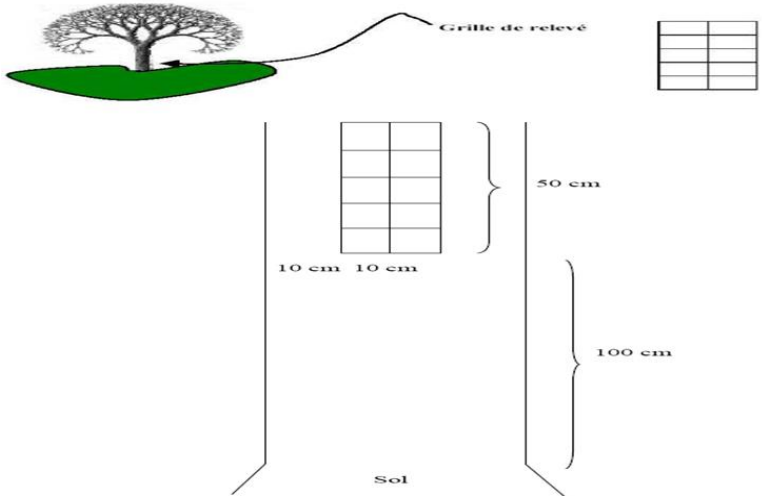


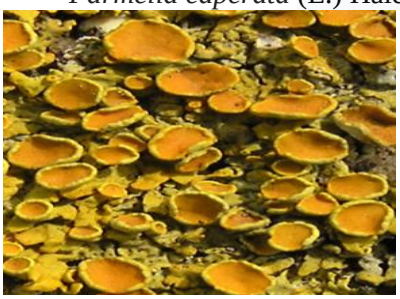
Figure 3: Sampling method (German environmental engineers /VDI – 3799-1995).

3- Results

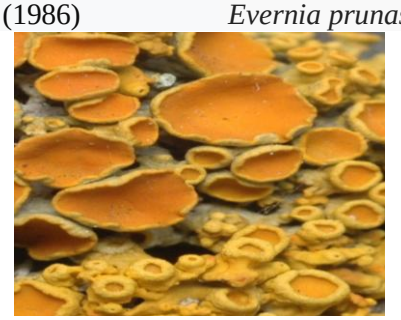
The following species were recorded and identified : *Parmelia caperata* , *Parmelia soredians*, *Evernia prunastri* and *Xanthoria polycarpa Xanthoria parientina*, (Figure 4).

Parmelia caperata (L.) Hale (1986)

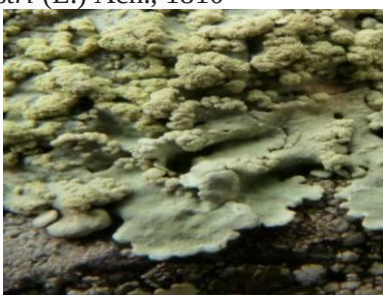
Evernia prunastri (L.) Ach., 1810



Xanthoria parietina (L.), Beltr.



Xanthoria polycarpa (Hoffm.) Rieber



Parmelia soredians Nyl.

Figure 4: Five lichen species identified in the study area of Sidi Bel Abbes

In the study area no trees were without lichens species however the distribution of lichen occurrence and abundance did vary. The number of lichens species varied between stations and two species is the minimum and maximum value is five species. In total, there are two stations with only two lichens species in the Faculty of Science and in the Industrial area, while the station with the maximum value of five species is on the mountain of El Attouche (Figure 5).

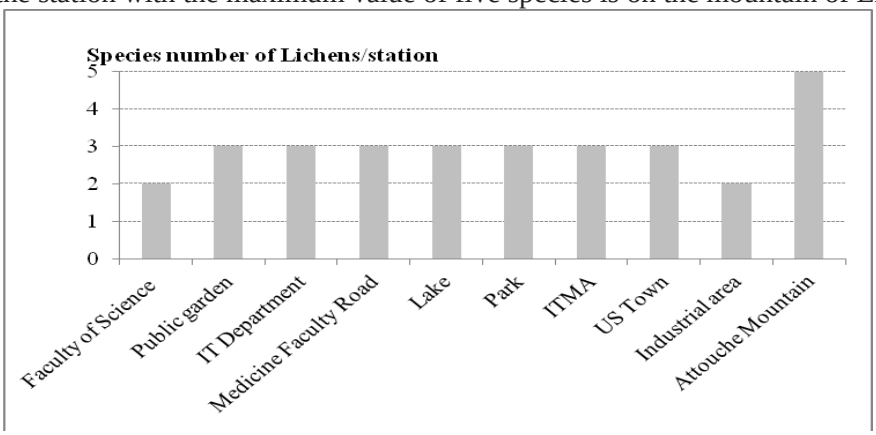


Figure 5: Lichens species number identified per station in the study area

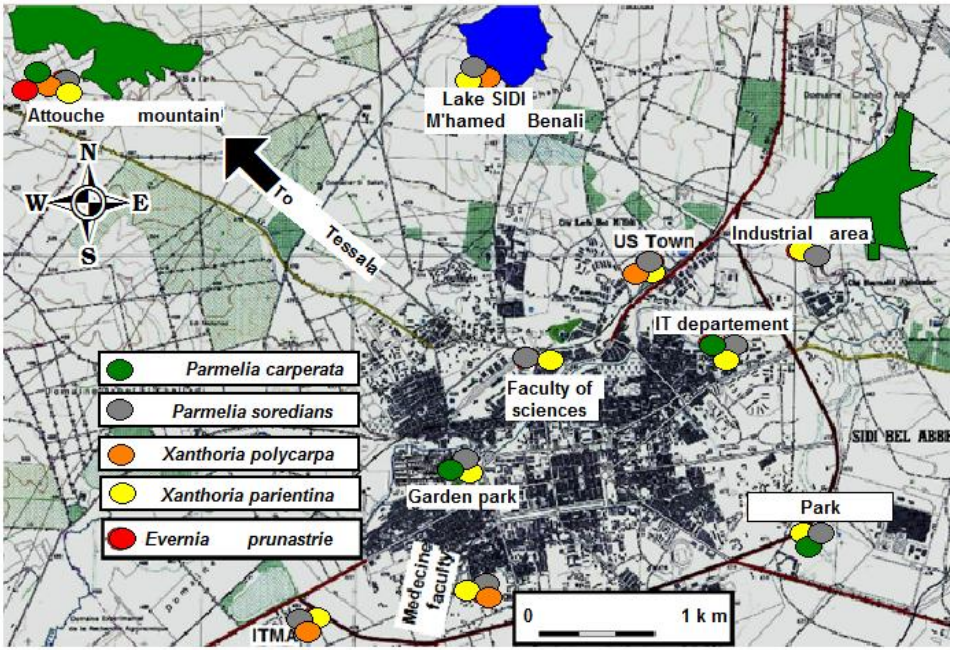


Figure 6: Geographical distribution of lichen species identified in the metropolitan area of Sidi Bel Abbes

Analysis of air quality index and hazard classes: The results in Tables 12 and 13 enabled to deduce the following challenges. Air quality index range between 12.28 and 38.99 according to the air quality classification scale of Kirschbaum and Wirth with six classes ranging from extremely high pollution with an index 0 to the very low hazard class with an index of 50 [6],[14]. This shows that the air quality indices vary between 39 and 12.3 indicating that air pollution was lowest in the Attouche Mountain site and highest in the industrial zone. The Jebel Tessala and specifically in the area of El Attouche, the highest index 38,99 it to qualify to belong to the lower class of pollution. Calculating the average Index of air quality for the ten stations we obtained 26 which places the town of Sidi Bel Abbes in middle class pollution (Figure 8).

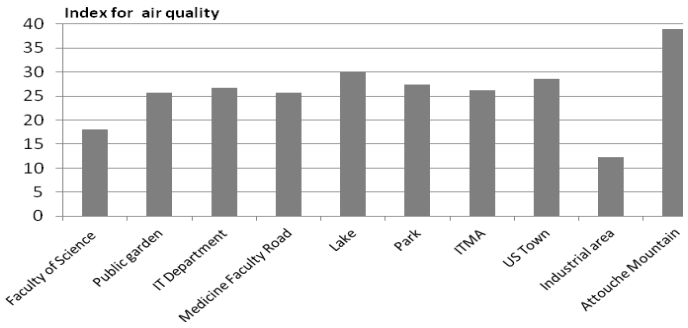


Figure 7: Air quality index for the ten sampling stations

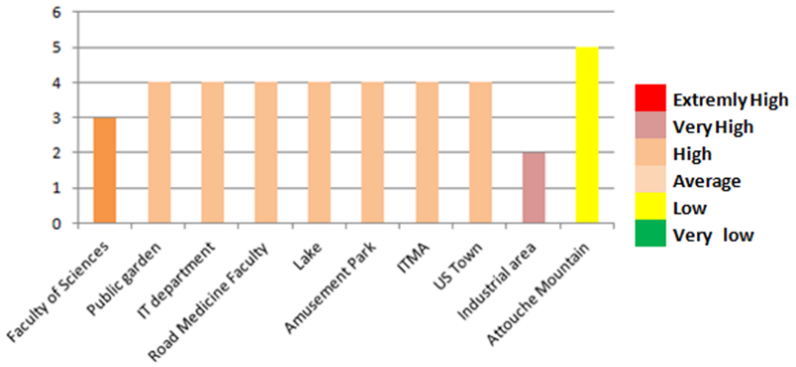


Figure 8 : Representation variation class of the air quality according to the sampling stations

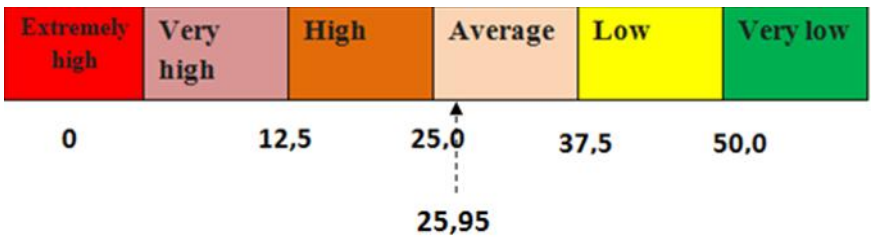


Figure 9: Index of air quality in the city of Sidi Bel Abbes

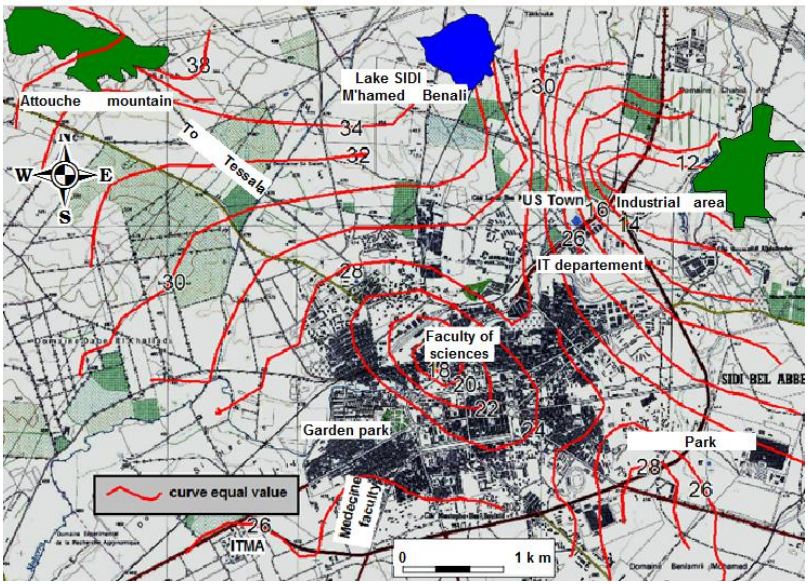


Figure 10: Mapping of air quality index of Sidi Bel Abbes

Results obtained from the ten stations throughout the city of Sidi Bel Abbes were processed to produce constant value air quality curves for air quality indices by using Surfer 3.5 software. By mapping these curves over the Sidi Bel Abbes regional area, we made a preliminary assessment that, according to the index vales, air pollution increases gradually in a south-easterly direction away city center (ZHUN EST), passing through the cities Sidi Yacine, Hai El Houria and across the ring road. A similar observation was made for the North zone (ZHUN NORD) towards the town of Tessala. To the north west a clear a progression in air quality index values occurred with the 34 index isoline passing through the northern suburban area and increasing to the cleaner area 38 isoline in the Attouche hills

4- Discussions

Results indicate that the city of Sidi Bel Abbes does not seem to be highly polluted, but several stations corresponding to zones with clearly different levels of pollution. The most polluted areas are in the Industrial zones (pollution class "very high" with low lichen diversity of only two species) where industrial activity is intense and nearby busy roads contribute to the problem. The Class "high" pollution at the station near the Faculty of Science. Had the same lower lichen diversity, belonging to this class can be justified by the station's location in the city center or car traffic is intense especially and the high traffic of train station. Seven Stations belonging to the "average" class air pollution (Public Garden, Litma, route to medical school, American village, the lake Sidi Hamed me benali, IT department and the amusement park), had varying indices of air quality but a similar number of species, three species in each sampling station. The results can be justified by the fact that most of these areas ring the city and are more or less equi-distant. The mapping of pollution indices as iso-lines is preliminary because the number of sampling stations is rather small and not systematically located. We can nevertheless suggest that one source of air pollution comes from automobile pollution from along various arterial routes near several stations, near the National Road No. 7, next ITMA and connections with the Prefecture of Sidi bel abbes in Tlemcen road. Agricultural activities and automobiles cause nitrogen pollution essentially justifying the presence of *Anthodia* Lichen species. One station classified "very low" pollution is in the el Attouche hills, here lichen diversity was high compared to other stations; and this may be explained by the abundant tree vegetation, its proximity away from the industrial zone (5 km) and the fact that all conditions for development of lichens are met (sun, humidity and relatively clean air). The remoteness of this wooded area away from sources of pollution and especially the lack of car traffic reflects the benefits of an open and rural area. It should be noted that this area hosts a center for asthmatics which is in accordance with good air quality indicated by the lichen data. These observations were verified by mapping the pollution indices using the German city of GAP method [4], and the City of Briancon [6]. The industrial zone is a special case far out of town has the lowest diversity (2 species) and the lowest index 12.28, so is classed "very high" pollution and this is logical because this area is the main source of pollution. The overall air pollution class in the city of Sidi Bel Abbes, an area of 9 km2, is "average" with a quality index of 26. This likely reflects, the geomorphological nature of the study area is in the form of bowl and so favours micro-pollutants accumulating and stagnating, especially in warm periods when there is little air mixing. The main sources of pollution in the general area of our study appears to be emissions from the automotive sector, and from the use of fertilizers in nearby agriculture and from the industrial area. There appears to be a relationship between the air quality index and agriculture and urban activities. Pollution generated by the business areas is indicated by the lichen vegetation. In general, the further away from the town center the morer the air quality indices tend to increase. The farthest station of the city (Attouche) has the greatest lichen diversity (5 species) and the largest index 38.99. We can see from the analysis of the figures 11 and 12 that if one considers the Faculty of Science as the center of the study area. These findings can be identified by the two graphs follows:

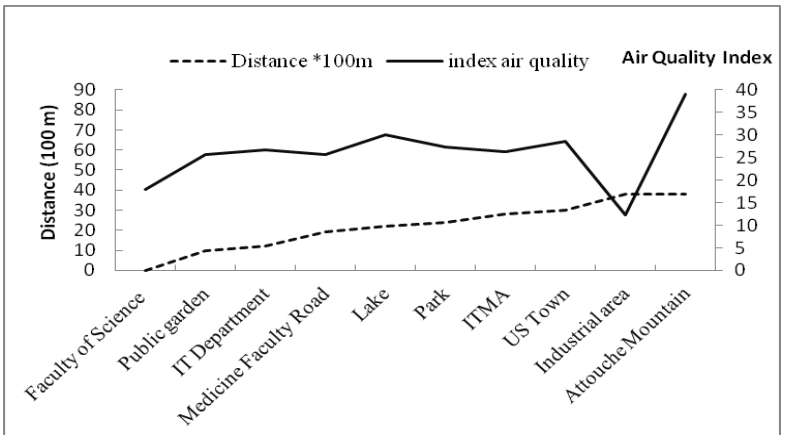


Figure 11: Assessment index according to the distance

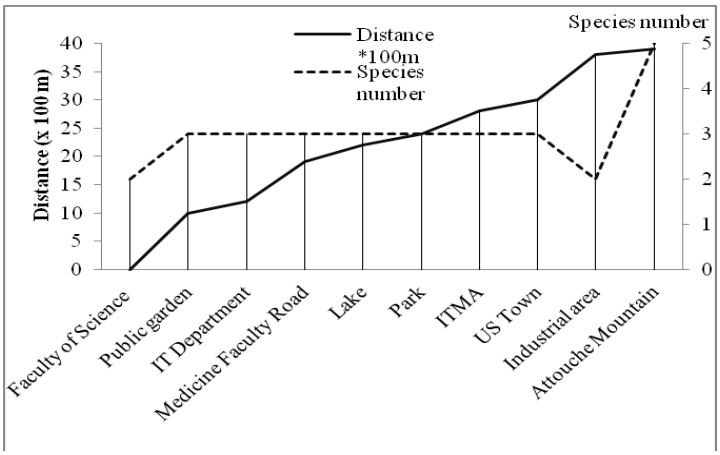


Figure 12: Representation of the variation in the number of species as a function of the distance

5- Conclusion

The lichen species occurrence are suitable organisms for biomonitoring studies. Pollution in the urban area of Sidi Bel Abbes, remains relatively modest with an air quality index of around 26. Some potential pollution sources are indicated and air pollution was intense in the industrial zone. Possible solutions to pollution problems in the study area concern the use of clean renewable energy (hydrogen, solar, wind, biofuels), encourage recycling and processing of waste, changing manufacturing processes and consumption practices. Different maps, analyzes and comparisons indicate that pollution remains relatively 'average' in the metropolitan area of Sidi Bel Abbes with an index quality of 25.96. Lichen diversity for the study sites, comprised five common species namely: *Xanthoria polycarpa*, *Xanthoria parientina*, *Parmelia soredians*, *Parmelia carperata* and *Evernia prunastri* enabling four classes of sensitivity to air pollution were adopted: low, medium, high and very high. According the lichen indicator indices, air pollution follows a centripetal direction from the city center to the periphery, this may be explained by regression of pollutant concentration in the center to the periphery (suburban area) . Our present study is not intended to present an accurate picture of pollution in the Sidi Bel Abbes area but does give a preliminary indication of the major trends. In addition it should be recognized that that lichens do not reveal a specific pollutant but are excellent indicators of an integrated mix of different pollutants. The current interpretation is incomplete but does show the potential values of the study of lichens to highlight air quality problem areas. Further work should include more sites and multivariate analysis incorporating weather data, traffic and land altitude and chemical measurements on the thallus of lichens which are excellent integrator of air pollutants. Confronting our analysis of surveys conducted by physical-chemical sensor could also be a study track. It is important that lichens suffer the least possible disturbance during sampling and, for this

reason, it is generally fee lichen with its support (fragment of bark or branch). The technique of transplantation, already widespread in bioaccumulation studies has been used more recently to search for biomarkers (fluorescence and chlorophyll content, ATP content, oxidative stress parameters [5].

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